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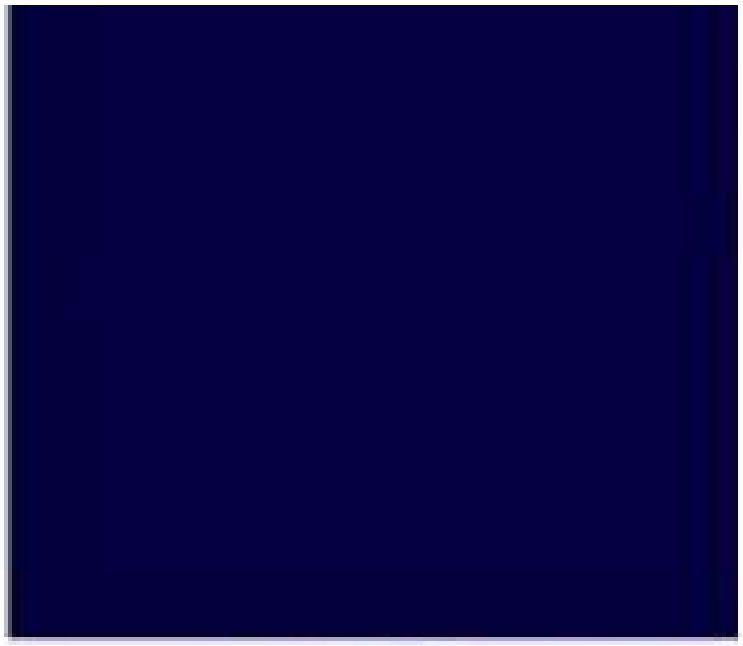

SRB's Surgical Operations

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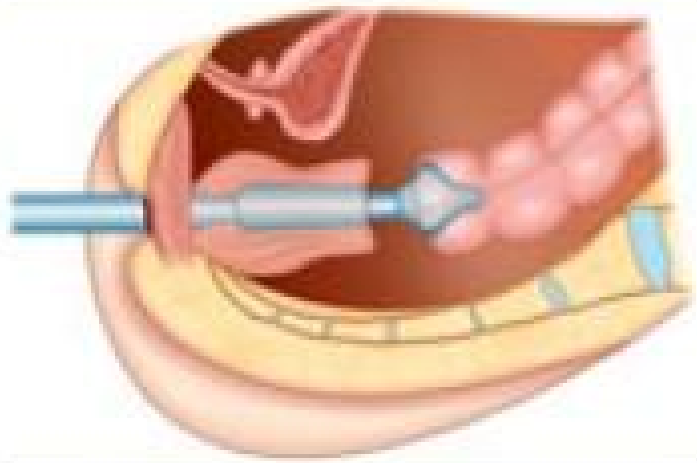

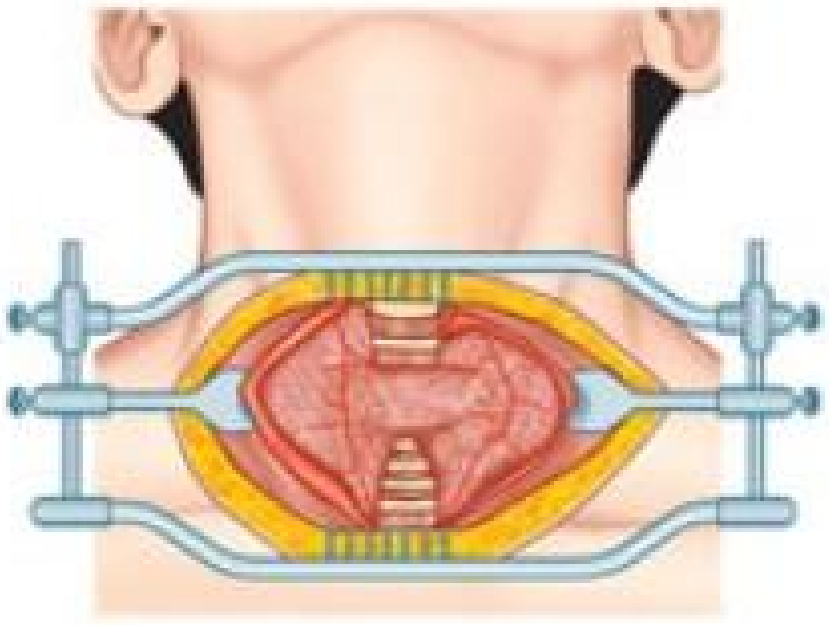

Sriram Bhat M

Forewords
K Ganesh Pai
Ashok Pandit

SRB's

Surgical Operations

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SRB's
Surgical Operations
Text and Atlas

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SRB's Surgical Operations: Text and Atlas

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This book is dedicated to
My beloved father

Late Mr Krishna Bhat Muguli

from whom I have learnt *simplicity, contentment, humility and dedication*.

and

Mangala Hospital and Mangala Kidney Foundation, Mangalore, India

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Foreword

It is my pleasure to write a foreword for *SRB's Surgical Operations*. Let me, at the outset, congratulate Dr Sriram Bhat M for launching this fantastic book. Dr Bhat belongs to a rare breed of surgeons, who has not only mastered the art of excellence of teaching but also bestowed with superb skill in surgery and documentation. This facet has been put on record by bagging Good Teacher Award twice from Kasturba Medical College, Mangalore, a constituent college of prestigious university, MAHE Manipal and churning out about half a dozen textbooks related to surgery. These books have been well received and sold like cakes within India and abroad.

I have gone through the contents of this book and it is quite fascinating. It has about 1,400 pages containing colored illustrations of operative procedures spread across fields of general surgery, GI tract surgery, urology, vascular surgery, and basic laparoscopy. A study of this book, at the very least, stimulates surgeons to think about their own technique. It is unlikely that a surgeon who is expert in a particular operation will turn to this book for advice about that operation, but it is to be expected that the same surgeon will obtain useful information from this book when called upon to operate in less familiar field. I sincerely appreciate and applaud with deep admiration the efforts put in by Dr Bhat (fondly referred as SRB by his students and colleagues) devoting his valuable time at the cost of his family and professional life towards this esthetic collection, which in a nutshell is extremely par excellent.

I, therefore, wholeheartedly support this book and recommend its use by undergraduate and postgraduate students, general surgeons and all those who need guidance in the field of operative surgery and basic laparoscopy.

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Foreword

No matter how well read and proficient in clinical skills, the ultimate test of a surgeon is the operation theatre. Although a mastery of operative surgery does require a lifetime's practice, having a good teacher/mentor and access to a thorough text on operative surgery, will shorten the learning curve. This textbook with its exhaustive coverage of practically all surgical procedures (common and otherwise) will definitely be useful to both undergraduate and postgraduate students of surgery as well as practitioners of the art. The plentiful illustrations are simple and enhance the understanding.

It is my distinct privilege to have been associated with Dr Sriram Bhat since his time as a postgraduate in surgery and has a great love for teaching. The large number of students who flock his weekly bedside clinics in district Wenlock hospital, ever since he joined the faculty of general surgery, are a testament to his ability to impart knowledge. Having worked with him for over 20 years, I have seen him grow in stature and knowledge as a surgeon. He picks up new skills like laparoscopy through sheer hard work. Dr Sriram also has prodigious literary output. He has written more than five books in relation to surgery for medical, dental and nursing graduates. His *SRB's Manual of Surgery* has proved hugely popular among undergraduates in India and abroad. Having seen his labour day and night at documenting the various surgical procedures and, of course, the laborious collating, writing and proofreading often into the wee hours of the morning reminded me of Duke Elder (of the classic ophthalmic text) who reputedly made with barely an hour's sleep! I thank Dr Sriram for giving me this unique honour of writing the foreword for this operative book which I am certain will also prove equally popular and useful.

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Kadri, Mangalore

Preface

It was my long dream after writing *SRB's Manual of Surgery* to pen in relations to operative technique in detail from simplest procedure to essential advanced major procedures needed to general surgeons and surgical postgraduates. I took nearly 4 years to make my dream near true in the form of *SRB's Surgical Operations*. I have included umpteen numbers of illustrations and photographs. Basic principles and techniques of suturing and dissection also dealt with in detail. It will be useful to all categories of students and consultants to learn basic. Gastrointestinal surgery is discussed in detail with illustrations. Urology mainly open methods are discussed adequately if not extensively. Basic laparoscopy and usual laparoscopy surgeries are discussed with highlighting the robotic surgeries, liposuction and so on. It differs from other operative surgery books by its unique presentations in detail with surgical anatomy and operative photographs of most of the procedures. I presume students and consultants will enjoy its reading. I am always grateful to Shri Jitendar P Vij for his support and encouragement towards me to bring out this book. Any comments and healthy criticisms are well accepted.

Sriram Bhat M
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I thank the Head of Department of Surgery, KMC, Mangalore, Professor Alfred Augustine, for his constant encouragement in academic work and progress.

I always remember my senior teachers, Professor CR Ballal and Professor Suresh Kamath, Professor K Prakash Rao, Professor Subramanya Bhat, Professor Bhaskar Shetty and Professor Ramachandra Pai, for their constant help.

I thank Dr Professor K Ganesh Pai, Paediatric Surgeon, for his encouragement and writing foreword to this book. He was my thesis guide and a very renowned surgeon too.

Professor Prakash Rao, as a guide and encourager to everybody, will be remembered as a special person by me always.

I thank my beloved friend, well-known popular urologist, Dr Ashok Pandit, Mangalore, who has been helping me in all aspects of my surgical career.

My special thanks to Dr Jayaram Shenoy and Dr Jayaprakash Rao, for their affection and support.

Dr Ashok Shetty, MCh, Cardiothoracic Surgeon, has helped me by adding contributions in chapter on surgeries of arterial diseases. I thank him a lot.

I appreciate District Medical Officer and Resident Medical Officer of Government Wenlock Hospital, Mangalore, for their kind help.

I am grateful to all my teachers and colleagues in surgery department who directly or indirectly helped me to bring out this book.

Surgical unit heads in our college Dr BM Nayak, Dr Thangam Verghese, Dr Harish Rao, Dr Shivaprasad Rai, Dr Yogish Kumar, and Dr Shivananda Prabhu are always supportive for my work and are worth to be remembered always. Dr Manohar Pai, Dr Ashfaque Mohammed, and Dr Keshavaprasad are of special mention. Dr Keshavaprasad has helped by adding contributions in few chapters of his interests.

I thank Dr K Venkatesha Udupa, Department of HPB Surgery and Liver Transplantation, St Vincent's University Hospital, Dublin, Ireland, contributed to chapter on surgeries of liver and gallbladder especially liver transplantation. I also thank Dr Arun Kumar MCh, Surgical Gastroenterologist, for contributing a lot of GI photographs. I thank Dr Ravishankar, Surgical Gastroenterologist, Bengaluru, for helping by providing photographs in chapter on surgeries of liver and gallbladder.

My wife Dr Meera Karanth helped me day and night by contributing the chapter of surgeries in obstetrics and gynaecology and without her help this could not have been possible. My beloved daughter Ananya helped me in drawing new diagrams artistically. I enjoy her love and affection towards me.

I thank Dr Suresh Pai, MCh, Dr Divakar Rao (Neurosurgeon), Dr C K Bantwal (Neurosurgeon), Dr Muralidhar Pai, MCh (neurosurgery), Dr Laxman Prabhu, Urologist, Dr Ranjith, Urologist, Late Dr Vivekanand Prabhu (Paediatric Surgery), Dr Sadashiva Rao, Paediatric Surgeon, and Dr Narayana Bhat, Paediatric Surgeon, for their help and contributions.

I thank Professor Anitha Ganapathy Bhat, Mangala Hospital, Kadri, Mangalore.

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I sincerely appreciate Dr Raghavendra Bhat and Dr Ravichandra, Consultants in Radiology Department, Yenepoya Medical College, Mangalore, for their contribution and affectionate help. My special thanks to Dr Prashant Mallya, Anaesthetist, for guiding me in many places.

My postgraduates are of special mention as they constantly helped by in taking photographs and proofreadings to mention Dr Aromol C, Dr Hemanth Makineni, Dr T Sudheendra, Dr Sunil Math, Dr Srikanth Soma, Dr Guruprasad Reddy, Dr Anand R Baid, Dr Nanjundiah, Dr Abid Ali Mirza, Dr Rama Mani Lam, Dr Vijay, Dr Ashish, and all others. I appreciate them for their affectionate help.

I remember my students Dr Ravi CR, Dr Ashwini Polnaya, Dr Ishwara Keerthi, Dr Sudesh, Dr Narasimha Murthy, and Dr Ashish Singh, for their special contributions.

I thank all my students especially postgraduates of surgery department who were helping regularly in bringing out this book.

I thank all staff in operation theatre and others in Mangala Hospital, Mangalore, for their help in taking needed photographs of the different procedures.

Words are not sufficient to remember all my patients who are the main material for the book. I pray for their good health always.

I appreciate Shri Jitendar P Vij Sir (Group Chairman), Mr Ankit Vij (Managing Director), Mr Tarun Duneja (Director-Publishing) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India. My sincere thanks to editing team members—Ms Sunita Katla (Publishing Manager), Mr KK Raman (Production Manager), Ms Seema Dogra (Cover Designer), Ms Geeta Srivastava and Mr Laxmidhar Padhiary (Proofreaders), Mr Kapil Dev Sharma and Mr Kulwant Singh (DTP Operators), and Mr Gopal Singh Kirola and Mr Rajesh Ghurkundi (Graphic Designers) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India, for their dedicated and affectionate work in bringing out this book. Also, my appreciation to working team in the Branches of Jaypee Brothers Medical Publishers at Bengaluru and Mangalore, for their timely help.

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Chapter

1

Introduction and Principles in Operative Surgery

Surgery is an *art,* but it is not just an art; it is an art with principles, dedication, determination, gentleness, tissue respect. It is an *irreversible art* work which if improperly done can be counter-productive. Doing surgery without principle is like an operator doing job without knowing the outcome.

It is often wrongly considered that quicker the surgeon, better he is. *Fast surgery* is probably *glamour* than an essentiality. *Speed* of the operator is only a *short term* impression. Rapid operator concept itself is a *myth*. It is the *accuracy and delicacy* of the procedure which is more important. Speed comes eventually by practice, experience, skill and knowledge. One should not force the speed; it should be spontaneous. It is the *precision* which is more important than speed. *However* quickness is needed in surgical emergencies especially in trauma and torrential bleeding situations. It again doesn't mean that one can violate the principles. *Art of surgery* means knowing proper surgical anatomy, surgical pathology, tissue respect and handling technique, gentleness, proper haemostasis, asepsis, good knowledge of different instruments and skill. *A surgeon* should be artistic, innovator, teacher, principled and superb operator.

Every surgical condition may not require surgery. Individual patient is assessed and planned for surgery individually. *Planning, thinking, skill, execution* are the assets of proper surgery. Doing wrong procedure in wrong time, with *wrong need* even through a brilliant technical execution will give a poor result. He may be considered as a *good operator* but a *poor* surgeon.

Often there are many surgical procedures as therapy for a single disease. *Merits and demerits* of each and which is ideal to that particular situation should be analysed prior to deciding the procedure. The so called '*decision making'* is very important since olden days.

Adequate length of incision; proper retraction; *minimum touch* technique (means dissection is done with instruments mainly and with fingers when needed and avoid unnecessary rough tissue handling); haemostasis; tissue respect; gentleness; patience; tolerance; avoiding restlessness; adequate exposure; safety methods; proper knowledge of different techniques; anticipation of problems; so prevention of problems; tackling ability of on table complications; taking help of additional/senior/experienced surgeons when needed without any ego—are the basic essentials of a *quality* surgeon.

Safe surgery needs–clear surgical anatomy; right anaesthesia; haemostasis; asepsis; skill with patience; learning attitude; dedication and determination.

Surgery should not be a glamour; but it should be a dedicated profession.

POSITION OF THE SURGEON

Surgeon has to spend hours of time continuously in the operation theatre. So he needs both physical as well as mental stamina for this. He should be comfortable, and relaxed. Posture is important while doing surgery. Otherwise surgeon may develop back/neck pain or other postural abnormalities. Many procedures like surgeries of hand and brain are often comfortably done in sitting position. It is good practice to make assistant and scrub nurse also to sit during such procedures as assistants also should be comfortable while doing procedure. Shoulder should be relaxed and elbow should be relaxed and flexed at 90°.

Suturing involves using of biceps muscle to move hand from a pronated to a supinated position in a natural rolling motion and is called as *forehand suturing*. So right hand surgeon assumes his body and foot for greatest efficiency. Suturing is done from right side with needle position aiming towards surgeons left foot. Both feet are placed perpendicular to the table; both parallel to each other.

Backhand manoeuvre is done by moving hand from supinated position to roll backward to reach pronated position. Position of feet and body of the surgeon should be reversed or altered depending on the convenient of technique like backhand suturing. Often both feet may be required to be placed parallel to the table. Scalpel blade is usually used in backhand movement. Suturing is preferred in *forehand* movement. Scissor is pointed towards left of the right hand surgeon. Electrocautery cutting is directed towards right foot like scalpel blade.

Position *of right hand* surgeon and *left hand* surgeon even though vary; it is better every surgeon to have a fair skill of using both hands effectively. Which side of the patient surgeon should stand even though is a matter of convenience; but in usual practice is surgeon stands on right side of the patient if he is a right hand surgeon or left hand surgeon. But surgeon should be flexible enough to *change the side* as required or as when difficulty arises during the procedure. There should not be prejudiced or have a prefixed idea about these things as *comfort of the surgeon* is the priority.

There are *separate instruments* manufactured for left hand surgeons. But due to limited availability and cost factor because of less number of left hand surgeons overall (even though exact ratio is not known, probably left hand surgeons are less than 1%) makes left hand surgeons compulsorily use right hand instruments successfully.

Even though it is often categorised as minor and major operations, it should be considered that *all surgeries are major*. By experience and knowledge surgeon may feel that surgery is minor. Practically if one

looks in patient's angle; for each patient whatever procedure he/she is undergoing is important and is always for the first time. For surgeon again it is imperative to execute enough care and skill whether the procedure/surgery are small or big. So optimum care is mandatory for all procedures, without any shortcomings.

HISTORY OF SURGERY

It is interesting to know little bit of the history in relation to surgery. Its evolvement was gradual, slow with lot of trial and errors. Acceptance, criticism were the problems in developing the newer avenues. There are so many contributors for development and progress of surgery since many centuries **(Figs 1-1 to 1-26)**.

Wound closure has originated as early as 17th century BC.

Fig. 1-1: Hippocrates (400 BC). He described umbilical hernia, acute abdomen, terminal ill patient in peritonitis, his famous oath.

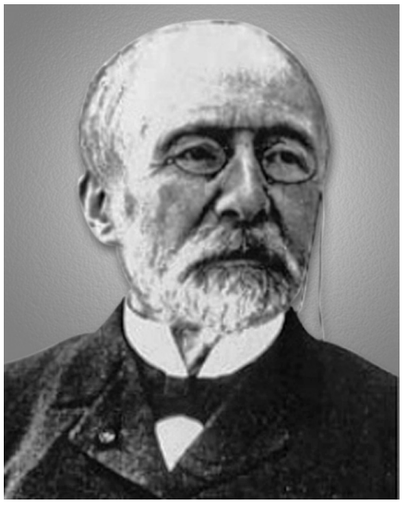


Fig. 1-2: Courvoisier. He did extensive work on biliary surgery. He originated his famous Courvoisier's law.

Sushruta in ancient India gave the concept of nasal reconstruction after punishment loss of nose in 600 BC. He repaired intestine perforation using ant heads–natural stapling. It was called as ' Sushruta era' **(Fig. 1-4)**. *Sushruta Samhita* is premedieval period treatise in surgery. Book had five sections.

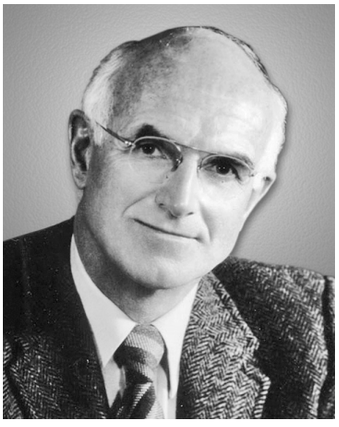


Fig. 1-3: Joseph E Murray. He got Nobel Prize in 1990 for organ and cell transplantation along with E Donnall Thomas. He did first successful human kidney transplantation between identical twins in December 23, 1954 on patient Richard Herric who lived and married recovery room nurse.

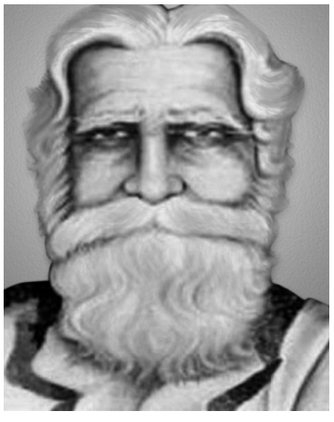


Fig. 1-4: Sushruta.

Abu Kassim (1000 BC) used animal intestine suture material to close the bowel. In 12th century silk became a suture material

Successful human skin graft was done by **Sir Astley Cooper** in 1817.

Andreas Vesalius from Padua, Italy (1514 - 1564) gave the importance of human anatomy in surgery **(Fig. 1-5)**. He gave concept of human dissection in learning anatomy and surgery. He wrote anatomy book 'De Humani Coporis Fabrica Libri'.

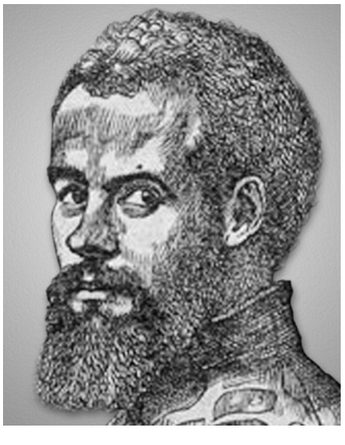


Fig. 1-5: Andreas Vesalius.

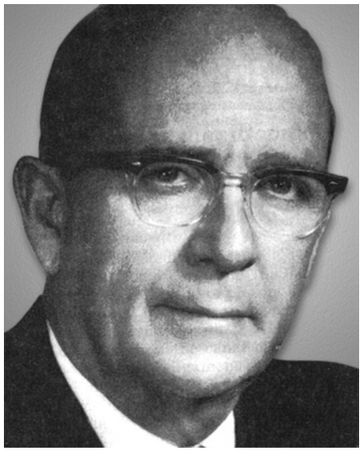


Fig. 1-6: Chester B McVay. He did extensive work on hernia surgery.

Ambroise Pare (Paris; 1510 - 1590) did revolution in surgery by practicing ligation of individual vessels doubly especially in amputation **(Fig. 1-7)**. He said, "I treated him; God cured him". He started concept of controlled experimentation.

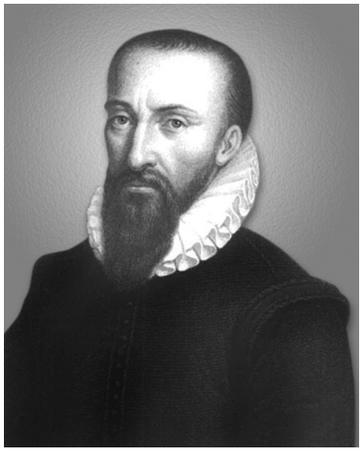


Fig. 1-7: Ambroise Pare.

Albucasis, Moorish clinician (A.D. 952, Arab) did first successful thyroidectomy; was bold, venturesome operator. He wrote that time famous medical book '*al–Tasrif*'. He also used catgut, cotton sutures. He also used to do small bowel anastomosis.

John Hunter (Glasgow, England; 1728–1793) an excellent surgeon **(Fig. 1-8)** of that time wrote many books on surgery, war wounds. He had outstanding collections of 13,000 specimens which were present in the Museum of Royal College of Surgeons which was destroyed during World War II by Nazi bombing. He described aneurysms and, its treatment, shock, phlebitis, nasogastric feeding, and respiratory assisting. He died of inoculation of syphilis and gonorrhoea by mistake. He thought of transplantation and angiogenesis and did experiments on it. He gave the importance of experimental surgery, study of anatomy and natural history in surgery.

Joseph Lister (Scotland/England; 1827–1912) evoluted the concept of asepsis and antisepsis. He started chemical antisepsis using carbolic acid. He originated proper cleaning of the wound and area prior to surgery to improve the results and reduce the sepsis. He started

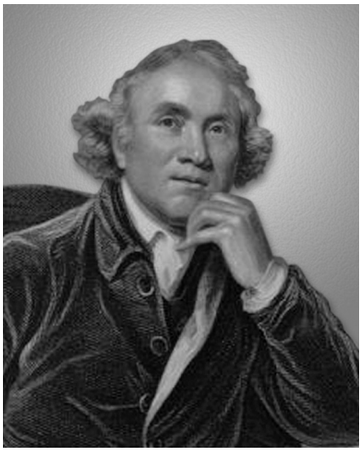


Fig. 1-8: John Hunter.

use of sterile sutures in surgery. His era is called as *Listerism*. He invented Lister's sinus forceps, pointed scissors, catgut ligature. He is rightly known as the father of modern surgery **(Fig. 1-9)**.

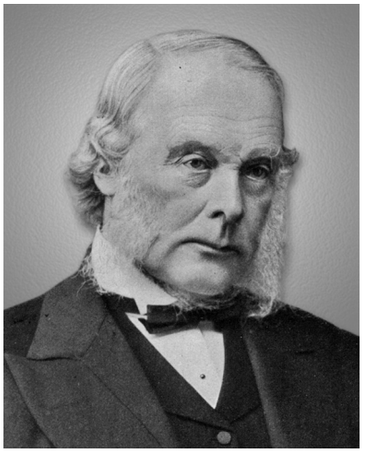


Fig. 1-9: Joseph Lister.

William T G Morton, a Boston dentist, on October 16th in 1846, first gave ether anaesthesia successfully to a patient operated by John Collins Warren on patient Gilbert Abbott to remove jaw tumour **(Fig. 1-10)**.

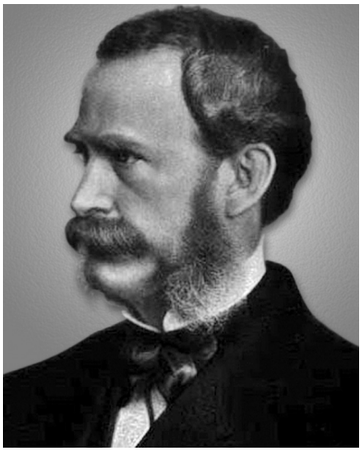


Fig. 1-10: William T G Morton.

Wilhelm Conrad Roentgen (1845–1923) invented X-rays (1895) also called as Roentgen rays as basic diagnostic tool. He got Nobel Prize for the same **(Fig. 1-11)**.

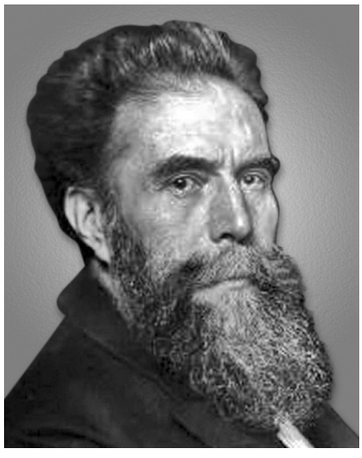


Fig. 1-11: Wilhelm Conrad Roentgen.

Rudolph Matas (America 1860–1957) **(Fig. 1-12)** was a pioneer in vascular surgery; started endoaneurysmorrhaphy.

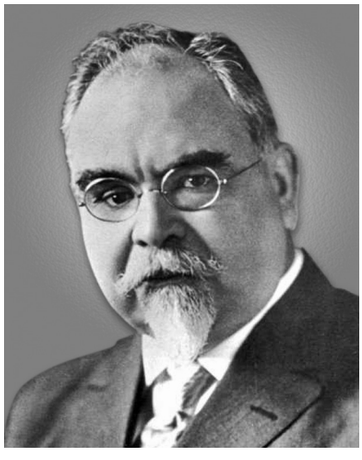


Fig. 1-12: Rudolph Matas.

William S Halsted (America 1852–1922) **(Fig. 1-13)** did extensive work on surgeries of breast and hernia. Halsted concept in carcinoma of breast and Halsted's radical mastectomy has ruled surgical era for a century until concept has changed from 1980 onwards. He started the use of gloves during surgery. He also started residency training in United States. He did works on hernia surgery also.

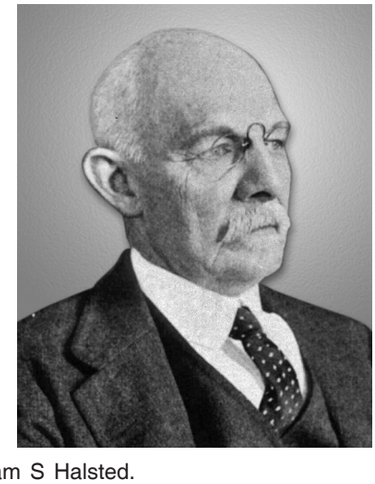


Fig. 1-13: William S Halsted.

Bernard von Langenbeck (German 1810–1887) **(Fig. 1-14)** did lots of contributions to surgery in technique, precision and instruments. He did first successful cholecystectomy in 1882.

Fig. 1-14: Bernard von Langenbeck.

Theodor Billroth (Vienna 1829–1894) **(Fig. 1-15)** did extensive work in abdominal surgery. Billroth anastomosis after gastrectomy is good old popular method.

Fig. 1-15: Theodor Billroth.

Schlatter first did successful total gastrectomy in 1897.

Senn did successful appendicectomy in 1889.

Lester Dragstedt did vagotomy for peptic ulcer.

Allen Oldfather Whipple (1881–1963) **(Fig. 1-16)** did successful pancreaticoduodenectomy for pancreatic cancer in 1935.

Franke in 1900 did total pancreatectomy.

Wendell did first successful hepatic resection in 1911.

Lembert (1826, France) started inverting seromuscular sutures.

Edoardo Bassini (1844–1924) started classical Bassini's repair for inguinal hernia in 1884 as tissue repair which dominated hernia treatment for nearly a century; but now becoming surgical legacy **(Fig. 1-17)**.

Fig. 1-16: Allen Oldfather Whipple.

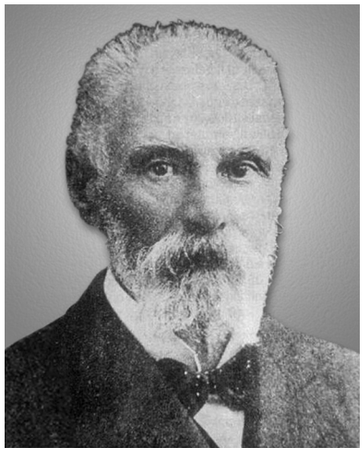


Fig. 1-17: Edoardo Bassini. He did lot of work in hernia surgery. Tissue repair for inguinal hernias under his name ruled the system for a century and now slowly becoming surgical legacy.

Theodor Kocher (Berne; Switzerland, August 25, 1841–1917) He was the *first surgeon to get Nobel Prize* (1909) (Fig. 1-18).

He did extensive work on thyroid surgeries and designed present technique of thyroid surgeries. He was from Switzerland. He first did excision of thyroid in 1876. By 2012 he did more than 2000 thyroidectomies with eventual mortality rate as 0.18%. He has written Kocher's Textbook of Operative Surgery in 1892. Many surgical avenues are after his name—Kocher's vein; Kocher's forceps (has got tooth in the tip); Kocherisation (duodenal mobilisation); Kocher's incision (Right subcostal for open cholecystectomy); Kocher's thyroidectomy incision; Kocher's test; Kocher's method for reduction of shoulder dislocation; Kocher's arched incision for opening the knee joint; Kocher's method of fixation of uterus; Kocher's invagination technique for inguinal hernia; Kocher's eye sign of thyrotoxicosis (on starring accentuation of lid retraction); Kocher-Debre Semelaigne syndrome (myxoedema, generalized muscle hypertrophy, cretinism, short stature); Kocher Lorenz elbow fracture (osteochondral fracture of capitellum). He did experimental works on gunshot injuries. Theodor Kocher Institute, Kochergasse, Kocher Park, are his memories in the city of Berne.

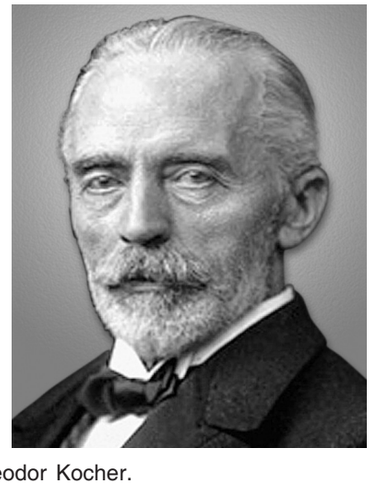


Fig. 1-18: Theodor Kocher.

Harvey Cushing, Halsted's resident, started the practice of experimental surgery. He was interested in the field of neurosurgery. He started and showed the essentiality of electrocoagulation in neurosurgery.

John H Gibbon (1903–1973) **(Fig. 1-19)** developed extracorporeal circulation for cardiac surgery.

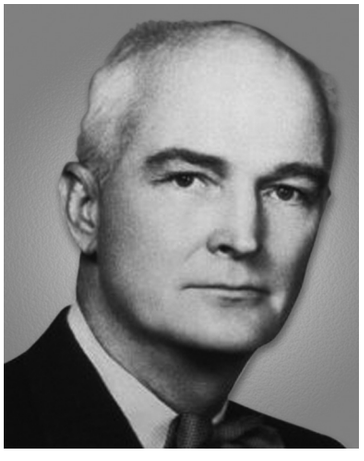


Fig. 1-19: John H Gibbon.

Alfred Blalock (1889–1964) **(Fig. 1-20)** was a pioneer in cardiac surgery. He discovered successful surgical therapy for Fallot's tetralogy.

Fig. 1-20: Alfred Blalock.

Owen H Wangensteen, a very popular surgical teacher pioneered in colonic surgery **(Fig. 1-21)**.

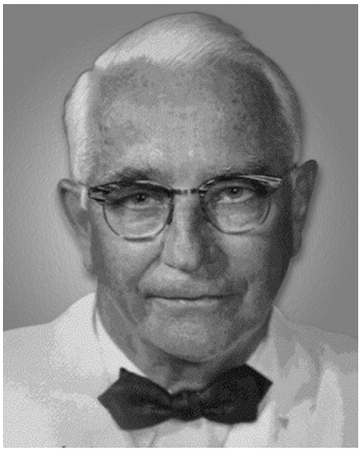


Fig. 1-21: Owen H Wangensteen.

Francis D Moore (Fig. 1-22) gave importance of metabolism in surgery.

Jonathan Rhoads (Fig. 1-23) did extensive work on surgical nutrition and surgical oncology.

Charles Huggins (Chicago) **(Fig. 1-24)** got Nobel Prize for effects of hormones on tumour growth and use of orchidectomy in advanced carcinoma prostate.

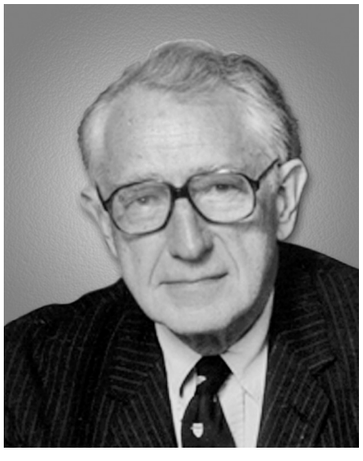


Fig. 1-22: Francis D Moore.

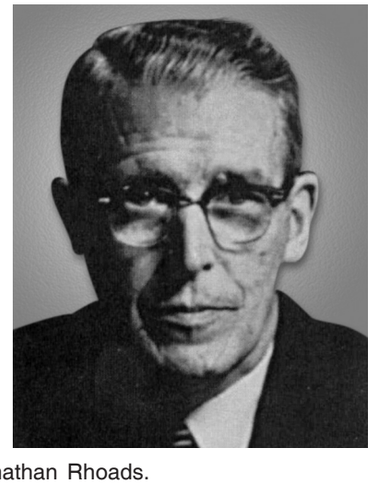


Fig. 1-23: Jonathan Rhoads.

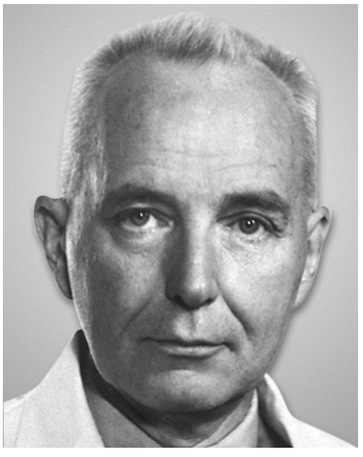


Fig. 1-24: Charles Huggins.

Alexis Carrel (1873–1944) **(Fig. 1-25)** got Nobel Prize in 1912 for his work on vascular anastomosis.

Christian Bernard pioneered in heart transplantation. He did first successful heart transplantation in 1967.

Ullmann in Vienna did first kidney transplantation (1902).

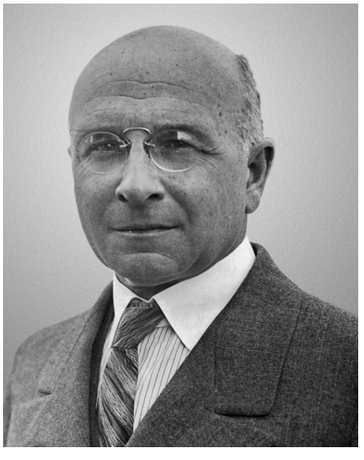


Fig. 1-25: Alexis Carrel.

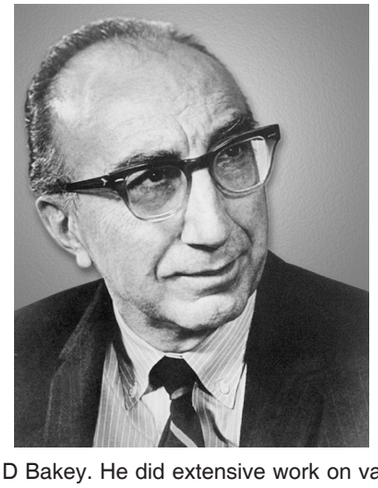


Fig. 1-26: Michael D Bakey. He did extensive work on vascular surgery and aneurysms.

George Kelling (Dresdon, 1901) did first laparoscopy using cystoscope in dog and called as celioscopy. Hans Christian started it in humans. Zollikofer (1924) brought CO_2 for pneumoperitoneum. *Kalk* is father of laparoscopy surgery. Janos Verres (Hungary 1938) used spring needle to create pneumoperitoneum. Fourestier, Gladu and Valmiere used cold light fiberglass illumination (France, 1952). Kurt Semm (German, 1977) used automatic insufflation device.

Semm in 1983 did first successful *laparoscopic appendicectomy*.

Mouret P did first *laparoscopic cholecystectomy* in France in 1987.

Surgeons who got Nobel prize are Theodor Kocher (1909); Alexis Carrel (for his work on vascular anastomosis–1912), Charles Huggins (urologist and oncologist for management of carcinoma prostate and hormone therapy–1966); Joseph Murray (organ transplantation–1990).

ETHICS IN SURGERY

Ethical principles are important. Finalising the accurate diagnosis or possibilities, recommending the treatment, explaining the merits and demerits of different procedures or recommended procedure, risks, complications should be explained to the patient.

Community values, its basic knowledge is essential to a surgeon in influencing the patient about the illness. In many countries, states and communities, relatives of a patient do not want to inform the patient about the major disease like cancer or life threatening illness. Here decision making is done by close relative of the patient like son/father/mother/brother/sister. The so called *truth telling* to the patient is purposely avoided to maintain the will power of the patient or details about the illness is informed to the patient gradually so that the patient is made to understand and accept the reality of the situation. It is always better to explain the patient that in many diseases, it is only possible to *give adequate care* but not complete cure.

Resources; individual identity of the patient; education of the patient; help of relatives; patient's ability to understand; planning are the important factors needed. Often it is better to reveal the details of the disease in presence of two attendees/relatives/caregivers. In the court of law/*legally* it is better to take signature of the witness for informed consent with date. Surgeon should have a registered *legally permissible recognised degree* certificate to perform different operations

Behavior of the surgeon with the patient, relatives of the patient, hospital staff, theatre staff, residents, students and colleagues should be proper. Shouting, abusing, manhandling should be avoided as much as possible even under stress.

Avoid negligence like retaining of mops during surgery, not giving adequate postoperative care, etc. Negligence is not accepted in court of law. In difficult situations surgeons should not hesitate to take the help of another surgeon. Reasonable care is essential. Act of omission or act of commission both are considered in negligence.

Documenting in detail about the surgery in case sheets, daily follow up, progress with timings, informed consent are important. It is better every surgeon should have a clear idea about legal aspects of his practice. It is also better to have a legal advisor to clarify the doubts whenever needed.

It should always be remembered that surgeon is basically a part of the *public life*. He should respect the dignity of patient and caregivers; psychological, social and spiritual aspect of the patient should be considered; refrain from committing crimes; competence, compassion should be present; should educate the patient and community; teach the *future learners* of surgical profession with love and interest. One should *never* bring cast, community, religion, race during practice. *Only human life* and humanity should be goal.

Oaths used in medical field are Hippocratic oath; Sushruta and Charaka oath of India; declaration of Geneva.

Medical Ethics

Medical ethics is a system of principles governing medical conduct. (1) Doctor-patient relationship is moral trust between two. Doctor is considered as close to God in India. (2) Professional confidence and secret about the patient is important. (3) Ethical practice is a must from the surgeon. Unethical practices are—advertising; selling medications; accepting gifts, commissions, bonus etc; unnecessary criticising professional colleagues; conflicts of interests. (4) In dealing with medical insurance. (5) In undertaking newer innovative techniques. (6) Ethics in blood transfusions: Permission should be sought before blood transfusions. Jehovah's witnesses are people with special faith as they never accept blood transfusions which is said to be against their eternal life. Care should be used in managing critical patient of such faiths. (7) Doctor should not refuse treatment and care based on certain diseases like–HIV infection. (8) Risk and benefits of surgery should be weighed before deciding the procedure. (9) Following proper legal backgrounds in organ transplantation–The transplantation of human organ act 1994. (10) Information about need for use of ventilator, duration, chances, risks, when to discontinue the ventilator need should be discussed with patient's close relative properly with informed consent. (11) Avoiding **medical negligence**–One should remember that anything that goes wrong is not negligence. *Reasonable standard of care and skill* is needed in treating the patient. Breach of duty by the doctor/surgeon to achieve standard care and skill is called as negligence. If there is damage, then only patient is allowed to claim the negligence. Without damage, patient cannot claim the negligence. General and special damages can be claimed by the patient as financial compensation. Act of commission or act of omission–both are considered in negligence. Surgeon is responsible for negligence of nurses, assistants, theatre staffs or technicians.

Res Ipsa Loquitur is obvious negligence–'thing speaks for itself' like retaining mop/gauze. Contributory negligence is due to act of omission.

Usually **section 304 A** is filed which is a bailable warrant in court of law with summons to the surgeon as accused. Expert witnesses and other documents like case sheets, medicine bills, and certificates are used in examination and cross examination.

Consumer Protection Act (1986) deals medical negligence cases. It is basically based on documents and affidavits provided by the patient and the doctors.

Often surgeons can be called as **expert witness** in the court of law. He should act fair and accurate without siding anybody. He should have enough proofs and evidences of standard books or journals about what he is telling and documenting in the court. He should be prepared prior about his witness role.

Consent

Permission granted by the patient to the surgeon to make a diagnostic or therapeutic intervention or to have therapy is called as **consent.**

Informed consent is more valid. All relevant information should be provided about benefits, risks of the procedure, present condition in acute cases, need for repeat procedures, intensive care, approximate expenses, probable period of hospital stay, etc. Abiding patient from taking the decision is not correct. *Prevailing silence* between doctors and patients is not right in present day of modern practice. During rounds patient or relative of the patient should be informed about the progress, response or any complications every time. It is always better to explain the patient about the illness in patient's own language.

Valid consent–Operating surgeon himself should obtain the consent; patient should understand the discussion/details given to give informed consent; patient must be free from coercion to give consent; details about the procedure, risks, benefits, complications of the procedure; patient should be allowed to query his/her doubts or to clarify his/her suspicions. Person giving consent should be above 18 years, conscious and mentally alert. Parents should give consent if patient is below 18 years. In handicapped or mentally retarded patients, parents or guardians can give consent. In an *emergency condition or in unconscious patient*, procedure and treatment can be done without consent even in the absence of any relative, but after informing and taking written permission from the hospital authority.

Patient presenting himself in surgeon's clinic itself is consent for examining–**implied consent**. When patient cannot give consent, consent taken from close relative is called as **substituted consent**. Consent taken for one procedure can be considered as consent for additional inevitable essential procedure (decided during initial procedure) and is called as *extension doctrine*.

Chapter

2

Preoperative Preparation, Operation Room, Postoperative Care

Operations may be *elective* wherein patient is properly prepared with all investigations and precautions or *emergency* wherein immediate surgery is required to save the life of the patient like perforation of bowel, haemorrhage and trauma.

Patient is admitted prior to date of the elective surgery. In young individual it is sufficient to admit the patient on the day of surgery, provided evaluation is done earlier on out patient basis. If patient is elderly or asthmatic or with systemic problems, it is better to admit him earlier and manage the systemic problems with the help of physicians, cardiologists and anaesthetists. Patient is evaluated with essential investigations like haemogram, urine analysis, ECG, blood electrolytes, chest X-ray, echocardiography, physician and cardiologist's opinion taken and required treatment given. If patient is anaemic prior to surgery, blood transfusion is required. Asthma, respiratory diseases, diabetes has to be managed properly. Electrolyte supplement prior to surgery is required

Prior to shifting the patient to operation theatre following rules should be followed:

- Correct identification of the patient–identification tag is a must.
- Consent for the surgery should be taken.
- Preparation of the patient according to the requirement. Present concept is preparation should be done just before surgery on the operation theatre table, even though what usually followed is preparation in the ward often on previous night which is convenient rather than a right way.
- Nothing should be given orally 6-8 hours before surgery.
- Bladder should be empty before sending patient to the theatre. If required the patient is catheterised.
- Enema, as by instruction should be given.
- Ornaments, dentures, nail polish, hearing aids; contact lenses should be removed before shifting the patient.
- The patient must wear head cover, feet covers, theatre dress.
- Pre-medication, as per instruction should be given.
- Ward nurse should accompany the patient to theatre and should hand over the patient to theatre nurse.

PREOPERATIVE ASSESSMENT

History

1. Chronic cough, smoking, alcohol, drug intake, drug allergy.
2. Any previous diseases like hypertension, diabetes mellitus, epilepsy, bronchial asthma, tuberculosis, hepatitis, cardiac diseases, bleeding disorders and renal diseases.
3. Drug therapy: Steroids, antihypertensives, sedatives, antibiotics, antiepileptics.
4. History relevant to different systems–cardiovascular; renal; hepatic; thyroid disease; endocrinal like adrenal; metabolic; nutritional.
5. History suggestive of fluid loss like diarrhoea, vomiting; obstruction; burns; haemorrhage; trauma.
6. Past history of surgery, its detail and if possible one should collect the old records.
7. History suggestive of coagulation disorders like haemophilia, anticoagulant therapy.

Patient with history of recent myocardial infarction should avoid surgery for six months unless it is an emergency. Patients with valvular heart disease/on prosthesis need prophylactic antibiotic. Patient with coagulative diseases need specific corrections as needed prior to surgery.

Examination

General: Posture, teeth, mouth opening, dilated veins, neck movements, tremor, airway, anaemia, oedema, jaundice and cyanosis.

Respiratory system: To look for asthma, tuberculosis, emphysema, COPD.

Airway: Mouth opening, Malampatti scoring, tyromental distance, temporomandibular joint assessment.

Cardiovascular system: Hypertension, ischaemic heart disease, arrhythmias, cardiac failure, valvular diseases.

Spine: Curvature, intervertebral space**,** skin over the back for any infection.

Other systems: Abdomen, skeletal system.

Preoperative Investigations

Haematocrit, blood sugar, blood urea, serum creatinine, electrolytes, chest-X ray, ECG, blood grouping, blood-gas analysis, cardiac assessment.

Prothrombin time, bleeding time, clotting time, platelet count, liver function tests, pulmonary function tests, arterial blood gas assessment, serum calcium, T3, T4, TSH—in specific surgical diseases.

Different imaging methods for confirming the diagnosis.

Preoperative Care and Treatment

Control of respiratory and cardiac diseases taking special care from cardiologists, chest therapists, and respiratory physiotherapist. Smoking should be stopped (at least 15 days prior to surgery, but ideally one month prior to elective surgery); prophylactic antibiotics; bronchodilators; steroid inhalers are given. Asthmatic patients are often on steroid therapy and may need intravenous hydrocortisone prior to surgery.

- Renal assessment with blood urea, serum creatinine, urine analysis (albumin, specific gravity) and serum electrolytes is done. In compromised kidney function, nephrologist's opinion and therapy is asked for. Adequate hydration, catheterisation in major surgery for hourly urine output monitoring, avoidance of nephrotoxic drugs in patients with renal failure are the steps to be remembered.
- Improvement of haemoglobin status, if anaemia is present. Minimum haemoglobin *ideally* needed for elective surgery is 10 gm%. (*Safer zone* for anaesthesia tolerance is 7 gm% haemoglobin). Nutrition should be adequate. Proper protein diet in elective surgery is good. In emergency situation, parenteral nutrition is given.
- Preoperative antibiotics are given as per instructions of the surgeon. It is used only if there is existing infection like abscess, skin infection or in peritonitis. In elective cases perioperative antibiotics are given like in inguinal hernia mesh repair.
- Blood should be kept ready for major surgeries for transfusion.
- Control of diabetes mellitus and cardiac diseases is important. It is better to take physician's help/cardiologist's opinion prior to surgery. An echocardiography or treadmill test is better for cardiac evaluation. On the day of surgery (two hours prior to surgery) fasting sugar should be checked. Urine sugar, urine *ketone bodies* and *serum potassium* estimation are relevant in diabetic patients. It is better to start on insulin therapy if the patient is on oral hypoglycaemic drugs prior to surgery. Often intravenous infusion of 5 units plain insulin in 5% dextrose and 5 mEq of potassium chloride at rate of 50 ml/hour are needed. Hourly blood sugar and serum potassium estimation is needed to maintain blood sugar level at 100- 180 mg% and potassium level at 4 -5 mEq/ml.
- **All smokers should be asked to stop smoking ideally** *four weeks prior to surgery* in elective surgeries even though patient may not follow the instruction.
- Any preoperative fluid deficits should be corrected with proper monitoring. Monitoring is done using estimation of *hourly urine output*, electrolyte estimation. Usually normal saline or ringer lactate is used.
- Purgatives/enema are given prior to surgery as sphincter relaxation occurs during general anaesthesia or spinal anaesthesia.
- Skin preparation is done by shaving the area, or by using depilation creams. Ideally it should be done just prior to surgery *in the operation theatre* using clippers. Patient should take proper bath prior to surgery.
- Patient should be kept nil oral for 8 hours (In children upto 4 hours prior liquid can be given for short duration procedures). Fasting prior to surgery is essential to prevent life threatening aspiration. In emergency surgical situations (like in trauma), nasogastric tube is passed to remove the gastric content; prokinetic drugs are given to rapid the gastric emptying; drugs which decrease the pH of the stomach and to decrease the gastric secretions are given.
- *Prophylactic antibiotics* are given in cardiac surgeries, prosthetic surgeries, trauma, gastrointestinal surgeries, gynaecological surgeries, and oral cavity surgeries. Overuse of antibiotics should be avoided due to development of resistance. Based on their features, wounds should be classified as clean, clean contaminated, contaminated and dirty infected. Clean wound has got less than 2% infection rate whereas dirty infected wound has got 30% infection rate. Common bacteria contaminating the surgical wounds are *Staphylococcus aureus, Staphylococcus epidermidis* and Gram negative organisms. Prophylactic antibiotics are given on the operation theatre table at the time of induction of anaesthesia. Further doses may be given during surgical procedure if operation time is more than 4 hours. Usually low toxic antibiotics like 2nd generation cephalosporins and metronidazole are given. Concept of antibiotics in contaminated dirty wounds, severe cellulitis, abscess, sepsis, peritonitis is different where patient is prone for septicaemia and its life threatening problems. Therefore higher dose of higher generation antibiotics should be used without any hesitation. Sepsis is more common in AIDS or immunosuppressed patient.
- Hyper/hypothyroidism both are equally dangerous for any surgery. Both should be corrected prior to surgery. Toxicity is controlled by proper antithyroid drugs. Hypothyroidism is corrected by oral L thyroxin once a day daily morning. Toxicity if not controlled may precipitate toxic crisis which has got very high mortality.
- Patients with long term steroid therapy for any cause should have injection hydrocortisone intravenously 100 mg 6th hourly prior to surgery, at the time of induction of anaesthesia and later 6th hourly for two days of postoperative period which gradually reduced and withdrawn.
- Special preparations for gastric/colonic or biliary surgeries should be done.
  - *Colonic preparation*—low residue diet for 72 hours; bowel wash with saline; gut irrigation using oral polyethylene glycol with electrolytes taken in two litres of water in 2 hours to clear the entire bowel. It acts by osmotic hygroscopic action. It is also achieved by oral intake of mannitol for 2-3 days. Bowel antiseptics like neomycin 1 gram three times/day prior to surgery is given. *Total gut irrigation* is done by passing nasogastric tube through which normal saline is infused. It is infused (8 litres of saline) until clear saline is passed per anum. [*On-table colonic lavage* can be done by passing a tube through performed appendicectomy opening (purse string suture is placed) and another opening in distal colon just proximal to obstruction and saline is irrigated from first to second tube continuously to achieve proper cleaning of the colon].
  - *Gastric preparation in gastric outlet obstruction*–Patient is having hypokalaemia, hyponatraemia, hypomagnesaemia, hypochloraemia, hypocalcaemia with metabolic alkalosis and *paradoxical aciduria*. Correction of dehydration, electrolytes, anaemia (blood), hypoproteinaemia (amino acids, total parenteral nutrition), hypocalcaemia (intravenous calcium gluconate) and alkalosis is essential in these patients. Gastric lavage is done for 5 days prior to surgery by passing stomach (Ewald's) tube using normal saline to remove residual food, to decrease mucosal oedema, to maintain gastric tone.
  - *In obstructive jaundice*–specific problems are altered prothrombin time (bleeding tendency), hypoalbuminaemia and malnutrition, sepsis, anaemia, dehydration and diminished carbohydrate reserve. *Hepatorenal syndrome* is specific problem postoperatively–due to endotoxaemia, acute tubular necrosis due to toxins, sludging of bile salts in the renal tubules, hypovolaemia. Management is by–adequate fluid infusion

(*hydration)*, fresh frozen plasma; mannitol infusion; antibiotics; injection vitamin K 10 mg intramuscular once a day for 5 days; intravenous dextrose to improve the carbohydrate reserve. Albumin infusion is usually *not needed* in these patients.

Note: Informed consent is absolute need.

OPERATIVE RISK ASSESSMENT

It is important in children, old age; obesity; liver, renal, respiratory and cardiac dysfunctions; sepsis; chronic illness; malignancy. If patient is undergoing surgery for some other disease like hernia which may be elective, here *risk due to concomitant disease* like of cardiac or respiratory or renal problems is important.

If patient is undergoing surgery for surgical problem like perforated appendicitis or acute gallbladder disease like empyema gallbladder or peritonitis, *here risk is of primary disease* (appendicitis/empyema gallbladder) due to sepsis.

Premedication

It is given one hour before surgery.

For sedation and relief of anxiety— Pethidine 50 mg/ morphine 10 mg/ diazepam 10 mg. Midazolam 1-2.5 mg.

To suppress vagal activity— Atropine 0.6 mg. IM.

To reduce vomiting—Promethazine (phenergan) 12.5 mg.

ASA (American Association of Anesthesiologists) grading of the patient for surgery:

1. Normal individual.
2. Mild–moderate one systemic disease under control - Diabetes and hypertension under control; mild obesity, alcohol intake, smoking.
3. Severe systemic disease/multiple systemic diseases–uncontrolled diabetes and hypertension; activity limited due to disease.
4. Incapacitating systemic disease–high risk.
5. Moribund status–imminent risk of life–surgery as life saving procedure.
6. Brain dead patient.

Class ' E' is added to each type if it is an Emergency surgery.

OPERATION THEATRE

Asepsis

Asepsis means organisms are prevented to access the patient or individual.

Sterilisation

It is freeing an article from pathogens by removing or killing all bacteria, spores, fungi and viruses.

Disinfection

It is killing of all bacteria, fungi and viruses but not spores.

Antisepsis

Antisepsis is inhibition of growth of microorganisms.

Different Methods of Disinfection

a. Physical Agents:

Burning or incineration is used to disinfect contaminated articles like dressings.

Hot-air oven: Here temperature used is 160 to 180 degrees for one hour.

Boiling: It kills bacteria but not spores and viruses. Temperature is between 90 to 99 degrees. It is used to disinfect syringes, utensils. It is not useful for gloves, rubber materials.

Autoclave: It is sterilisation using steam under pressure. Temperature attained is between 120-135 degrees. It is sterilised for 20 minutes with 15 pounds/sq.inch (2 kg per square cm) pressure. It kills all organisms including spores. Completeness of sterilisation is confirmed by using specific gelatin protein which precipitates only in steam under pressure for 20 minutes. Green coloured strip turns black if autoclave is complete (*The Bowie-Dick test) (signaloc).* Surgical gloves, linen, cotton, paper, bottles, plastics, dressings, surgical instruments are sterilized by this method. Sharp and plastic instruments cannot be sterilized by this method. *Bacillus thermophillus* spores are used to assess the completeness of the sterilisation in mass scale. Double autoclaving is done for instruments of orthopaedic or ophthalmic surgeries. Modern rapid autoclaves can sterilise in 3 minutes with 143 degree temperature or in 10 minutes at 121 degree temperature **(Fig. 2-1)**.

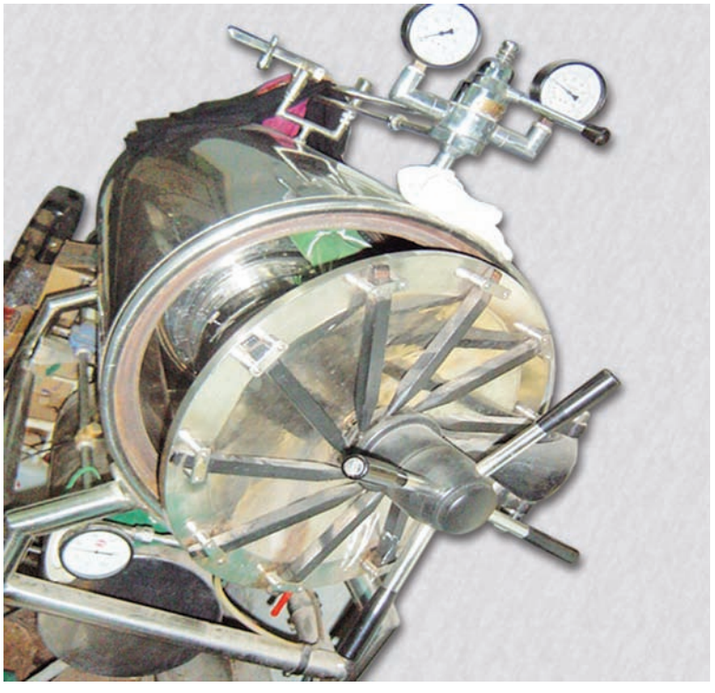


Fig. 2-1: Autoclave machine used for sterilisation.

Radiation:

- *Ionising type of radiation:* Atomic gamma radiation is used for commercial purpose to sterilise suture materials, disposable materials in packets. It is viable, safe and cheaper. All disposable materials like gloves, tubes are sterilized by this method.
- *Non-ionising radiation,* either infra-red radiation or ultra-violet radiation is used to reduce the bacteria in air, water. Bacteria and virus are vulnerable to ultra-violet rays below 3000A°. Exposure to eyes and skin can cause burn injury.

Materials	*Methods of sterilisation*
All theatre appliances	Autoclave
Sharp instruments (scissors, needles, blades), plastic materials	Glutaraldehyde 2 %, Lysol
Endoscopes	Glutaraldehyde
Rubber equipments	Glutaraldehyde
Syringes	Autoclave, hot air oven, gamma radiation
Heart-lung machine	Ethylene oxide
Disposable articles	Gamma radiation
Operation theatre and rooms	Ideally by U-V radiation or by formaldehyde
Sera and biological materials	Filtration
Lab glassware	Hot-air oven
Ward, sick room, furniture	Formaldehyde, iodophor spray, glutaraldehyde
Clothes, bed sheets especially for burns patients	Autoclaving
Soiled dressings, materials, animal carcasses	Incineration, Lysol, iodophors
Excreta	Lysol, iodophors
Cleaning of skin before surgery	Iodophors 2%, savlon and spirit
For cleaning infected wounds	Iodophors, acriflavine, savlon, H_2O_2
To remove slough from the wounds	EUSOL, H_2O_2
Before injection	Spirit is used to clean the skin
Cleaning the ward	Phenol, cresol, Lysol
Hand wash	Chloroxylenol, savlon, spirit, iodophors
Bladder wash	0.1 % potassium permanganate solution (Condy's lotion), solution of acetic acid and silver nitrate
Water	Chlorination, potassium permanganate
Fruits, vegetables	Potassium permanganate

b. Chemical Agents:

Phenol: It is used as standard to compare the efficacy of other agents.

Cresol is more powerful and nontoxic. 5% solution is used.

Lysol is emulsified cresol with soap. 2% solution is effective.

Chlorhexidine (hibitane) is useful antiseptic.

Hexachlorophane: It is not used in infants and children because it can get absorbed through intact skin in this age group causing severe neurotoxicity.

Dettol (chloroxylenol) 5% solution is used.

Cetrimide is cationic surfactant (cetavlon). 2% solution is used.

Savlon is combination of cetrimide and hibitane. It is very commonly used antiseptic in operation theatres and wards.

Halogens:

- Bleaching powder.
- Sodium hypochlorite.
- *EUSOL: Edinburgh University Solution* contains sodium hypochlorite, boric acid and calcium hydroxide.

Eusol bath is dipping the ulcer bearing part in dilute eusol solution for 30 minutes 2-3 times a day.

- Iodine.
- *Iodophors:* These are antiseptics and also sporicidals. They are non-irritant and do not stain skin. *Povidone-iodine* is a good example, which is commonly used.

Alcohols: Ethyl or isopropyl alcohols are used.

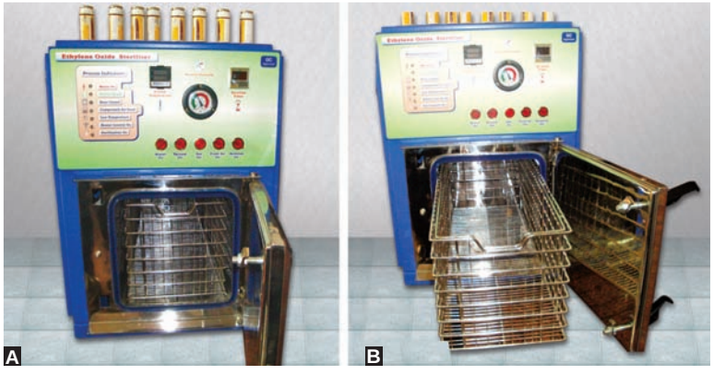
Formaldehyde: It is useful to disinfect the rooms like operation theatre. It is effective at a high temperature and humidity of 80-90%. It is commonly used to fumigate the room. 500 ml of formalin with one liter of water is boiled to get formaldehyde vapour. Adding potassium permanganate to the same solution can create formaldehyde vapour. Room is kept closed for 12 hours.

Glutaraldehyde (cidex 2%): It is used to sterilise sharp instruments. Instruments should be dipped for 10 hours to achieve complete sterilisation. It is potent bactericide, sporicide, fungicide and viricide.

Hydrogen peroxide (H_2O_2): It is used as topical oxygen therapy. Because of its effervescence and release of nascent oxygen it removes the tissue debris. It is used to clean wounds, cavities, ulcers and as mouth wash, as ear drops to clear earwax.

Acriflavine and proflavine are orange-red coloured dyes used as antiseptics. It is effective against gram positive and few gram negative organisms. It retains its activity in pus and body fluids.

Ethylene oxide sterilisation (ETO): Here instrument is packed in a sealed plastic cover. It is kept in the ethylene oxide steriliser. Total 12 hours sterilisation is needed. 6 hours for gas sterilisation and another 6 hours for gas to come out. It is good way of sterilization. Once instrument is sterilized, it can be kept and used for 6 months. Problem is cost factor, time duration needed (minimum 12 hours) for sterilisation **(Figs 2-2A and B)**.



Figs 2-2A and B: Ethylene oxide steriliser.

OPERATION THEATRE ROOM

Operation theatre is like a temple to all surgeons.

Theatre Plan

Every operation theatre should have a waiting area, entrance, surgeon's changing and relaxing room, separate changing room and relaxing room for nurses, autoclave and sterilisation room, OT scrub area, all sets of instruments, instruments for anaesthesia, adequate number of racks, toilets, air–conditioned ventilator, OT tables, trolleys

to shift patients, OT laundry, good light, ultrasound machine, C-ARM image intensifier.

Operation theatre should have an adjoining post-operative ward. This ward should be close to the OT, easily accessible (surgeon and anaesthetist should able to rush to the postoperative ward in short period without changing their OT dress).

In many theatres light music is played to calm the patient just before inducing anaesthesia.

It should be easy to clean floor, roof and walls. An individual unit for instrument cleaning, washing, and arranging should be present where the instruments are kept ready, packed and autoclaved as directed.

A separate room for pathologists with facilities for frozen section and relaxing should be present.

Principles of an Operation Theatre

- An air-conditioning is a must to have a filtered continuous flow of air.
- Doors and windows should be kept closed as much as possible.
- Ward nurse should hand over the patient to theatre nurse with all details, case sheets, tag, side of surgery, blood to be transfused, and pre-medication details. While shifting the patient ward nurse must take care of the air way and IV line of the patient, must keep tongue depressor, swabs, airway in the trolley.
- Patient should be shifted to theatre always in a trolley. Patient should remove all ornaments and wear theatre gowns, cap, and feet covers.
- Patient must be transferred from ward trolley to theatre trolley, which should have modern accessories like oxygen, side guards, drip stand, oxygen masks, pulse oximeter placing area, tiltable couch.
- Patient's trolley and ward blankets should not be taken inside the operation theatre.
- Initially patient should be kept in preoperative room and later should be shifted to theatre. Anaesthetist and surgeon and also theatre nurse should accompany the patient. .
- Theatre nurse should confirm the consent form, case sheets, site and side of the surgery etc.
- Separate theatre shoes should be worn by surgeons, anaesthetists, theatre nurses and assistants.
- Unnecessary movements, speaking loudly, laughing, should be avoided as patient inside the theatre may be awake especially when spinal anaesthesia is given.
- All persons entering the theatre should wear theatre dress (pant and shirt), cap, mask, footwear or shoes (shoes are ideal). Material for dress should be smooth, non-woven fabric, which is easily boilable. Cap should cover and conceal hair fully.
- Clothes, dresses should be washed, cleaned, ironed and kept ready every day. Fresh, clean cotton blanket should be used for the patient in theatre.
- Ideally all mobile phones should be switched off inside the theatre.
- Any public person or relative of the patient should not be allowed inside the theatre. Selected people may be allowed only by prior permission from medical director of the hospital and from operating surgeon.
- One ***senior nurse*** is made in charge of all activities in the theatre like shifting patients, arranging theatre tables, autoclave and other sterilisation methods, cleaning the instruments, packing the instruments for autoclave. She decides the duties of her junior nurses and makes a list of nurses for that day surgical scrubbing. ***Operation theatre assistant and technicians*** are also under her supervision and should follow her instructions strictly. She should be answerable for any default and problems in the theatre occurred or created by her fellow nurses and theatre boys.
- ***Scrub nurse*** is the one, who washes to assist the surgeon, arranges the instrument table and gives instruments to surgeon during procedure. She should be well aware of the steps of surgery and instruments required. She should be alert, quick, and understandable
- One nurse in each theatre works as a ***circulating nurse*** who provides additional instruments required during surgical procedure. She also takes care of the counting of the surgical mops and swabs used. Used mops or swabs should be kept hanging in mop rack or swab rack which should be visible to the operating team. Name, procedure and number of mops collected and used should be written on a blackboard. Scrub nurse and circulating nurse are fully in charge and responsible for swab counts. *She also will be legally questioned and penalized along with the surgeon if there is negligence in mop count.*
- Theatre nurse and OT assistant should accompany the patient while handing over to postoperative nurse from OT.
- Patient should be shifted outside the OT once anaesthetist confirms the fitness for shift. It is the anaesthetist who decides when to shift, how to shift and how long the patient should be in postoperative ward.

Modes of infection and sepsis in OT

- Patient's skin
- Surgeon, nurses and OT technicians, by unclean hands, nostrils, throat, skin
- Contamination of OT floor and wall
- Improper sterilisation
- Poor handling of instruments
- Poor packing and poor storage of instruments
- Theatre clothes, footwear and shoes
- Not disinfecting the OT properly and adequately after using the OT for infected cases.

Scrubbing and Wearing of OT Gown and Glove

Both hands, forearms up to elbow joints should be rinsed with running water and soap. Any ring, jewellery, wristwatch should be removed prior to the scrub. Using brush and soap, finger nails, hands on both sides are cleaned. Then forearm is brushed and washed. Procedure is repeated three times (presently whether need to brush the hands are *controversial*). After thorough rinsing the hands by running water, hands are washed with antiseptic solution and then with warm water. Once fully scrubbed, she/he should not touch with hands any objects or his/her own face or parts of body. She should keep her hands and fingers tucked with each other with forearm and hands outstretched. Using a sterile towel, forearm and hands are dried up. Both hands are inserted into the armholes of the sterile gown. The gown is not touched or pulled but both arms are kept outstretched. Circulating nurse will pull back the tapes of the gown and ties it over the back.

A *back wrap gown* has got two tapes to tie on the front aspect. After wearing gloves, one tape is given to the scrub nurse/surgeon who has already with gown and gloves **(Figs 2-3 and 2-4)**. She/he will encircle the gown round and bring it in front and give to the surgeon to tie it with other tape.

Circulating Nurse

One who supplies all additional instruments and mops. She also keeps the mop counts.

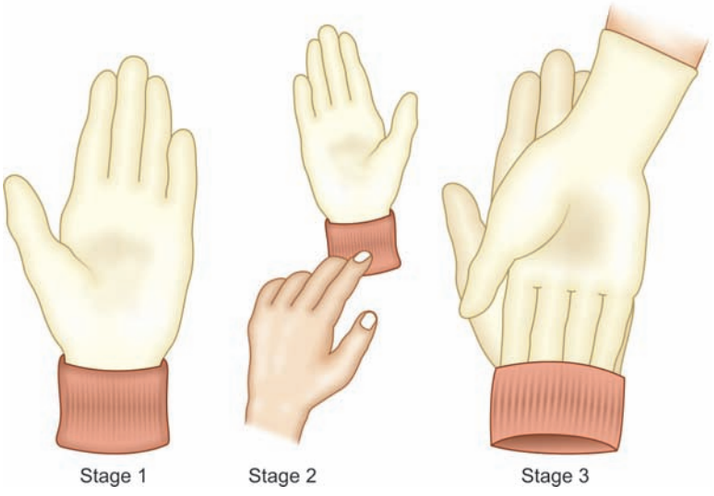


Fig. 2-3: Figure showing the correct method of wearing gloves.

Theatre technique of wearing gloves

- After using glove powder, with the bare hand inner aspect of the cuff of the glove is held. It is pulled over the hand. It should not be wrapped over the wrist cuff of the gown at this stage.
- Fingers of this gloved hand should hold the cuff of the other glove from outside and it is slided over the fingers and hand.
- Now cuff of the glove is pulled proximally over the wrist of the gown using other gloved fingers.

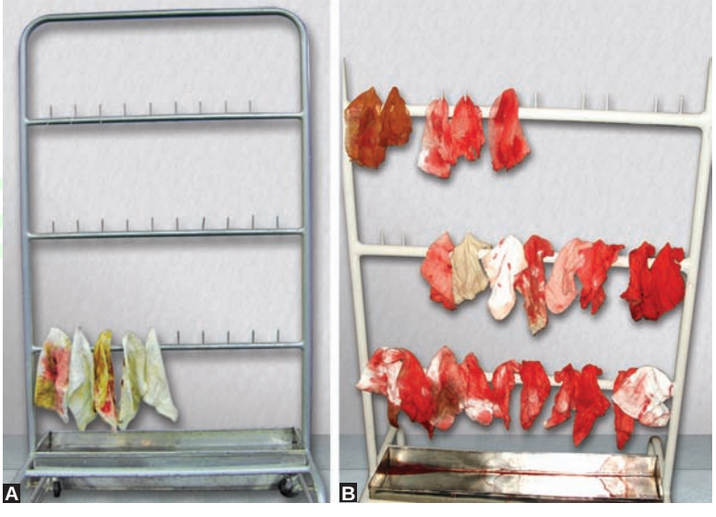
Duties of Circulating Nurse

- Keeping counts of instruments, and mops given to scrub nurse. Instruments are kept in bundles of five, ten and so on. So counting will be easier.
- Taking care of swab rack, collecting the used mops from scrub nurse and hanging the mops in groups of five. Mops presently used in many theatres are having radio opaque threads and so can be easily identified when needed by taking X-ray or through a C-ARM.
- Collection of specimens, pus, fluids and labeling with name, unit, number. It may be for culture, cytology or for histopathology.
- Keeping account of the disposable instruments and suture materials, drugs and fluids used in each procedure.
- Noting the duration of the surgery, quantity of blood transfused and type of anaesthesia given.
- Documenting in record book or theatre computer.

Theatre nurse should not discuss outside or reveal about the procedure or technique done in theatre with anybody. It is surgeon's duty to explain about the patient's condition, procedure done and problems. She should never comment about anything in theatre (Figs 2-5A to 2-6D).

Septic Operation Theatre

- All infected cases like abscess drainage, amputation for gangrene, slough excision, dressing of large ulcers should be done in a separate OT. Otherwise clean surgeries may get infected. It is especially important when orthopaedic surgeries are going on.
- Entrance to septic OT must be separate from that of main OT.
- Staffs working in septic OT should not enter main OT.



Figs 2-5A and B: OT mop rack to keep used mops during surgery.

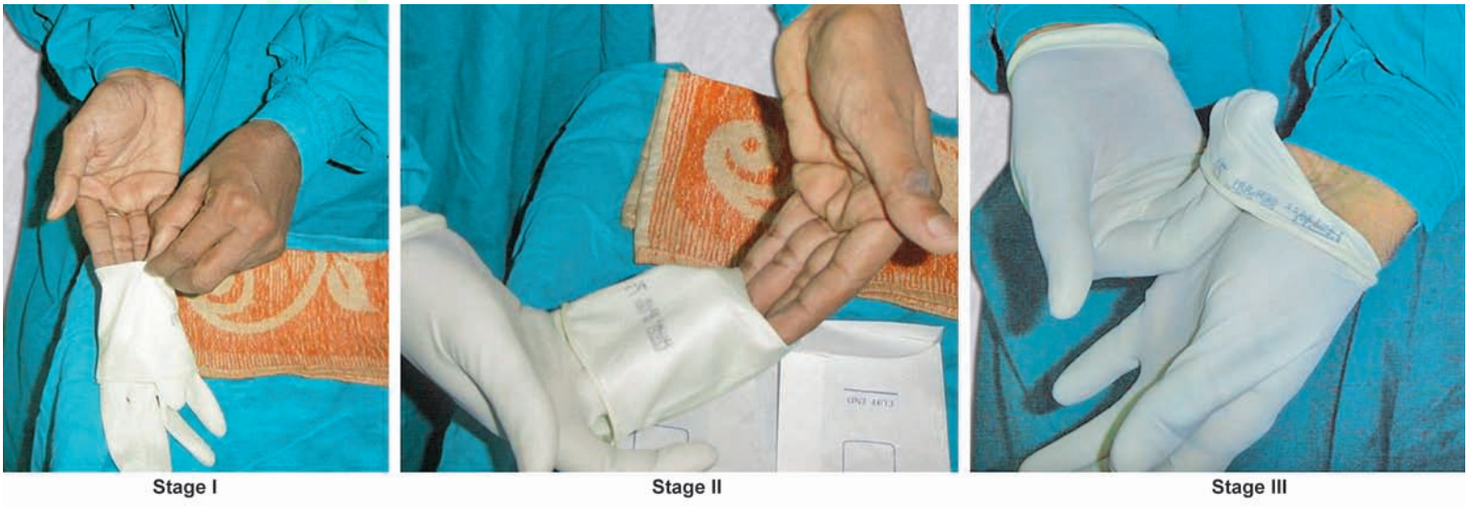
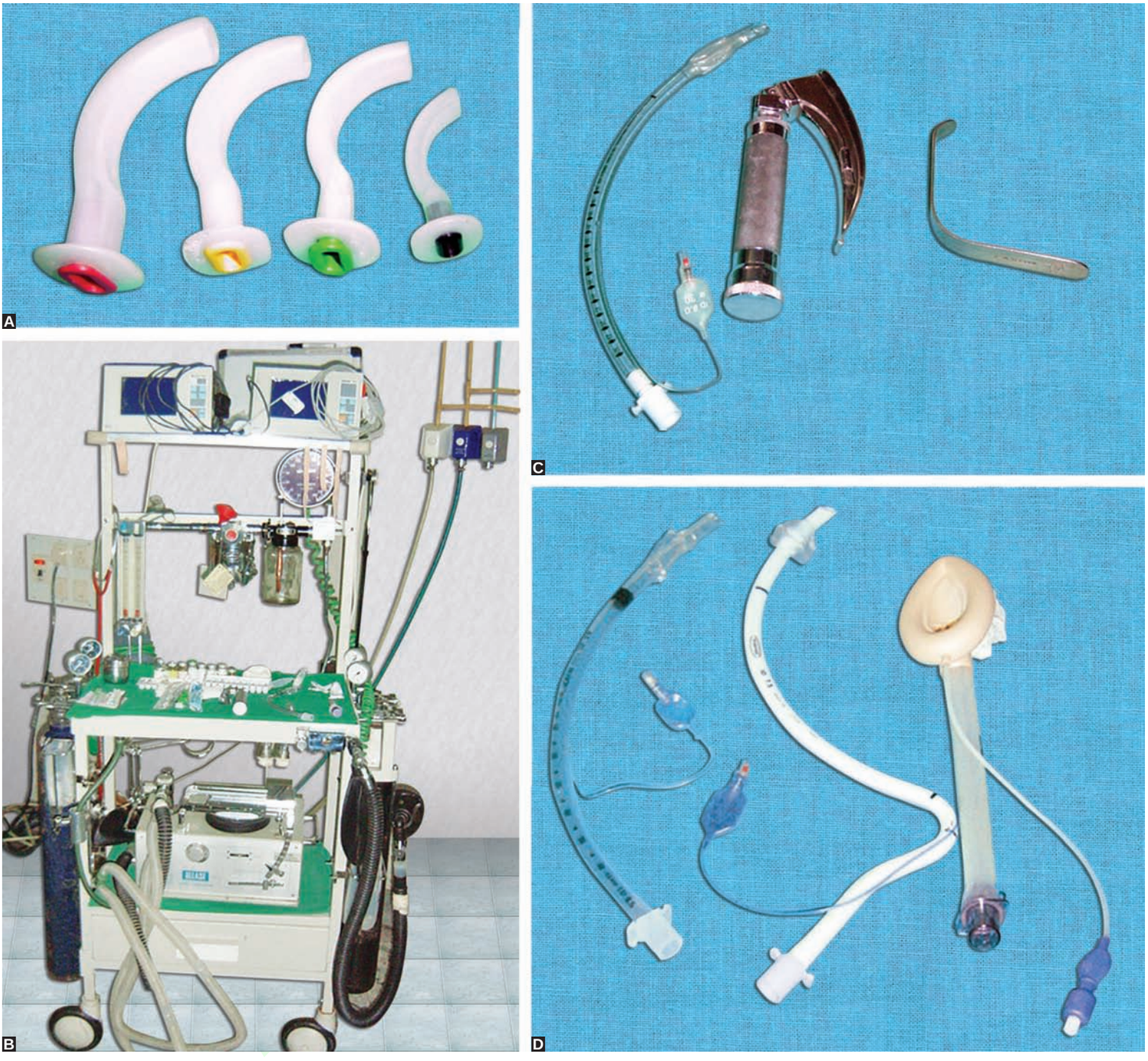


Fig. 2-4: Photos showing method of wearing glove.



Figs 2-6A to D: Different materials required to give anaesthesia– (A) airway; (B) Boyle's apparatus; (C) Direct laryngoscope; (D) Laryngeal mask airway (LMA)–a special device tube to give anaesthesia.

- Instruments should be kept separate for septic OT.
- Drapes, towels, mops should be placed in a plastic bag after use and sent to laundry immediately. It should be labeled as *infected.*
- Circulating nurse should wear gloves while working in a septic OT.
- Disinfection of shoes is essential once it is used in septic OT.
- Daily disinfection of OT is essential.
- Swab culture of the OT materials at regular intervals is needed.
- Separate Boyle's apparatus is used in septic OT.
- Dress is changed when one comes out of septic OT and enters the main OT.

Prevention of infection

- Cleaning of the patient's skin where incision is placed by povidone iodine, cetrimide, spirit.
- Isolation of surgical area by proper draping with green towels.
- Transparent sheeting of the skin through which skin incision is placed.
- Adhesive films to the skin.
- Use of on table parenteral antibiotic in major cases.
- Always clean cases are done first and then infected cases.
- Proper sterilisation.
- Double autoclaving for orthopaedic and ophthalmology cases.

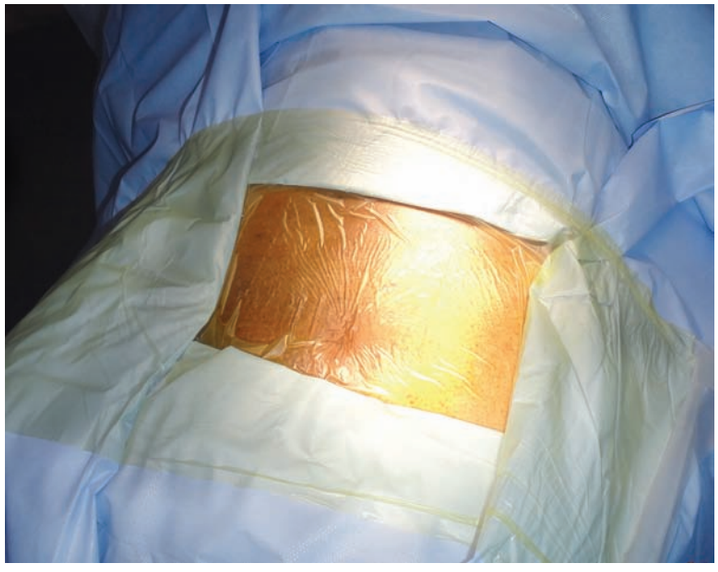


Fig. 2-7: Adhesive plastic draping in operation theatre reduces the chances of wound or deeper infection.

Precautions in an Operation Theatre

- In the absence of proper safety measures and precautions, OT is a place where one is prone for accidental trauma and injuries, which may be danger to patient as well as to theatre personnel.
- Main danger exists in some anaesthetic agents, which may cause life-threatening explosions. It may cause burns, loss of vision, hearing loss, damage to OT, may also sometimes cause death. Ether is one, which can be explosive.
- An OT has got high power electric supply for its basic needs like air condition, lights, machines, cautery, suction apparatus, other modern instruments like laparoscope, C- ARM, etc. Because of the presence of too many electric circuits and possibility of dangers of static electricity, theatre staff should take enough precautions to prevent any electric injury to patients and theatre personnel.
- Good earthing is essential.
- It is ideal to use theatre dresses made of cotton (cotton clothes) to patient, surgeon and nurses. Drapes and other materials should also be made of cotton **(Fig. 2-7)**.
- Rubber should be used wherever required like in wheel of trolley, Boyle's apparatus, mattresses, floor, wall of the theatre.
- When cautery is used, electric shock is common and so enough precautions have to be taken. Often cautery burns can occur to the patient.
- An electrician should be immediately available whenever there is problem like power failure, short circuit, and default in any of the electrical instruments.

Beware of possible anaesthetic explosions and electrical injuries in OT.

Most important people in OT

- First and foremost is the ***patient***.
- Next are surgeon and anaesthetist.
- Essential are theatre nurses and theatre assistant.
- Surgery is a team work. All are important.

POSTOPERATIVE CARE

In all major prolonged surgeries, patient is kept in postoperative ward. Postoperative set up is clean, air conditioned, well equipped set up with restricted entries. Rules followed in operation theatre should be followed here also. Postoperative ward should be adjacent to the main operation theatre. It should be equipped with all essential life saving drugs, tubes, ventilators, oxygen supply line, suction devices, and monitors to each bed. One nurse should exclusively attend one patient. An anaesthetist should be in charge of the postoperative ward. Nurse should be well trained, quick, and observant and should able to manage emergency situation. Defibrillator and needful things to manage cardiac arrest should be available in postoperative ward **(Figs 2-8 and 2-9)**.

Fig. 2-8: Infusion pump is used in postoperative period to have a proper control about the infusion of fluids, drugs, etc.

Fig. 2-9: Pulse oximeter. It is usually portable. Different types may be available. One showing just O2 saturation and pulse rate to cardiac waves is available. It is non-invasive, continuous real time device. Amount of light absorbed by a solution is directly proportional to the amount of solute in it. It contains two light emitting diodes–660 nm (for reduced haemoglobin absorption) and 940 nm (for oxyhaemoglobin absorption). Ratio of absorption of these two wavelengths is oxygen saturation. Normal saturation is 98-100%. It is monitored in fingers, toes. Limitations are patient movements, electrical interference, and vasoconstriction, presence of carboxyhaemoglobin or methaemoglobin.

Figs 2-10A and B: Postoperative drain should be taken care of.

Following care should be taken:

- Use of dry bed sheets, clean beds and clothing, waterbeds/air mattresses, change of position, leg exercises, needed positioning which depends on obesity, respiratory reserve, and type of surgery the patient underwent should be taken care of. Oxygen is given through mask or cannula.
- *Proper monitoring* with oxygen saturation, pulse, blood pressure, respiration, and urine output is needed. CVP line is often required for major cases.
- *Drains, tubes* (Nasogastric tube, urinary catheters) should be observed for quantity and colour of the contents. Intercostals tubes, abdominal drains, tubes like T tube, stenting tubes should be taken care of **(Figs 2-10A and B)**. Often if patient is having many tubes in postoperative period it is better to label each tube for better nursing purpose. Nasogastric tube is placed in most of the abdominal surgeries to decompress stomach, to prevent aspiration, and as a therapy for ileus. It is usually kept connected to a bag/bottle allowing continuous flow. Intermittent suction also should be added to clear the stomach at 4th hourly interval. Tube is removed once bowel sounds are heard, patient passes flatus or stool and once total aspiration becomes less than 200 ml per day.
- Surgical cases done under spinal anaesthesia or in case of small procedures, patient can be kept for 3 hours in recovery room for observations before sending to bed. But it is surgeon's discretion to decide how long to keep the patient in postoperative ward. For example, patient who underwent transurethral resection of prostate (TURP) under spinal anaesthesia is usually kept in postoperative ward for minimum of 12 hours to watch for irrigation and bleeding.
- *Postoperative fluid management* should be proper and adequate. It is decided on individual patient depending on type of surgery, on table complications, duration of recovery, respiratory reserve, electrolyte status etc. Fluid need is monitored by hourly urine output and CVP measurement. *Extracellular fluid loss and third space fluid loss* occurs in first postoperative period. *Commonest electrolyte deficit* in postoperative period is *potassium* which usually occurs after 48 hours. Potassium supplement is started when needed, after confirmation by estimation usually at the end of 2nd postoperative day. It is given by *slow infusion* as 1 mEq/Kg body weight. Experienced nurse should give this supplement as bolus push of potassium may cause cardiac arrest. Sodium also commonly gets deranged. It is corrected after estimation, using double strength saline. Calcium and magnesium supplement is also often needed. *Sensible loss of fluid* is obvious loss of fluid by nasogastric tube, drains, urine output; *insensible loss* is due to metabolism, temperature, and hyperventilation. Both should be carefully calculated for adequate fluid therapy.
- *Postoperative assessment chart*—regular recording of blood pressure, pulse, respiration, urine, drain, etc is a must. Postoperative examination of respiratory system for crepitations (pulmonary oedema), of legs for DVT (pain, swelling and tenderness in calf), cardiovascular system and of abdomen is done daily.
- *Postoperative respiratory physiotherapy* is given to remove secretions. Respiratory distress may be due to cough, secretions, pain causing poor diaphragmatic movements, drugs like atropine. Proper pain relief; coughing, removal of secretions, breathing exercises using balloons or spirometer, steam inhalation, saline nebulisation, bronchodilators, mobilisation are encouraged **(Fig. 2-11)**. To prevent DVT leg exercises and early mobilisation are done. It is better to take the help of a physiotherapist for the same.
- Postoperative investigations are done as and when needed based on clinical and monitoring grounds. Haemoglobin %, total count, serum electrolytes, serum creatinine, serum bilirubin are commonly done. In critical patients arterial blood gas analysis,

Fig. 2-11: Flow based incentive spirometer is commonly used as it is light weight and portable. Three chambers has got three balls one in each of different colours. Each registers an air flow of 600/900/1200 cc/second respectively. Volume inapired can be calculated. Rise of the ball in chamber indicates the extent of flow of air. It is used in postoperative lung expansion. It is also used to prevent atelectasis, preoperative improvement of respiratory reserve. Larger device indicating inhaled air volume also in use.

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haematocrit, platelet count, prothrombin time are done at regular intervals. Chest X-ray should be done if pneumonia, effusion or ARDS is suspected postoperatively. ECG should be taken when needed.

- *Antibiotics* are continued for 48 hours and stopped. It is continued in infective/septic cases or in septicaemia.
- Diabetes should be managed depending on blood sugar level using insulin. Later it can be changed to oral hypoglycaemic drugs after consultation with physician in charge.
- *Postoperative nutrition*–oral feeding is started in usual surgeries in 6-8 hours once patient is conscious and without any nausea. Initially to start with 50 ml/hour liquid, later semisolid and finally solid normal diet is used. It takes 2 days to have normal diet in surgeries other than gastrointestinal. In abdominal surgery it is delayed until, bowel sounds appear, patient passes flatus and nasogastric tube aspiration becomes less than 200 ml per day. Early oral feeding in abdominal surgery is under trial at present. In gastrointestinal surgery, it takes usually 5 days to start oral feeding. In major gastrointestinal surgeries, intestinal fistulas, total parenteral nutrition is a must (TPN) with all essential elements, otherwise sepsis, wound dehiscence, anastomotic leak can occur.
- *Postoperative pain* relief is essential. If pain is not relieved tachypnoea, tachycardia, pneumonia, atelectasis, hypertension, aggravate cardiac problems. Pain units are there in hospitals to manage pain by analgesics like NSAIDs and tramadol, sedation like morphine and pethidine, epidural analgesia. Often *continuous intravenous infusion* of analgesics is needed. *Patient controlled analgesia* is training patient to self-administer the drug using triggering button which delivers the controlled dose of analgesics. Opioids can cause nausea and vomiting and so antiemetic should be given. NSAIDs can be nephrotoxic especially in elderly and gastric irritant and so patient should be monitored. Antihistamine injection like ranitidine (50 mg intravenously) or injection of proton pump inhibitors should be given along with NSAIDs. Pain reduces in intensity in 48 hours after surgery. If pain persists after 48 hours, it should be evaluated for sepsis, haematoma, ileus, collection, nerve irritation, pneumonia, DVT, etc.
- *Prevention of postoperative DVT* is important. Risk of DVT is 30% in postoperative period. It is more common in orthopaedic surgeries, surgeries for malignancy, in obese patients, in elderly. Risk is categorised as low (age less than 40 years; short time surgery without immobilisation); moderate risk (age more than 40 years; major surgeries; patient taking oral contraceptives); high risk (age above 40 years, cardiac illness, major operation, pelvic surgery, malignancy, prolonged postoperative immobilisation). Prophylactic low dose heparin/low molecular weight heparin can be given on the day of surgery and continued for 5 days post-operatively. Early mobilisation, compression stockings to legs during surgery and postoperative period, leg exercises, pneumatic compression devices are other modalities used. Patient should stop oral contraceptives 4 weeks prior to major surgery.
- *Postoperative fever* is the one surgeon is really worried about. Fever in 24 hours may be due to intravenous fluid, inflammatory response, atelectasis, DVT, inflammation at the site of intravenous cannula, urinary infection. Upto 5 days it may be due to pneumonia, catheter induced infection, cellulitis at infusion site, thrombophlebitis, DVT. After 5 days it may be due to collection at operative site, bacteraemia, septicaemia, pneumonia. Total count, liver function tests, urine analysis, chest X-ray, blood culture, ultrasound of the site like abdomen, occasionally CT scan is needed for proper evaluation to identify the cause of fever. Higher generation antibiotics are needed. Proper monitoring is needed. Anastomotic leak, subphrenic abscess, pelvic abscess has to be thought of. Empyema, late DVT has to be ruled out. Doppler scan of both limbs should be done if suspected. Drainage of pus, re-surgery has to be considered.
- *Surgical wound management* is also important. Clean surgical wound is inspected only after 48 hours. Infected wound should be inspected in 24 hours. Timing of suture removal depends on type of surgery, site of surgery. It is removed usually in 4-5 days in face, in 7–10 days in the abdomen, back, limbs. There may be danger of wound dehiscence in early removal of sutures. Very late removal may cause wound infection. Timing is decided by surgeon on individual basis. Suture is removed with all aseptic precautions. It is removed from deeper part of the knot which is pulled towards the line of incision **(Figs 2-12A and B)**.

Figs 2-12A and B: Dressing solutions used in different dressings. Patient dipping his ulcer leg in dilute eusol solution—Eusol bath (Edinburgh University Solution–boric acid, sodium hypochlorite, calcium hydroxide).

SURGICAL COMPLICATIONS

It is said that complications tend to occur in spite of adequate precaution and care in surgical practice. If any surgeon tells that he had zero percent of complications then it is logic that he has not operated at all. But complications can be reduced; often can be prevented by proper preoperative care and preparation. One has to remember that complication is not negligence. Complications during postoperative period is categorised as respiratory, cardiac, renal, hepatic, gastrointestinal, generalised, postoperative fever, deep venous thrombosis and so on.

It is usually classified as (1) ***Intraoperative*** complications. (2) ***Immediate postoperative*** complications. (3) ***Late postoperative*** complications.

Respiratory Complications

It is the *most common* postoperative complication. Precipitating factors are old age, obesity, smoking, asthma, bronchitis, associated cardiac illness, postoperative pain, aspiration. 25 % of postoperative deaths are due to respiratory infection.

Atelectasis

Atelectasis is collapse of basal lung alveoli which can be prevented by respiratory physiotherapy, control of pain, effective coughing. It is

the most common postoperative respiratory complication. Narcotics, anaesthetic agents, abdominal/thoracic wound pain cause pulmonary shunt development eventually leads into atelectasis, pneumonia, respiratory failure, etc. It is common in smokers, and obese individuals. Pneumonia can develop eventually in these patients. Deep breathing, proper coughing, usage of spirometer, respiratory physiotherapy are the important ways to treat and prevent it.

Aspiration

Aspiration *i*s common in postoperative period causing collapse of lung, bronchopneumonia–***Mendelson's syndrome***. Large quantity of aspiration can cause complete blockage of airway and instant death. Often it is due to chemical (acid) induced and severe laryngeal spasm. Immediate ventilation using intubation and ventilator; suction and clearing of airway, bronchoscopy and clearing are the measures needed. *Postoperative pneumonia* is commonly due to nosocomial infection by pseudomonas, klebsiella and enterobacter. Both lung pneumonia/atelectasis may be life threatening and an emergency situation. Prevention of aspiration is important. Keeping the patient nil oral in postoperative period for 12 hours is beneficial. Sideward positioning of the patient; prokinetics, passing nasogastric tube are often needed. Once aspirated sudden laryngeal spasm, sepsis, bronchospasm, respiratory failure may develop. It is treated with antibiotics, immediate bronchoscopy, bronchodilators, and ventilator support. Role of steroid support is *not well* accepted even though commonly practiced.

Pulmonary Oedema

Pulmonary oedema with accumulation of fluid in the alveoli causing hypoxaemia is common postoperative complication. It is due to fluid overload, cardiac cause and acute lung injury due to toxins, sepsis. Pulmonary capillary wedge pressure (PCWP) is ideal to identify it with abnormal chest X-ray. It is treated with restricted fluid, diuresis, and oxygen supplement often with ventilator support.

ARDS (Acute/Adult Respiratory Distress Syndrome)

*Acute/Adult Respiratory Distress Syndrome (**ARDS**)* is a form of respiratory failure with fluid accumulation in the alveoli, widened/thickened alveoli–capillary space, diffuse inflammatory response in both lungs with PaO_2/FIO_2 ratio less than 200 and PCWP less than 18 mmHg. It is critical entity leading into respiratory failure and death. Patient develops tachypnoea, tachycardia, dyspnoea, cyanosis with coarse crepitations all over the lungs on both sides. Patient will be on respiratory failure with reversal of arterial PaO_2 and $PaCO_2$. *Management*: Patient needs ventilator with initial FIO_2 at 100%; PEEP (positive end expiratory pressure); tidal volume 6-8 ml/Kg; peak pressure at 35 cm of water; $PaCO_2$ is maintained at 40 mmHg; inspiratory/expiratory ratio is at 1:2. Later FIO_2 is weaned to 60%. ARDS is now classified as classical type III respiratory failure. Chest X-ray is useful tool to diagnose. Monitoring of pulmonary capillary wedge pressure (PCWP) is needed. Fluid restriction and diuretics are part of the therapy. Complications of ventilator have to be watched for–dependency, sepsis with resistant bacteria, endotracheal tube blockage. Tracheostomy if needed is *always* better. TPN, enteral nutrition, prevention of thrombocytopenia and bleeding by transfusing FFP or platelets whenever needed is essential. Development of uraemia should also be watched for by assessing the renal functions repeatedly.

Criteria for weaning ventilator are–respiratory rate less than 25/minute; PaO_2 more than 70 mmHg; $PaCO_2$ less than 45 mm Hg; minute ventilation 8 liter/minute; tidal volume 6 ml/Kg; negative inspiratory force is minus 25 cm of H_2O.

Acute lung injury is similar but PaO_2/FIO_2 ratio is less than 300 and PCWP is less than 18 mmHg. It is little less severe than ARDS.

Respiratory Failure

Respiratory failure is defined as a status with arterial partial pressure of oxygen less than 60 mmHg; arterial partial pressure of CO_2 more than 60 mmHg. Aspiration, pneumonia, sepsis, lung injury, transfusion, ARDS, acute lung injury, fat embolism are common causes. There is diminished diffusion across alveolar membrane causing cyanosis and hypoxia. *Type I respiratory failure* is *hypoxic condition* with reduced PaO_2 but normal $PaCO_2$. There is hypoventilation, AV shunts, ventilation perfusion mismatch, and low venous oxygen. *Type II hypercapnic respiratory failure* is reduced PaO_2 with increased $PaCO_2$. There is also increased CO_2 production with widened dead space. *Type III respiratory failure is typical ARDS* with development of hyaline membrane; reduced diffusion; decrease in surfactant; raise in pulmonary arterial pressure; progressive atelectasis; respiratory arrest. Management is similar to ARDS. Monitoring at regular intervals is essential. Tracheostomy may be a life saving need **(Figs 2-13 to 2-15)**.

Other than above measures, nitric oxide inhalation; partial liquid ventilation; fluorocarbon assisted gas exchange; extracorporeal membrane oxygenators are used.

Fat Embolism and Pulmonary Complication

Fat embolism and pulmonary complication occurs after fracture of femur/tibia. Cutaneous petechiae, bilateral respiratory involvement due to small/medium sized emboli; cerebral/retinal/renal problems are the other features. It is treated with ventilator, steroids, and heparin.

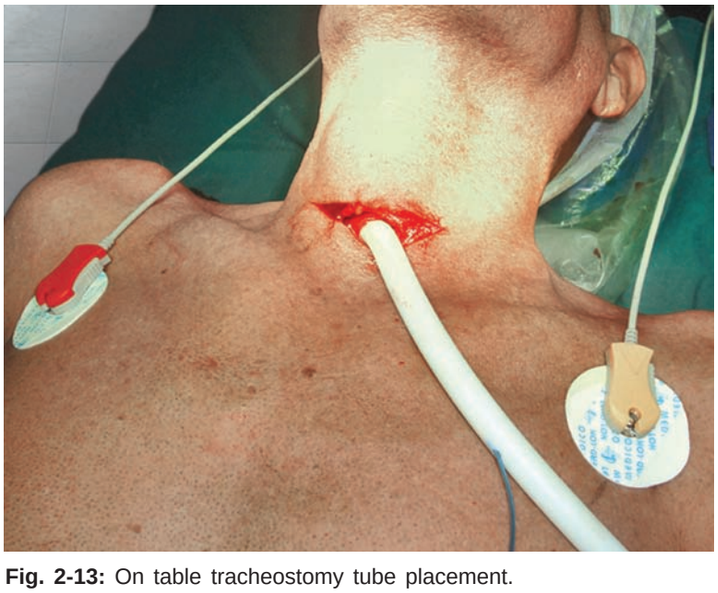

Fig. 2-13: On table tracheostomy tube placement.

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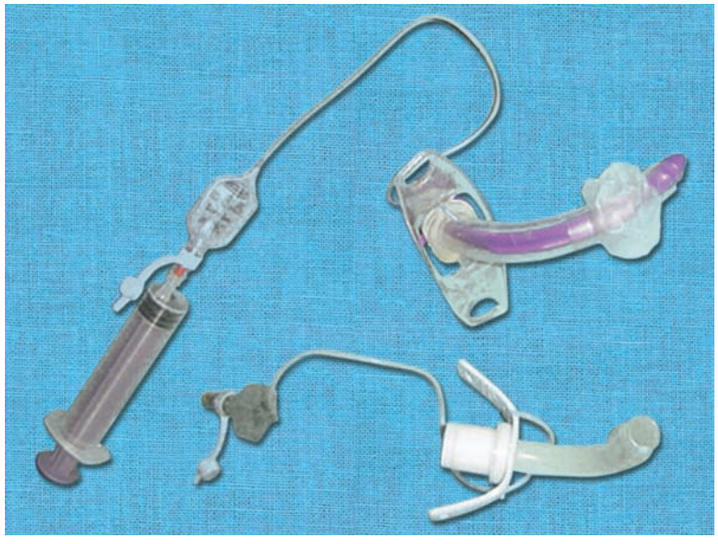


Fig. 2-14: Synthetic tracheostomy tube–PVC.

Fig. 2-15: Fuller's biflanged tracheostomy tube having outer tube and inner tube. Inner tube is having an opening on the convex surface. Inner tube is longer than outer tube.

Pulmonary Embolism

Pulmonary embolism is often life threatening complication in postoperative period. Its incidence is 30% with death rate 10%. Endothelial damage, stasis, hypercoagulable status are the *risk factors*. Trauma, fractures, major surgery, obesity, old age, post partum period, pregnancy, malignancy, venous catheters, neurologic causes, varicose veins, inherited thrombophilia are *main causes*. Commonest origin is deep venous thrombosis (DVT) in *iliofemoral* region. Pulmonary embolism may be *massive* in 10% of cases blocking pulmonary artery and instant death. *Medium and small emboli* block the lung capillaries at periphery causing infarction. *Presentations are*–pain, swelling, tenderness in the leg; pleuritic chest pain; sudden onset dyspnoea; tachycardia; haemoptysis; inspiratory crackles; loud second heart sound; audible fourth heart sound; tachypnoea. *ECG* shows right bundle branch block, right axis deviation, P wave pulmonale. Chest X-ray may show infarction in lung (*wedge shaped*). Change in arterial blood gas is obvious. Venous duplex US shows evidence of DVT in legs. *Pulmonary CT angiography* even though is *gold standard*, ideal most sensitive investigation; it is not commonly done as it is invasive, not available, needs expertise to do it. *Echocardiography* is noninvasive, can be done bed side, available in most of the centers. It shows hypokinesia and dilatation of right ventricle, paradoxical motion, pulmonary hypertension; but it is not as sensitive as pulmonary angiography. *D-dimer* assay is typical as negative result excludes pulmonary embolism; but positive result will not confirm the diagnosis. D-dimer is degraded product of a cross-linked fibrin blood clot. *Helical CT angiogram* is technically easier, commonly done CT than CT pulmonary angiogram. *V/Q lung scan* is the initial test of choice but it is not available. Echocardiography, helical CT angiogram scan, venous Doppler scan, D-dimer assay are commonly practiced evaluatory methods. *Treatment*–heparin; LMWH; fondaparinux (synthetic pentasaccharide anticoagulant which inhibits factor Xa. *Ultrafractionated heparin* is very useful as a bolus 70 units/Kg followed by 1000 units/hour intravenously with maintaining partial thromboplastin time two times the control. Warfarin, oral anticoagulant 5-10 mg daily is started as an *overlap therapy* with heparin for 2 days before stopping heparin. *Thrombolytic agents* like streptokinase, urokinase, and recombinant tissue plasminogen activator that dissolves the clot rapidly is useful in massive pulmonary embolism. Transcatheter thrombolysis and embolectomy is also useful. IVC filter placement is better method to prevent embolism in high risk groups.

Cardiac Complications

Elective operation in a patient who had myocardial infarction recently should be ideally deferred for 6 months. In an emergency situation such rule can not be applied.

Myocardial Infarction (MI)

Myocardial infarction can develop on table preoperatively which has got high mortality; or in postoperative period. Old age, obesity, patient already with history earlier of ischaemic attacks are more prone to develop MI. In suspected cases repeated cardiac isoenzymes–CPK MB should be done. ECG and echocardiography, immediate call for cardiologist is a must. Often MI is precipitated by surgical stress, shock, haemorrhage, hypovolaemia, hypoxia, electrolyte imbalance and prolonged anaesthesia. Measures taken are–pain relief, oxygen, nebulisation, CVP monitor, avoiding fluid overload, vasopressors, emergency angiogram and angioplasty by balloon or stent.

Postoperative Hypertension

Postoperative hypertension may be due to pain, hypoxia, hypothermia, fluid overload, trauma (head), internal bleeding, and crisis of certain disease like pheochromocytoma. *Hypertensive crisis* in postoperative period is dangerous. There is severe raise in blood pressure (diastolic > 110 mmHg); organ dysfunction; cerebral and subarachnoid haemorrhage; stroke; acute cardiac problems; bleeding from surgical wound site. Sodium nitroprusside, nitroglycerin, labetalol, esmolol, enalaprilat, nicardipine are the different drugs tried. At time 25% of blood pressure is controlled, which then is gradually allowed to become normal. Rapid control may lead into stroke, organ hypoperfusion.

Cardiac Arrest

It is the cessation of the heart. Heart stops contracting. Causes: All causes for shock. Structural causes like coronary artery diseases, myocardial hypertrophy, carditis, cardiomyopathy; conduction

problems; valvular heart diseases; hypoperfusion status due to shock of any cause; metabolic causes; sudden reduction in cardiac output due to tension pneumothorax, pulmonary embolism, anaphylaxis, acute blood loss; toxins; drugs. There will be finally *ventricular fibrillation* before leading into cardiac arrest. Profound circulatory failure develops causing typical features.

Features of cardiac arrest

- No palpable pulse–radial/femoral/carotid.
- Heart sounds not heard.
- Cessation of respiration, apnoea — cyanosis occurs.
- Development of unconsciousness with convulsions.
- Pupils start dilating.
- Cessation of bleeding.
- ECG shows asystole/ventricular fibrillation.

Critical period—Once heart and lungs stop, brain death occurs in 3 minutes.

Immediate measures–Cardiopulmonary resuscitation (CPR)

- **Airway** open by head tilt–chin lift; jaw thrust manoeuvre; clean the airway by finger or Heimlich method
- **Breathing**–spontaneous/mouth to mouth/bag and mask
- **Cardiac** compression
- **Drugs** and **Defibrillator**
- **ECG**, **Endotracheal** tube and Monitor

Basic life measures:

- **External cardiac compression (massage)** — Patient is laid flat on a *hard surface (never on soft surface)*. Manual compression is exerted over the lower sternum, using both hands one over other without bending the elbow at a rate of 60 to 70 per minute. Rib cage damage during procedure can very well be ignored. (Heel of right hand is placed over the sternum 5-8 cm above xiphoid process and left hand is placed over it) **(Fig. 2-16)**.

Fig. 2-16: Technique of cardiac massage.

- At the same time, another person should give *mouth to mouth breathing* at a rate of 10-20 per minute after clearing the airway by removing froth, and dentures if present **(Fig. 2-17)**. A bag with mask can be used to ventilate using air or oxygen.
- Endotracheal intubation and ventilator support.

Fig. 2-17: Technique of mouth-to-mouth respiration. Note patient's nose should be held closed with right hand of the doctor/ assistant and with left hand lower jaw should be pushed forward.

Observations to be made are:

- Groin pulse
- Respiration and breath sounds
- Blood pressure
- Pupillary reaction
- ECG activity

Once patient recovers, the cause and sequelae has to be managed properly.

Sequelae are due to hypoxia and circulatory collapse

- Cerebral oedema and permanent brain damage.
- ARDS (Acute/Adult Respiratory Distress Syndrome)
- Renal failure.

Advanced life support

- Intubation, 100% oxygen support.
- Proper venous line ideally central or peripheral as an emergency should be assessed.
- Endotracheal administration of epinephrine/atropine/lignocaine in 10 ml saline is given twice as intravenous dose. Intracardiac drugs are *not used* now.
- **Internal open cardiac massage:** This method is used when cardiac arrest occurs in the operation theatre during surgery, acute tamponade, and acute bilateral pneumothorax. Left side thorax is opened through a *rapid lengthy* incision along 4th or 5th intercostals space. Initially heart with intact pericardium is rhythmically compressed and relaxed using left hand against sternum. Mean time costal cartilages above and below are cut with a knife to have a better exposure. Pericardium is opened in front of the phrenic nerve. Direct cardiac massage is undertaken until heart regains its function and later shifted to ventilatory support and critical care **(Fig. 2-18)**.

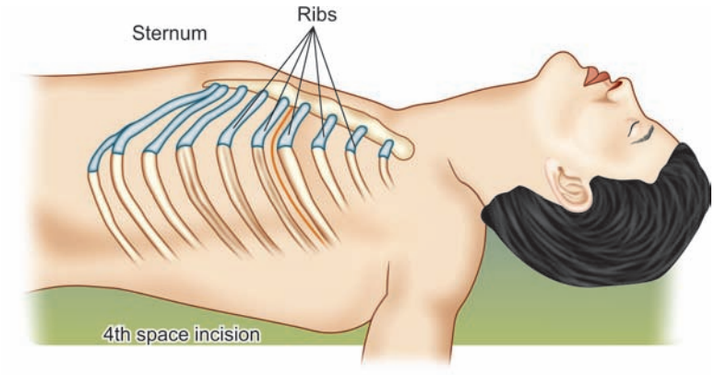


Fig. 2-18: Left thoracotomy for open internal cardiac massage.

- **Defibrillation technique:** Jelly is applied to the site of electrodes. One electrode is placed at the base of heart to the right of the sternum, other over the estimated area of the apex of the heart **(Fig. 2-19)**. ***Ensure that nobody is in contact with the patient***. The defibrillator is activated. Ventilation and ECG monitoring is resumed immediately. Defibrillation upto 3 times (200; 300 and 360 Joules) is done.
- Injection of 1:10,000 adrenaline (1 mg IV) and 10% calcium chloride intravenously. It is repeated every 3 minutes. Lignocaine 1.5 mg/Kg IV; repeated every 3 minutes. Procainamide 30 mg/minute up to a total dose of 17 mg/Kg; atropine I mg intravenously.
- Correction of hypoxia, acidosis, hypothermia, hypotension, hypovolaemia, potassium imbalance.
- Sodium bicarbonate 8.4% injection, hydrocortisone injection.
- Analysis of blood gas (PCO_2 and PO_2), and assessment of serum electrolytes at repeated intervals.
- Urinary catheterisation, Ryle's tube insertion.
- Monitoring the patient with BP, pulse, respiration, and temperature chart–critical care in ICU.

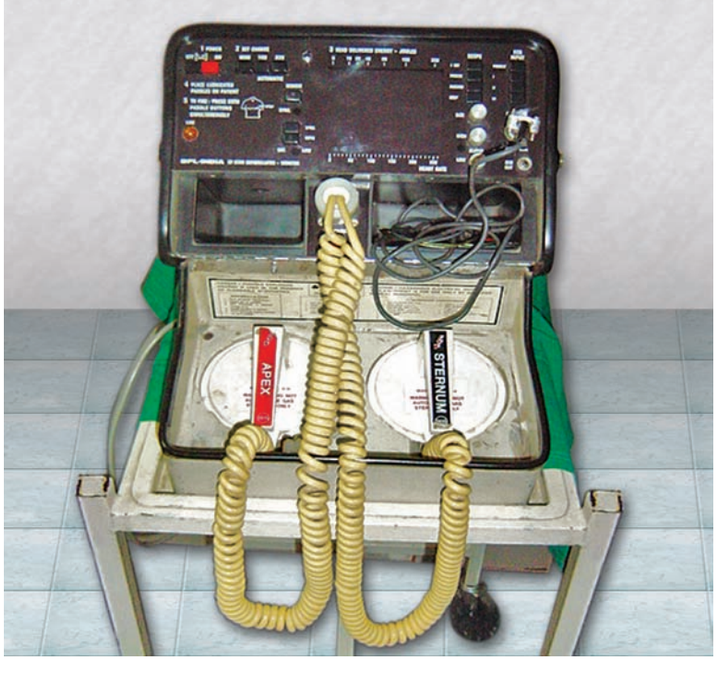


Fig. 2-19: Defibrillator is used in case of cardiac arrest.

Renal/Urinary Complications

Postoperative Retention of Urine

Twenty percent of postoperative patients develop retention of urine. Perineal, gynaecological, pelvic surgeries are common causes. Surgery done under spinal anaesthesia is also common cause. Wound pain, difficulty in straining, pre-existing prostate enlargement, stricture urethra, phimosis, drugs (sympathomimetics, anticholinergics, antihistamines) and constipation are the reasons. Hot water bag placement over hypogastric region, relieving anxiety, mobilisation, doing rectal examination may make the patient to pass urine. If still retention persists then Foley's catheterisation is done. Alpha adrenergic blockers, prazocin are also used often.

Acute Renal Failure in Postoperative Period

Acute renal failure in postoperative period is common and often it is real challenge to manage. It is increase in serum creatinine level–relative increase of 50% or absolute increase by 1 mg%. It can be oliguric ARF (output less than 480 ml/day) or nonoliguric ARF (isosthenuric urine output more than 2 liter/day but does not clear toxins). Both cause electrolyte and haemodynamic imbalance. True volume depletion in postoperative period is the *common* prerenal *cause*. It may be due to vomiting, diarrhoea, inadequate postoperative fluid replacement, haemorrhage presenting as tachycardia, hypotension, low jugular venous pulse, dry tongue. ARF can develop due to associated pulmonary oedema, congestive cardiac failure, as hepatorenal syndrome, nephritic syndrome, renal disease itself. It can be also immunologic, idiopathic, transfusion induced; *septicaemia induced* (decreased peripheral vasoconstriction, increased renal vasoconstriction, toxins) also. Aminoglycosides, *NSAIDS* (inhibits glomerular afferent vasodilatation) are nephrotoxic and renal parameters have to be monitored in these patients. Haemolysis or rhabdomyolysis can cause renal failure. It needs adequate fluid therapy, mannitol therapy–25 gram intravenous, sodium bicarbonate intravenous to keep urine pH more than 6.5 so that pigment heme gets dissolved. *Investigations*: **Prerenal ARF** is identified by low urinary sodium (less than 20 mEq/liter), less than 1% of fractional excretion of sodium, high serum sodium, and blood urea nitrogen and creatinine ratio is more than 20:1. In **renal cause of ARF**, fractional excretion of sodium is higher than 1% due to tubular damage. Urinary sodium level is more than 50 mEq/liter. Creatinine clearance test is ideal. *Treatment:* Haemodynamic management; *fluid challenge* using 500 ml normal saline infusion in 30 minutes; frusemide 100–400 mg intravenously; 20% mannitol; *dopamine i*nfusion at a rate of 3 µg/kg/minute; haemodialysis until kidney regains its function adequately. During haemodialysis, fluid intake should be monitored properly by taking help of a nephrologist; twice a day monitoring of serum electrolytes; *sudden hyperkalaemia* more than 5.5 mEq/dl is a risk for cardiac arrest and so potassium supplement should be avoided and IV calcium, DNS with insulin should be started. Adequate calorie is essential and is supplemented orally or parenterally **(Fig. 2-20)**.

Gastrointestinal Complications

Acute Erosive Gastritis

It is seen in critically ill patients; ICU patients; severe trauma; burns *(Curling's ulcer);* head injury and intracranial diseases (Cushing's

Fig. 2-20: Haemodialysis to a renal failure patient.

ulcer); drugs like aspirin, NSAIDs. It is due to gastric mucosal disruption, ischaemia, decreased gastric epithelial turnover, and reduced prostaglandin production (PG increases epithelial turnover, bicarbonate, mucus, mucosal blood flow). Gastroduodenoscopy confirms the diagnosis. It is treated by nasogastric aspiration, saline wash, proton pump inhibitors or H2 blockers. Sucralfate is an aluminium salt of sulfated sucrose binds only to ulcer bed but not to normal gastric mucosa, which increases the prostaglandin level, binds pepsin and bile acids, blocks the back diffusion of hydrogen ions, and protects stomach from colonisation by bacteria. Vasopressin, misoprostol (It is PGE1 used in NSAIDs-induced gastritis), laser coagulation using gastroscope are other methods. Vagotomy, total gastrectomy to control postoperative bleeding is rarely needed nowadays.

Postoperative Ileus

Ileus is a complicated process involving altered gastrointestinal nervous system, local hormonal factors, inflammatory factors, bowel handling and narcotic analgesia. Resection and anastomosis of bowel temporarily ceases the bowel activity due to inability to transmit the peristaltic waves from duodenal. Small bowel ileus recovers usually in 48 hours. Colonic ileus recovers in 4 days, gastric ileus in 4-5 days. *Note:* Patient without ileus, recovery of motility of small bowel occurs in 12 hours; of stomach in 48 hours; of colon in 72 hours. Observation, correction of electrolytes, sepsis control, and nasogastric aspiration is usually sufficient. Aspiration through nasogastric tube less than 200 ml; passing of flatus, return of bowel sounds are signs of recovery. Rarely if ileus causes abdominal compartment syndrome laparotomy may be required and decompression is done using decompressor. *Bowel obstruction* occurring within 30 days after surgery is called as *early postoperative* bowel obstruction. It can be due *to primary ileus* without any precipitating factors or *secondary ileus* with precipitating factors or *mechanical bowel obstruction* commonly due to adhesions (90%). *Ileus* is a complicated process involving altered gastrointestinal nervous system, local hormonal factors, inflammatory factors, bowel handling, and narcotic analgesia. Resection and anastomosis of bowel temporarily ceases the bowel activity due to inability to transmit the peristaltic waves from duodenal pacemaker. *CT abdomen* is ideal to diagnose type of bowel obstruction, complications, peritonitis and also to decide whether surgical intervention is needed. *Treatment* is initially conservative–fluids, correction of electrolytes, sepsis. But if needed re-exploration is done to correct the mechanical obstruction of the bowel.

Acute Abdominal Compartment Syndrome

It is increased intraabdominal pressure more than 12 mmHg (Normal pressure is about 5 mmHg) with hypoxia, increasing peak airway pressure, poor ventilation, oliguria. *Causes:* Ascites, pancreatitis, bowel wall oedema, fluid collection, major abdominal procedures, liver transplantation, contents of large long standing hernias once reduced into the peritoneal cavity, non-compliant abdominal wall when closed with tension, trauma, packing abdomen, paralytic ileus, coagulopathies. Diaphragm gets displaced upwards causing hypoxia, hypercapnia, and acidosis. Pressure more than 25 mmHg causes compression of IVC and portal vein leading into reduced venous return to heart and increased peripheral resistance. Right atrial and pulmonary arterial occlusion pressure decreases. Kidneys get compressed directly leading into decreased GFR and urine output. Mesenteric vein compression → decreased perfusion → intramucosal acidosis, bowel wall oedema. Increased CVP reduces the cerebral blood outflow and increases the intracranial pressure. *Features:* Difficulty in breathing, oliguria, tense distended abdomen, reduced cardiac output, deterioration in level of consciousness, acidosis and respiratory failure. *Investigations:* Measurement of pressure using a transducer through a urinary bladder Foley's catheter; measurement through gastric catheter; abdominal perfusion pressure measurement; assessment of renal infiltration gradient; CT abdomen. Pressure is graded as Grade I–10–15 cm H_2O; Grade II–15-25 cm H_2O; Grade III–26–35 cm H_2O; Grade IV–> 35 cm H_2O. *Treatment:* Emergency surgery and decompression, drainage of the abdominal fluid, muscle relaxant, ventilator, laparostomy, mesh/biomesh/sterile bag cover, vacuum assisted closure are methods available.

Postoperative Gastrointestinal Bleeding

It may be upper gastrointestinal or lower gastrointestinal bleeding. Upper GI bleed may be due to peptic ulcer, stress gastritis, variceal bleed, Mallory Weiss bleeding, AV malformations and anastomotic bleed. Bleeding stress ulcers can occur, when gastric pH is less than 4.0. Lower GI bleed may be due to diverticulosis, colitis, bowel ischaemia, AV malformations. Precipitating factors are trauma, burns, head injury, coagulopathies, sepsis, DIC, drugs. Tarry coloured stool/melaena and haematemesis or blood in the nasogastric tube is the feature of upper GI bleed. Haematochezia, loose stool are the features of lower GI bleed. Rapid bleed can cause hypotension, tachycardia and shock. Gastroscopy or colonoscopy confirms the diagnosis. *Treatment:* Blood transfusion; conservative therapy by saline wash, intravenous H2 blockers (Ranitidine 50 mg/Famotidine), proton pump inhibitors, sucralfate, monitoring and maintaining the clotting factors, antibiotics, maintaining the INR using injection vitamin K or fresh frozen plasma, platelet transfusion; endoscopic control of bleeding by tamponade, epinephrine, laser, clips, banding, heater probe; angiographic embolisation using gel foam, clot, coils through superior or inferior mesenteric arteries. Occasionally surgical intervention is needed especially when there is refractile anastomotic leak. Re-anastomosis or subtotal gastrectomy, vagotomy are the procedures used.

Stomal Complications

It can be early or late. Early can be retraction, necrosis, abscess formation, high output systemic failure, and leak. Late can be prolapse, stenosis, parastomal hernia, fistula, excoriations, and bowel obstruction.

Anastomotic Leak

It is a common complication in gastrointestinal surgery often dreadful and life threatening. It may be intestinal or pancreatic or biliary fistulas/leak.

Factors: Poor blood supply, sepsis, emergency resections, malignancy, old age, obesity, smoking, immunocompromised patients, fluid collection or abscess formation, steroid therapy (steroid prevents collagen formation and healing), hypotension and hypoxia on table and in immediate postoperative period, presence of drains, shock, malnutrition, deficiencies, stapler related factors, specific diseases like carcinoma, tuberculosis, Crohn's disease, diverticulitis. Uncontrolled leak, abscess formation, electrolyte imbalance, anaemia, malnutrition, sepsis are the effects. Renal failure, multiorgan failure and death can occur if not controlled. Fistula should be *classified as low output or high output* depending on the quantity of fluid effluent in the fistula. If it is less than 500 ml it is called as low output fistula; if more than 500 ml it is high output fistula. Often it is *also* classified as *low* (below 200 ml/24 hours); *moderate* (between 200–500 ml); *high* (more than 500/day). In pancreatic fistula if less than 200 ml it is classified as low or more than 200 ml it is high. *Skin excoriation* (effluent dermatitis) initially allergic later with skin infection is common presenting as pain, ulcers, intractable itching. In proximal fistula electrolyte imbalance, fluid loss, malabsorption is severe whereas in distal fistula (colonic) it is less severe.

Investigations: CT abdomen, CT fistulogram, contrast GI studies, enteroclysis, endoscopies, cystoscopy to see enterovesical fistula.

Treatment: TPN; evaluation of site of leak as whether it is end/lateral/low/high fistula; antibiotics; skin care with zinc oxide cream, adhesives, barriers, sealants, pouches; blood transfusion; rest to bowel by keeping the patient nil orally so that luminal secretions are reduced. If there is abscess, bleeding, peritonitis, bowel ischaemia re laparotomy is done. Timing of re exploration is in 24–48 hours once patient is stabilized. Thorough peritoneal wash with warm saline is given. Site of leak is identified. Ileostomy, colostomy or internal by pass procedures are done depending on individual patients and site of pathology. *Spontaneous closure* of fistula is expected in 60% of patients. *Favorable factors for spontaneous closure of fistula are*–tract more than 2 cm, single straight tract, lateral type, non-epithelialised tract, without sepsis or abscess or foreign body, defect in the bowel wall less than 1 cm, without distal obstruction and absence of specific diseases, adequate nutrition. Forty percent cases *surgical intervention* and correction is needed. *Unfavorable factors are*–short tract less than 2 cm, multiple tracts, associated internal tracts, end fistula, epithelialisation, presence of infection or abscess, and bowel wall defect more than 1 cm, presence of specific diseases, foreign body, and malnutrition. Somatostatin and its analogues help in reducing the GI secretions to reduce the fistula output. Enteral nutrition can be very well used in low proximal fistulas or in colonic fistulas. *Fistuloclysis* is a newer method of infusing the nutrient fluid directly through the fistula into the GI tract.

Bile Leak

Bile leak is related to biliary surgery. It is 0.2% in open cholecystectomy and 0.7% in laparoscopic surgery.

Causes may be–leak from cystic duct stump, leak from accessory duct, injury to common bile duct or hepatic duct, biliary anomalies, thermal injury to CBD, late disruption and leak. Complete transection of CBD or hepatic ducts, avulsion of cystic duct, complex injuries with laceration of CBD can occur. *MRCP is diagnostic*. ERCP and CT abdomen is also done to assess proper pathology, site of disruption and to plan the proposed therapy. Pathology may be bilioma formation, biliary peritonitis, biliary fistula through drain site or through the wound, formation of abscess **(Fig. 2-21)**.

Presentations are–initially asymptomatic but later jaundice, cholangitis, abdomen pain and tenderness, features of sepsis.

Treatment: ERCP and stenting, aspiration of bilioma, in partial injury T tube with repair by open method, in complete transaction then choledochoenterostomy should be done. It needs proper care, skill, patience and meticulous dissection. Drains must be placed at the site.

Clostridium Difficile Colitis

Clostridium difficile is a Gram positive spore bearing anaerobic bacillus. Spores exist in the environment and GI tract as a dormant status. *Antibiotic use* disturbs the microflora of the colon allows this organism to get released from germinated spores. Bacteria release toxins - toxin A (enterotoxin) and toxin B (cytotoxin) cause various effects. *Effects are*–asymptomatic, mild colitis; pseudomembranous colitis; fulminant colitis; toxic megacolon. Its incidence is increased by over use of antibiotics. Its mortality is also increased now (15%). It is common in general surgery, vascular surgery, old age, patients in ICU, HIV, patients

Fig. 2-21: Biliary fistula in a difficult postoperative laparoscopic cholecystectomy patient. It needs ERCP and stenting.

on chemotherapy. Patients with long duration or multiple antibiotic therapies are more prone to its infection. Even single dose antibiotic therapy is known to cause *Clostridium difficile* sepsis. *Features:* Pain abdomen, foul smelling loose stool, fever, distension of abdomen, septic shock, dehydration, toxaemia are the features. *Treatment:* Careful use of antibiotics, aseptic precautions are important to prevent the infection. It is treated with *vancomycin (*orally/enema/IV) or metronidazole or rifampicin. Use of *lactobacillus acidophilus and saccharomyces cerevisiae* is also helpful. Occasionally surgical intervention with total colectomy and ileostomy may be needed as a life saving measure.

Postoperative Psychosis

Acute postoperative psychosis is often seen. Presentations are either depression or mania or like schizophrenia with delusions. It is often difficult to differentiate the condition from electrolyte imbalance and other metabolic derangements. Proper evaluation and then help of a psychiatrist is needed. Usually patient becomes alright once he recovers from the actual illness and postoperative period, but needs counseling and drug therapy.

Postoperative Fever (See above)

It is the common problem in postoperative period. ***Malignant hyperthermia*** is rapidly increased metabolic crisis during/after exposure to anaesthesia which is often life threatening (10% mortality). It is usually inherited as *autosomal dominant* disease where there is increased calcium efflux in skeletal muscle from sarcoplasmic reticulum to myoplasm. *Triggering anaesthetic agents* (halothane, enflurane, isoflurane, desflurane) and depolarising muscled relaxants like succinyl choline causes increased calcium concentration in myoplasma. It leads into uncontrolled hypermetabolism in muscles leading into hypoxia, lactic acidosis, hypercapnia, breaking of ATP (adenosine triphosphate), excessive heat generation, hyperkalaemia, myoglobulinuria, DIC, systemic ischaemia and failure. Commonly susceptibility runs in family, with earlier or family history of recurrent myalgia, pain and fever after exercise, and often caffeine intolerance. Muscle biopsy (creatine kinase assay), halothane/caffeine contraction tests are useful. Such susceptible patients should have trigger-free anaesthesia like barbiturates, benzodiazepines, propofol, ketamine, nitrous oxide, non-depolarising neuromuscular blockers). *Manifestations* usually develop *immediately* after administering the triggering drugs like tachycardia, arrhythmias, temperature, and muscle rigidity, inability to open the mouth with masseter spasm, tachypnoea, hypotension, and hyperthermia. *Treatment strategies* are–discontinuation of the surgery, stop and use alternate anaesthetic agent, dantrolene intravenously 2.5 mg/Kg bolus and repeated once in 5 minutes until recovery, hyperventilation, surface cooling by different methods like tepid sponging of entire body, coolant usage, cool parenteral fluids, correction of acidosis, beta blockers, lignocaine injection, correction of hyperkalaemia, hypercalcaemia, hypercapnia, dialysis if needed, ICU care.

Postoperative Hypothermia

A 2° C drop in the core temperature causes hypothermia with metabolic derangements.

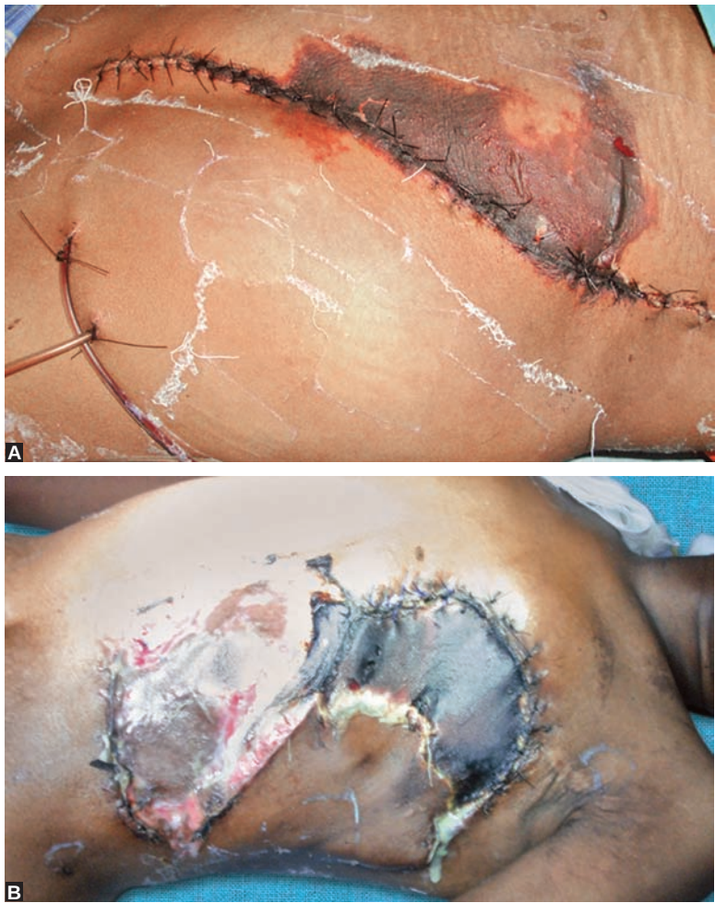
Causes of hypothermia are prolonged surgical procedure, transfusion, intravenous fluids, low room temperature (air condition), anaesthesia (propofol), and vascular phenomenon.

Effects of hypothermia–vasoconstriction, poor organ perfusion, arrhythmias, decreased coagulation function (risk of bleeding), altered macrophage action and sepsis, reduced oxygenation of tissues, poor healing, neurological disturbances, acid base imbalance, poor cardiac and respiratory effort, bradycardia, coma. A temperature *below 35° C* is critical. Shivering with coldness is the initial presentation. Core temperature is *monitored* in pulmonary artery blood, tympanic membrane, oesophagus, pharynx, rectum and urinary bladder. Warm intravenous fluids, warmed clothes, humidifier/warmer, usage of warming device, covering of the head, humidifying inhalation gases, warm saline wash in surgical fields, rewarming infusion devices, rarely cardiopulmonary bypass–are the *treatment plans.* Single dose hydrocortisone may be helpful.

Surgical Wound Complications

Seroma Formation

A seroma is a collection of liquefied fat, serum, lymph fluid in a closed surgical wound under the skin in subcutaneous plane and is clear, yellow and viscous. It is often seen after skin grafting, mastectomy, surgery in inguinal region, after lymph node dissections, after mesh placing surgery. Suction drains prevent seroma formation. Once seroma is formed, it is aspirated. If there is failure even after two times of aspiration, then open drainage is done. Often seroma can get infected when it should be drained and fluid should be sent for culture. When mesh is present underneath, it need not to be removed in every patient. Mesh should be removed only when there is resistant infection. Only if resistant infection is there then mesh should be removed **(Figs 2-22A and B)**.



Figs 2-22A and B: Postoperative flap necrosis.

Haematoma Formation

It is an abnormal collection of blood either under the wound (traumatic or surgical) or in a potential space developed pathologically or after surgery. It can occur in subcutaneous plane, in the muscle, deep to muscle or in cavities like in the abdomen, thorax or intracranially **(Fig. 2-23)**.

Fig. 2-23: Postoperative haematoma formation.

Causes: Inadequate haemostasis during surgery, slipping of ligatures, drug induced (anticoagulants, aspirin, clopidogrel), depleted clotting factors.

Presentations: Pain, localised bluish or purple swelling, skin discoloration, tenderness often fluctuant. Large haematoma at different locations can cause different problems like airway obstruction in neck; paralytic ileus in the abdomen, features of raised intracranial tension in brain; respiratory distress in thorax etc. Anaemia, DIC, sepsis are other problems. Often bleeding may not get controlled and may be life threatening especially in the cavities. It can get infected also.

Investigations: Haematoma is confirmed by ultrasound, aspiration or CT scan (inside cavities). Prothrombin time, partial thromboplastin time, platelet counts, haemoglobin estimation, are other needed evaluation methods.

Treatment: It should be treated by surgical drainage, correction of clotting factors. Patients on heparin therapy should stop the heparin 3 hours before surgery; Low molecular weight heparin (LMWH) 15 hours before surgery; warfarin therapy 3 days before surgery; clopidogrel 6 days before surgery. International normalised ratio *(INR)* should be *less than 1.5* before surgery.

Surgical Site Infection

It may be (superficial) in skin and subcutaneous tissue; (deep) in fascia and muscles; internal cavities at the site of operation (Organ space*). Superficial wound infection* will show purulent discharge with erythema, pain and oedema involving skin and subcutaneous infection in less than 30 days. *Deep wound infection* is purulent discharge from deeper plane, with clinical or sonological or radiological evidence of deeper abscess, fever, pain, tenderness or wound dehiscence through deeper plane in less than 30 days. *Organ space infection* is purulent discharge from a drain placed at organ space, bacteria cultured from fluid from organ space, confirmed abscess in organ space clinically or by evaluation methods with infection in less than 30 days without an implant or with infection less than one year with an implant. *Commonest bacteria* are group D enterococcus, *Staphylococcus aureus,* and *Escherichia coli*. *Commonest time* of postoperative infection is 5-6 days postoperatively. 80% of infections occur within 30 days. *Factors related to surgical wound infection–(Patient factors)* old age, obesity, smoking, alcohol intake, ischaemia, poor blood supply, diabetes mellitus, anaemia, malnutrition, immunosuppression, steroid therapy, associated malignancy, hypoxia, hyperlipidaemia, radiotherapy site*; (Treatment/Hospital factors)* foreign body in the wound, improper sterilisation, poor asepsis methods, presence of drains, emergency surgery, surgery in sepsis, lengthy surgical procedure, nosocomial infection. Surgical wounds are classified as clean, clean contaminated and dirty **(Table 2-1)**.

Management of infection: Features of *infected wound* are presence of pus/infected fluid in the main wound, pus spontaneously draining from disrupted wound, fluid culture positive for bacteria. For infected wounds *therapeutic antibiotics* are given. For clean contaminated wounds preoperative antibiotics are indicated. It is given 30 minutes before surgery and is continued every 4 hours until surgery is over and later standard dose is continued. Only in certain clean surgical cases like mastectomy *prophylactic antibiotics* are given preoperatively; but it should be stopped in immediate postoperative period (usually antibiotics are not necessary in clean cases except in certain occasions) **(Figs 2-25 to 2-28)**. Wound sutures are opened. Fluid/pus are drained. Fluid is sent for culture study (controversial). Open wound debridement is done and thorough warm saline wash is given. Wound is packed and dressed. Regular dressing is done until wound granulates well. Wound may close spontaneously by epithelialisation or scarring or may need secondary suturing or skin grafting if wound area is wide. Wound vacuum dressings are very useful in large, deep wounds **(Fig. 2-24)**. Use of drain in surgical wound is controversial. Closed suction drains in deep spaces are advised. In usual surgical wounds drain is not necessary.

Table 2-1: Surgical wounds–classification

Clean wound	*Clean contaminated*	*Contaminated*	*Dirty wound*
Primary closure of the wound	Primary closure of the wound	Open/traumatic wound	Open–suppurative wound
No hollow viscus injury	Controlled hollow viscus injury	Evidence of inflammation is present	Evidence of severe inflammation
No evidence of inflammation	No evidence of inflammation	Spillage of viscus is present–uncontrolled	Untreated, uncontrolled spillage of the content
Proper aseptic methods used	Mechanical drain usage	Infection rate – 25%	Pus in the surgical field
Elective surgery	Infection rate–< 8%		Infection rate–40%
Infection rate–< 3%			

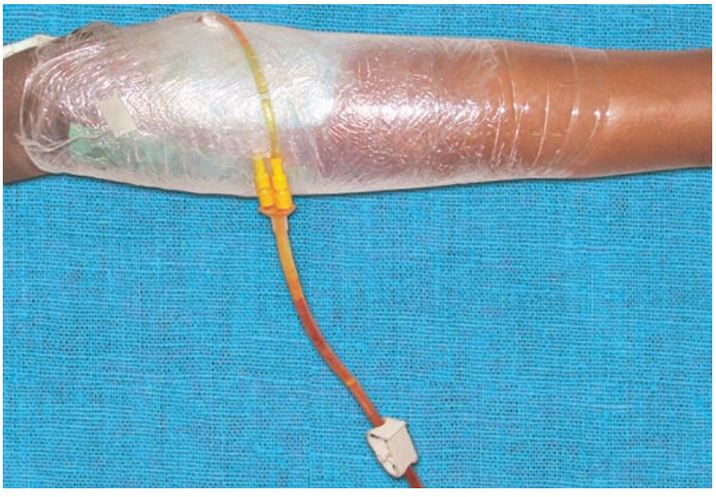


Fig. 2-24: Vacuum dressing.

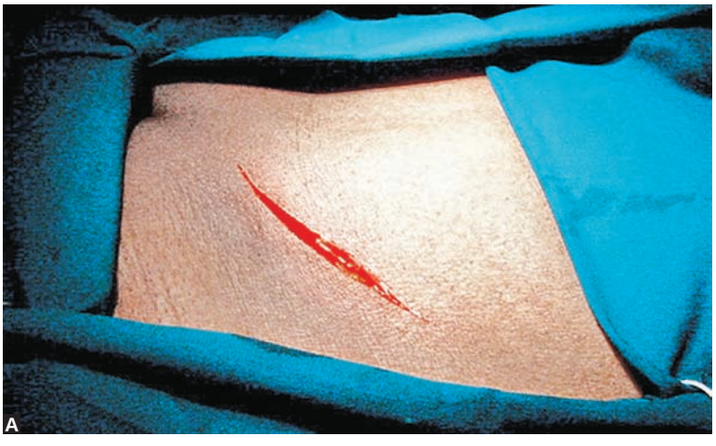
Prevention of surgical wound infections

- Proper aseptic care.
- Proper meticulous dissection, haemostasis, preservation of blood supply, gentle tissue handling.
- Proper wash, irrigation using warm saline.
- Avoiding foreign body in the wound, maintaining normal temperature.

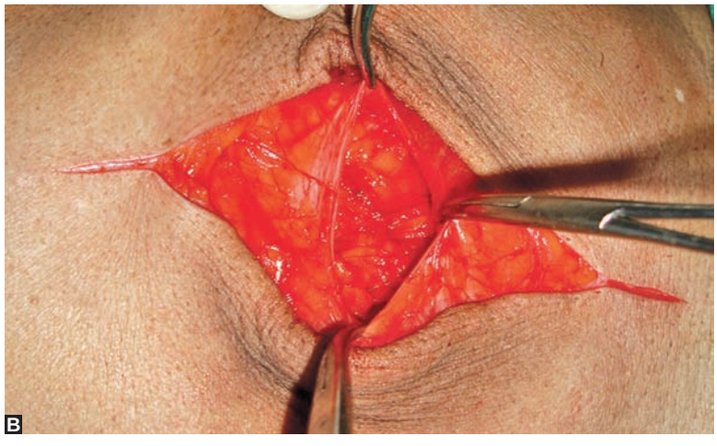
Chronic Wound

A wound which is not healed completely in 30 days is called as chronic wound **(Fig. 2-29)**.

Causes: Debilitating illness, steroid therapy, immunosuppression, poorly nourished patients, obesity, malignancy, radiotherapy. These wounds are covered with granulation tissue may be healthy, unhealthy or exuberant. Once granulation tissue becomes healthy with clear discharge skin grafting is done to cover the defect. Often if area is not wide, then secondary suturing is done.

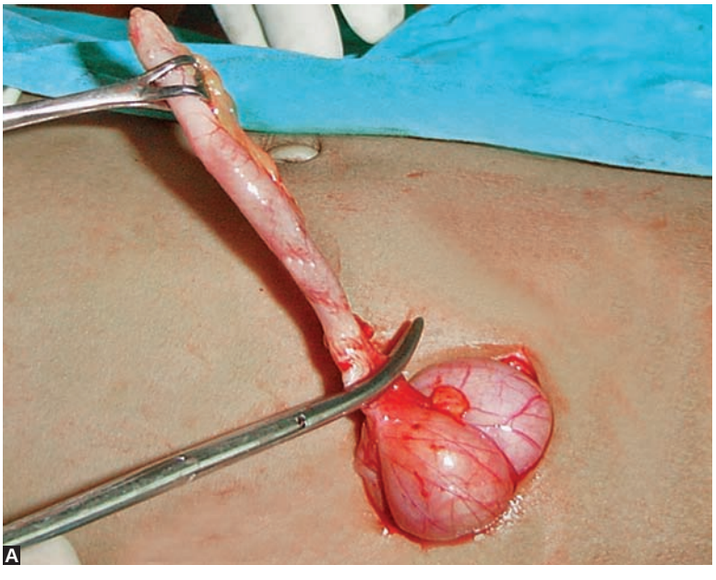


A

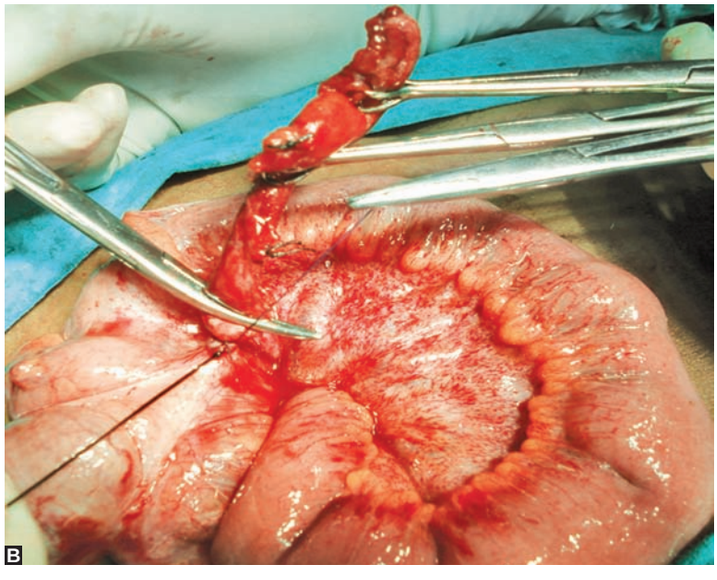


B

Figs 2-25A and B: Clean wound (see Table 2-1).



A



B

Figs 2-26A and B: Clean contaminated wound (see Table 2-1).

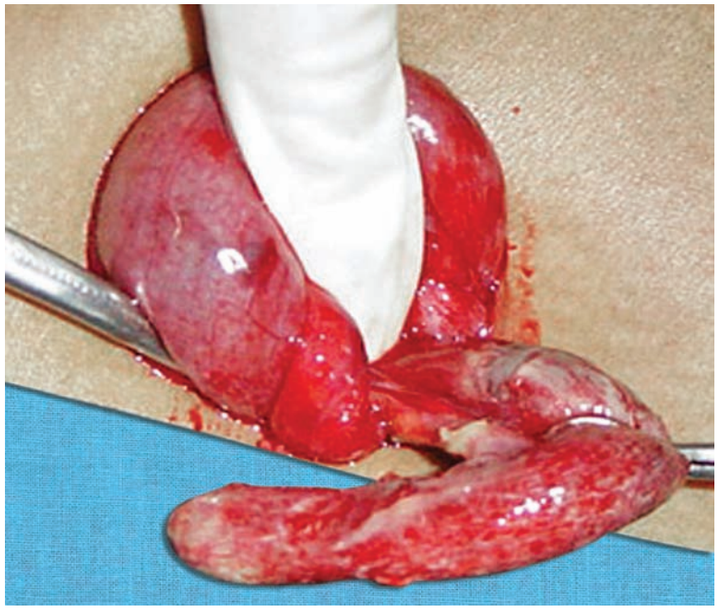
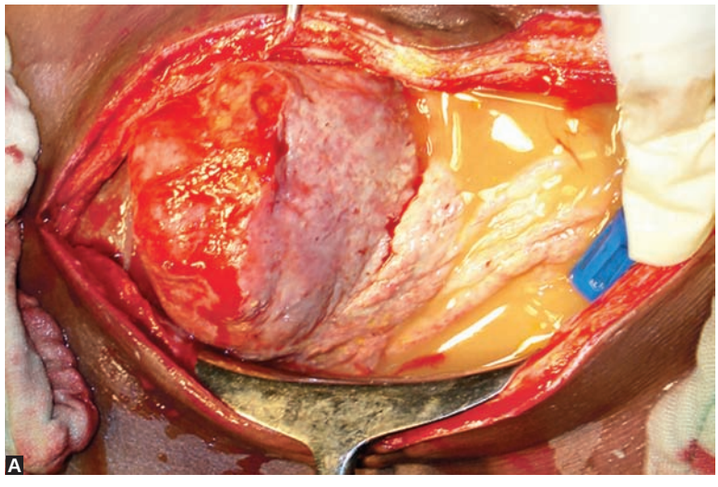


Fig. 2-27: Contaminated wound (see Table 2-1).



Figs 2-28A and B

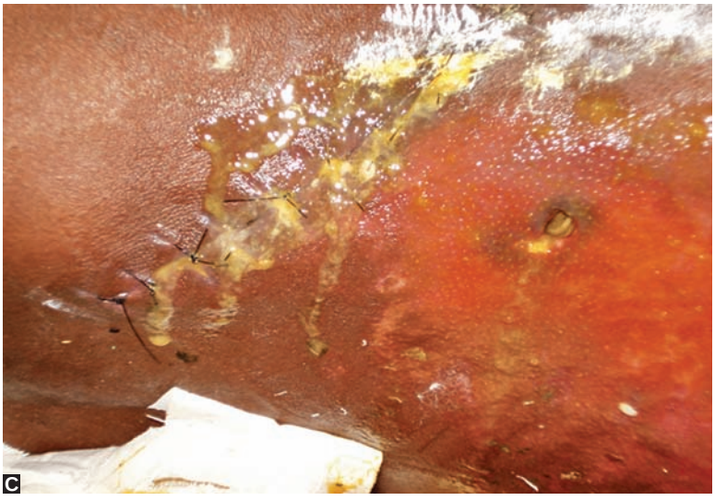


Fig. 2-28C

Figs 2-28A to C: Dirty wound (see Table 2-1).

Fig. 2-29: Chronic wound.

Wound Dehiscence

It is *acute wound failure* in postoperative period with separation of wound edges including *all layers*. For all practical purposes it is observed in abdominal wound and so it is synonymous with *burst abdomen/abdominal wound dehiscence* **(Fig. 2-30)**. It is sudden, rapid all layer wound giving way precipitated by severe cough or vomiting causing salmon coloured serosanguinous discharge. Intraabdominal

Fig. 2-30: Burst abdomen/acute wound failure/abdominal wound dehiscence.

anastomotic leak has to be considered other than usual causes of wound sepsis. Under anaesthesia, thorough exploration of the contents is done. After warm saline wash, wound is closed primarily with interrupted non-absorbable monofilament sutures or using absorbable mesh or biologic prosthesis (decellularised porcine submucosa/dermis or human cadaveric dermis). Wound vacuum system using cell foam, semiocclusive drape and suction over the wound can be very useful. It gives immediate cover to the contents; removes the interstitial fluid, reduces the bowel oedema; increases the perfusion and healing; lessens the bacterial contamination. Intestinal fistulas, late hernia formation are the problems.

Adrenal Insufficiency

Acute Adrenal Insufficiency

Acute adrenal insufficiency in postoperative period may be due to destruction of gland by haemorrhage, necrosis, thrombosis which is secondary to sepsis, toxins, antiphospholipid syndrome or postpartum necrosis; critically ill patients; abrupt stopping of long-term steroid therapy; surgical adrenalectomy. Acute adrenal insufficiency is *difficult to diagnose* in a critically ill patients. Unexplained hypotension, haemodynamic instability, hyponatraemia not responding to normal saline, hypoglycaemia and uraemia persistent inflammation are the features. *Treatment* is high dose intravenous hydrocortisone or methylprednisolone, volume correction, correction of hyponatraemia. Sodium level *below* 120 mmol/Litre is dangerous.

Chronic Adrenal Insufficiency

Chronic adrenal insufficiency may be primary or secondary. *Primary* is due to primary adrenal gland destruction by autoimmune disease (Addison's disease). *Secondary* is due to diseases of hypothalamous or anterior pituitary or due to chronic use of steroids causing suppression of hypothalamo-pituitary-adrenal axis inducing adrenal atrophy. *Features*: Fatigue, weakness, anorexia, weight loss, diarrhoea, decreased libido, depression, dizziness hyponatraemia, hypoglycaemia, hyperkalaemia, acidosis. *Primary type* shows increased pigmentation of skin and mucous membrane due to elevated ACTH. *Secondary type* shows headache, visual disturbances, hypoadrenalism, and decreased ACTH level, loss of hair, pallor, hypothyroidism, oligomenorrhoea, and diabetes insipidus. Morning plasma cortisol level less than 3 µg/dl (83 mmol/Litre) is diagnostic (Normal is more than 19 µg/dl); between 3–19 is equivocal but suspicious of adrenal insufficiency; above 19 µg/dl rules out adrenal insufficiency. In primary type ACTH level in plasma is more than 100 pg/ml. In secondary type ACTH level is less. Aldosterone level in plasma may be reduced. *Rapid ACTH stimulation test* is useful. 250 µg cosynthropin is injected IV/IM and serum cortisol is measured in 60 minutes which will be 20 µg/dl or more in normal individual. If cortisol secretion is not increased then it is adrenal insufficiency. *Metyrapone test*: After oral administration of metyrapone, if there is insufficient increase in plasma 11–deoxycortisol and low plasma cortisol level (< 8 µg/dl) then it is secondary adrenal insufficiency. Condition is treated by IV hydrocortisone and fludrocortisone.

Other Complications

Hyperthyroid Crisis or Hypothyroidism

Hyperthyroid crisis occurs in improperly controlled hyperthyroid patient undergoing surgery of thyroid or other surgery. It causes dehydration, shock, hyperthermia, hypotension, cardiac arrhythmias. It is treated in critical care unit with beta blockers, antithyroid drugs, hydrocortisone, tepid sponging, antipyretics, Lugol's iodine, digitoxin, fluid therapy, heparin, plasmapheresis, proper monitoring. *Hypothyroidism* is not rare and is equally dangerous in anaesthetised patient. It should be confirmed by assessing T3, T4 and TSH levels. It is treated with l thyroxin therapy.

Syndrome of Inappropriate ADH Secretion (SIADH)

It causes chronic normovolemic hyponatraemia (serum sodium less than 135 mmol/Liter). *ADH* is arginine vasopressin synthesised in hypothalamus transported to and stored in posterior pituitary; secretes into blood to regulate water excretion. ADH is secreted by thirst, nausea, hypoglycaemia, hypovolemia and drugs like ACE inhibitors, dopamine, NSAIDs. SIADH is caused by trauma, stroke, ADH producing tumour, drugs. *Features* are anorexia, lethargy, convulsions, hyponatraemia, hypotonic plasma, urine osmolality in excess of plasma osmolality, increased urinary sodium excretion, absence of oedema, normal kidney function. *Treatment:* Fluid restriction is the main therapy, IV normal saline in significant symptomatic SIADH (not to every patient), or acute SIADH of less than 3 days duration. Slow gradual correction is the principle as rapid correction of sodium level causes permanent neurological damage. Frusemide occasionally can be used.

Postoperative Convulsions

It could be *primary* related primary intracranial diseases like tumour/trauma/haemorrhage in the brain. It could be *secondary* due to electrolyte imbalance, metabolic derangements, sepsis, systemic diseases, MODS, hypoxia, hypoglycaemia, hypomagnecaemia, drugs. Intravenous diazepam or phenytoin sodium is used. In refractory cases gabapentin is used. Later patient is assessed with CT head and electroencephalogram.

Postoperative Stroke

It is due to either ischaemia (common) or haemorrhage. Ischaemia is due to hypotension, thrombosis or emboli from heart. Haemorrhagic stroke (less common) is due to bleeding disorders, hypertension and anticoagulants. Patient is evaluated with CT head, echocardiography and cardiac evaluation, blood analysis (bleeding time, clotting time, prothrombin time and platelet count), carotid angiogram (CT angiogram). It is managed with the help of cardiologists and neurologists using mannitol, dexamethasone, anticonvulsants, cardiac management, thrombolytics.

Postoperative Epistaxis

It may be due to blood dyscrasias, anticoagulants, hypertension and trauma during intubation (nasal) or during insertion of nasogastric tube. *Anterior epistaxis* is due to septum and turbinates and is commonly due to tubes. It is controlled by pressure using thumb and fingers or packing using gauze. Posterior nasal bleeding (*posterior epistaxis*) is more dangerous and is torrential; difficult to manage. It needs posterior nasal packing; Foley's catheter insertion per nostril and inflating balloon with 30 ml distilled water to cause tamponade for 3-5 days; blood transfusions; occasionally ligation of sphenopalatine and ethmoidal arteries is needed.

Postoperative Sinusitis

Postoperative sinusitis commonly involving the maxillary sinus is of nosocomial origin mainly due to *Staphylococcus aureus* and Pseudomonas bacteria. It is also common in patients with ventilator. It is often dangerous as it may lead into life threatening postoperative pneumonia or brain abscess. Purulent nasal discharge, facial pain (if patient is awake), fever are the features. CT sinus and discharge study confirms the diagnosis. Proper antibiotics, often sinus drainage are the treatment needed.

Postoperative Parotitis

Postoperative parotitis is not an uncommon entity especially in elderly postoperative patients and in diabetic and immunosuppressed patients. Pain, tenderness, diffuse swelling, trismus, stridor due to airway obstruction, oedema of floor of the mouth, dysphagia are the features. Often it can cause toxaemia and septicaemia. Once abscess forms it needs proper incision and drainage through proper incision under general anaesthesia. Tracheostomy is often a need.

Intensive Care in Surgery

A critically ill patient is one who has life threatening illness or injury with one or more failing organs, essentially needing intensive care support **(Figs 2-31A and B)**.

Mortality is 50% if there is two organ failures; 85% if there are three organ failures; near 100% if there is four organ failures.

Figs 2-31A and B: Intensive care unit showing ICU bed with facilities. *Courtesy:* Unity Health Complex, Mangalore.

Monitoring

Arterial Blood Pressure

Non-invasive measurement of blood pressure is commonly done using either manual cuff or automated device. Measurement by invasive direct intra-arterial blood pressure is done by placing a cannula into the artery (radial artery) and connecting to a pressure transducer to record every beat accurate blood pressure. Intra-arterial cannulation can cause complications like haematoma, thrombosis of artery, infection, bleeding, arteriovenous fistula and pseudoaneurysm.

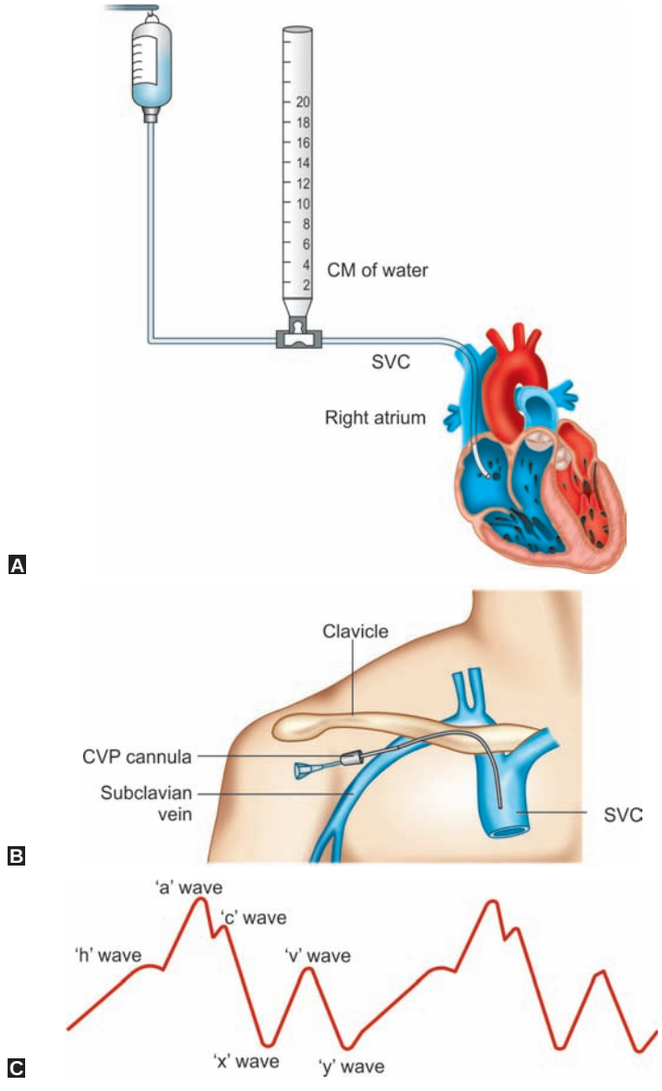
Monitoring Heart Rate, Respiratory Rate and Temperature

Heart rate and respiratory rate are assessed through monitor in the ICU. Temperature is assessed by placing the thermometer in the axilla. Special temperature monitoring devices are also available. Continuous ECG monitoring gives heart rate (above 100 is tachycardia; below 60 is bradycardia). Lead II is used to assess P wave. Chest leads are used to assess infarction and dysrhythmias.

Central Venous Pressure (CVP)

It is a method to measure the right atrial pressure by placing a venous catheter (20 cm) into the SVC. Commonly for CVP monitoring, a venous catheter is passed through right internal jugular vein or infraclavicular subclavian vein to the SVC (used for TPN purpose). Or occasionally a long catheter (60 cm) can be passed through basilic vein (not commonly done). Under radiological guidance, initially a needle is passed 3 cm above the medial end of the clavicle, in the hollow between the two heads of sternomastoid muscles, directing towards the suprasternal notch into the right internal jugular vein. Then through a guidewire, a venous catheter is passed into the SVC through right internal jugular vein, which can also be confirmed by changes in flow during inspiration and expiration. Catheter is connected to saline manometer, taking manubriosternal angle (*angle of Louis*) as zero point. Normal value is 2-10 cm of water/0-4 mmHg. CVP has got a, c and v upwards waves; x and y downwards waves. *'a'* is atrial contraction (absent in atrial fibrillation); *'c'* is tricuspid valve bulging during ventricular contraction; *'x'* is atrial relaxation; *'v'* is atrial filling; *'y'* is tricuspid valve opening and ventricular filling. If less than 2 cm, more fluid is infused. If more than 10 cm, fluid infusion should be restricted. Right atrial pressure is directly related to ventricular end diastolic pressure, i.e. filling pressure of right ventricle which is directly related to ventricular end diastolic volume, i. e. evidence of overall volume of fluid in the body. *CVP monitoring is used* for fluid resuscitation in shock, patients with hypotension of any cause; for multiple drug therapy; for TPN. CVP is a useful indicator of cardiac filling if both right and left ventricles are functioning equally well. In ischaemic heart disease, cardiomyopathies, cardiac valvular disease left ventricular function is affected. In pulmonary hypertension right ventricular function is affected. Response to bolus of 500 ml fluid administration shows transient rise with a fall of central venous pressure suggests low circulating volume **(Figs 2-32A to C)**.

Complications of CVP: Pneumothorax; haemothorax; injury to brachial plexus and vessels; bleeding; sepsis; air embolism; catheter erosion into bronchus, right atrium; catheter displacement.



Figs 2-32A to C: Central venous pressure (CVP) is used to monitor the patient. Note the location of the central venous catheter. Note the CVP wave pattern.

Pulmonary Capillary Wedge Pressure (PCWP)

It is a better indicator of circulating blood volume and left ventricular function. Catheter used *is Swan Ganz* triple channel pulmonary artery balloon catheter. It is used to differentiate right and left ventricular failure, pulmonary embolus and septic shock; to measure cardiac output, to monitor fluid therapy, inotropic agents and vasodilators. **Procedure**: Under strict aseptic precaution, using cannula and guidewire, catheter is passed through internal jugular vein, into the right atrium. Balloon is inflated by 1.5 ml of air and then negotiated into pulmonary artery, until it reaches a small branch and wedges it. Pressure at this point is called as *pulmonary capillary wedge pressure. PCWP* normally is 8-12 mmHg, considering midaxillary point as zero reference point. After that balloon is deflated to get pulmonary artery pressure which is normally 25 mmHg systolic and 10 mm Hg diastolic. PCWP catheter can be kept *in situ* only for 72 hours. PCWP gives left atrial pressure and filling pressure of left ventricle. Present pulmonary artery floatation catheter (PAFC) has got a lumen at superior vena cava or right atrium to give CVP also **(Fig. 2.33)**.

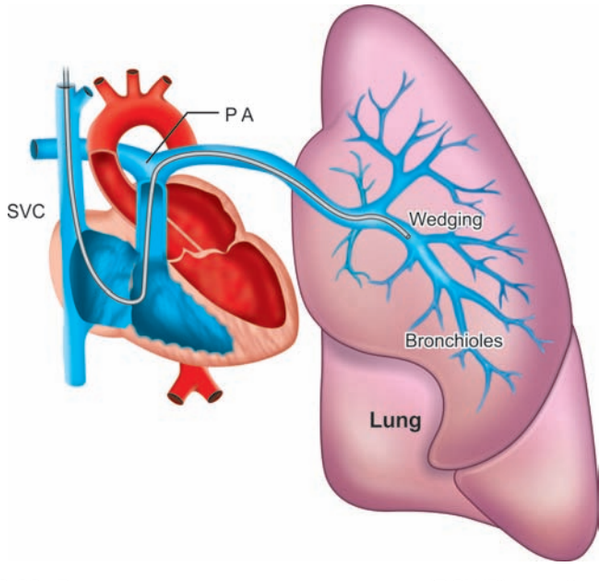


Fig. 2-33: Pulmonary capillary wedge pressure (PCWP) is better index of shock. But it is technically difficult and cannot be kept for more than 72 hours. It cannot be used for perfusion purpose unlike CVP line.

Complications of PCWP: Arrhythmias; heart block; pulmonary artery thrombosis; pulmonary artery rupture; balloon rupture; pulmonary infarction; pneumothorax; haemothorax; bleeding; sepsis; thrombosis.

Arterial Oxygen Saturation Measurement

Pulse oximeter gives continuous reading of the oxygen saturation which is placed on the pulp of the finger. It is by using diode light probe having two wavelengths–red band of 660 nm for reduced haemoglobin; infrared band of 940 nm for oxygenated haemoglobin. Difference in absorbance of both gives saturation. It is easier rapid way of assessing the oxygen saturation. *Limitations of pulse oximeter* are–it is not accurate once saturation is below 70%; vasoconstriction, hypovolaemia, hypothermia, drugs, carboxyhaemoglobin, shivering, improper positioning will give false values.

Arterial Blood Gas Analysis

It is ideal way of assessing the metabolic or hypoxic or oxygenation status. It includes pH (7.30–7.44); PCO_2 (35–45 mmHg); PaO_2 (75–100 mmHg); PAO_2 (alveolar partial pressure of oxygen); CO_2 concentration (TCO_2 24–28 mmHg); bicarbonate estimation (22–26 mmol/Liter); O_2 saturation (95%) and temperature. Normal capnograph shows initial steep upstroke (sudden increase in CO_2 in expired gas); slow raising plateau (suggests alveolar emptying); a rapid fall (during inspiration). 6th hourly ABG analysis is needed in critical patient.

Core Temperature Assessment

Core temperature is measured by placing thermometer in oesophagus or rectum or at tympanic membrane. Rectal temperature is 0.5°C more than oesophageal temperature. Temperature below 35°C cannot be measured with standard thermometers but needs low reading thermometers.

Urine Output Measurement

Hourly urine output should be measured. It should be more than 1.0 ml/kg/hour which indicates good cardiac output. Urine output less than 0.5 ml/kg/hour indicates poor cardiac output.

Cardiac Monitoring

Continuous cardiac monitoring is essential. It indicates rhythm changes, rate, wave forms, etc.

Other Assessments

Assessment of blood urea, serum creatinine, serum electrolytes, urinary electrolytes, urinary urea and creatinine. In *prerenal failure* urinary sodium is less than 10 mmol/Liter. Urinary urea and serum urea ratio is 10:1. It is more than this when there is inability to concentrate urine. Assessment of liver function, *coagulation profiles* (bleeding time—BT, clotting time—CT, prothrombin time—PT, activated partial thromboplastin time—APTT, thrombin time—TT, fibrin degradation products—FDP, D dimer assay, platelet count) are also important. Total count may be increased in sepsis but it is a poor indicator as it may not be raised in cold septic shock. Neutrophil count is more reliable. Intracranial pressure monitoring (ICP) is ideal in patient with head injury, with encephalopathy using invasive ICP bolts. Acidosis/alkalosis should be assessed.

Scoring of Illness

Therapeutic intervention scoring system *(TISS)* is used. Scoring is between 1-4. More the score means more intervention is needed and worse outcome. *APACHE* (Acute Physiology Assessment and Chronic Health Evaluation) is another scoring system used in places. APACHE 3 is the present version used. *APS* (Acute Physiology Score) is also used with 34 parameters and each having 0-4 grading.

ICU Management

Fluid Management

Initially it is with crystalloids like normal saline or ringer lactate; later by colloids, blood. It is decided at regular intervals in individual patients in individual diseases.

Inotropic Agents

Inotropic agents like dopamine, dobutamine, adrenaline, noradrenaline or isoprenaline are used in hypotension and altered cardiac status. *Dopamine* is given as 2 to 5 μg/kg/minute (low dose) in oliguria to improve urine output as it causes renal and splanchnic *vasodilatation*. Moderate dose of 5 to 10 μg/kg/minute is *inotropic* through β1 receptors of the heart. High dose of more than 10 μg/kg/minute causes peripheral *vasoconstriction* through α1 receptors. Dopamine is mainly used in septic shock. *Dobutamine* has mainly inotropic effect on heart without vasodilatation or vasoconstriction effects. Dobutamine is mainly used in cardiogenic shock.

Management of Respiration

It is second most important in ICU. Respiration should be assessed for existing problems. Endotracheal intubation, tracheostomy, management of ARDS, placement of intercostals tube when needed, assessment of respiratory failure, antibiotic therapies are important. Laryngoscopes, endotracheal tubes, Magill's forceps, fiberoptic intubation set, CO_2 detector should be available in ICU. If initial oxygen therapy is not adequate, then artificial ventilation is started using endotracheal intubation. Tracheostomy *is ideal* if prolonged ventilation is needed (more than 7 days). Problems with these tubes are–infection, bleeding, blockage and causing crisis, disconnection, acute gastric dilatation.

Management of renal failure, hyperkalaemia, acidosis, electrolyte derangements as required. Often haemodialysis may be needed.

Nutritional Support

Polymeric diet (proteins, glucose, triglycerides) or elemental diet (free amino acids, glucose, fat soluble medium and long chain fatty acids) or disease specific diet are given. Patient on ventilator are given with low carbohydrates, proteins and high fat diet. Patient with hepatic

encephalopathy are given more branched chain amino acids with less aromatic amino acids. Enteral nutrition *is ideal* either orally or through nasogastric tube or through gastrostomy or jejunostomy. *Total parenteral nutrition (TPN)* is used *when needed*–poor GI absorption; acute pancreatitis; severely malnourished and catabolic patients; when oral food/enteral nutrition cannot be given for 10 days; GI fistulas. TPN is given through central vein like subclavian or internal jugular vein. ***Harris Benedict equation*** is used to calculate the required calorie [For men = 66 + (113.7 × weight in Kg) + (5 × height in cm)–(6.8 × age in years). For women = 655 + (9.6 × weight in Kg) + (1.8 × height in cm)–(4.7 × age in years)]. 60% of total calorie needed is provided from glucose and 40% of calorie is from fat. Protein is given to maintain the nitrogen to calorie ratio as 1:150. TPN fluids contain 20% dextrose, 20% fat in emulsion; 20% amino acids, electrolytes, vitamins, trace elements. *Complications of TPN* are–catheter displacement, sepsis, bleeding, pneumothorax, electrolyte imbalance, trace element deficiency (zinc, copper, chromium and selenium), essential fatty acid deficiency, biotin deficiency, hyperosmolarity, catheter block, cholestasis.

Other Supportive Methods

Often neuromuscular blocking agents may be required to paralyse the patient. Sedation is commonly used to reduce anxiety, reduce oxygen demand, to improve ventilation. Analgesics are often given to reduce pain. Antacids/H2 blockers/proton pump inhibitors/sucralfate are given orally or parenteral (H2 blockers and proton pump inhibitors) to keep gastric pH above 4.

Chapter

3

Basic Principles of Incision, Dissection, Suturing and Haemostasis

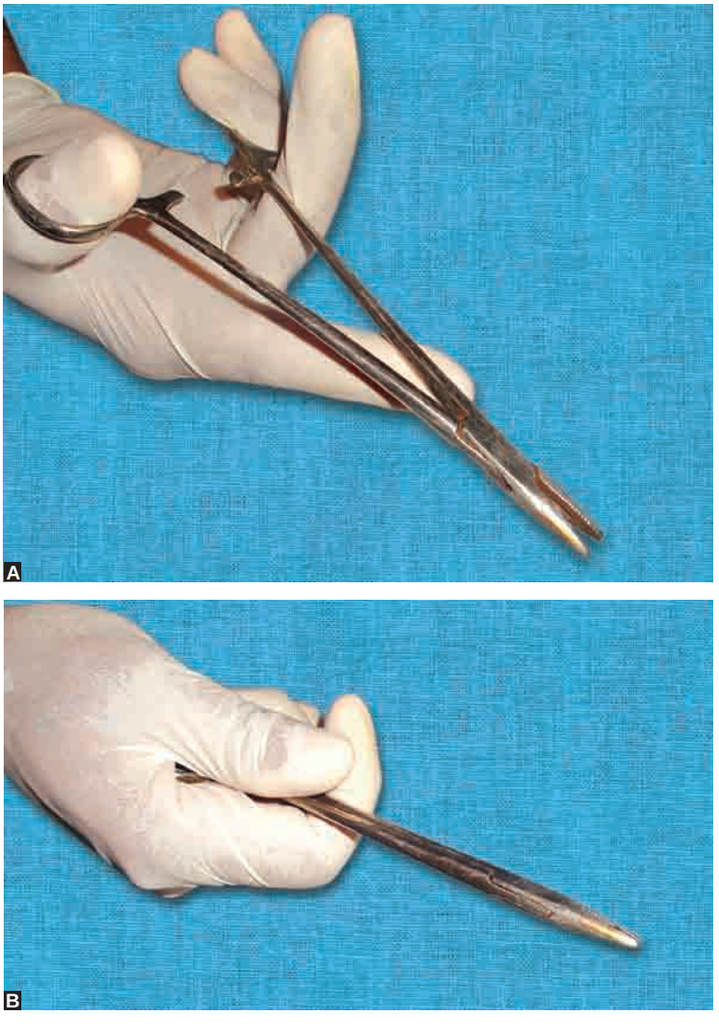
PRINCIPLES OF INCISION

Holding the Instruments

Surgical instruments are essential armamentarium for proper surgery. Instruments are held in two ways. *Better method* is by *finger tip pressure* wherein thumb and ring fingers are placed in finger bows of the instrument. Precise fine relaxed movements are essential for proper work up of the instruments. Bizarre hurried movements will not give precision. *Second method* of holding the instruments is tight *vise like grip* using fist of the hand. It gives a good grip but precision may not be adequate. Surgical trainee to begin with prefers this method as he will think that grip is essential part in holding the instrument. Even though this method may be useful in some situations, it is ideal to use the method of finger tip pressure and practice it for eventual smooth precise work **(Figs 3-1A and B)**. Middle finger of the surgeon is kept behind the handle and index finger is extended along the length of the handle. It is said that slow, definitive, precise and non-repetitive movements actually gives faster surgery than haphazard, frenzied, rapid movements. (Please refer chapter 5–Instruments for details about each instruments).

Surgeon should be like *an artist* (creative/innovative worker) *not just an artisan* (skilled worker).

One should remember that surgeon *risks the lives* of others daily and so optimum *efficiency* is needed in him. Both sin of commission or sin of omission should be avoided as much as possible.

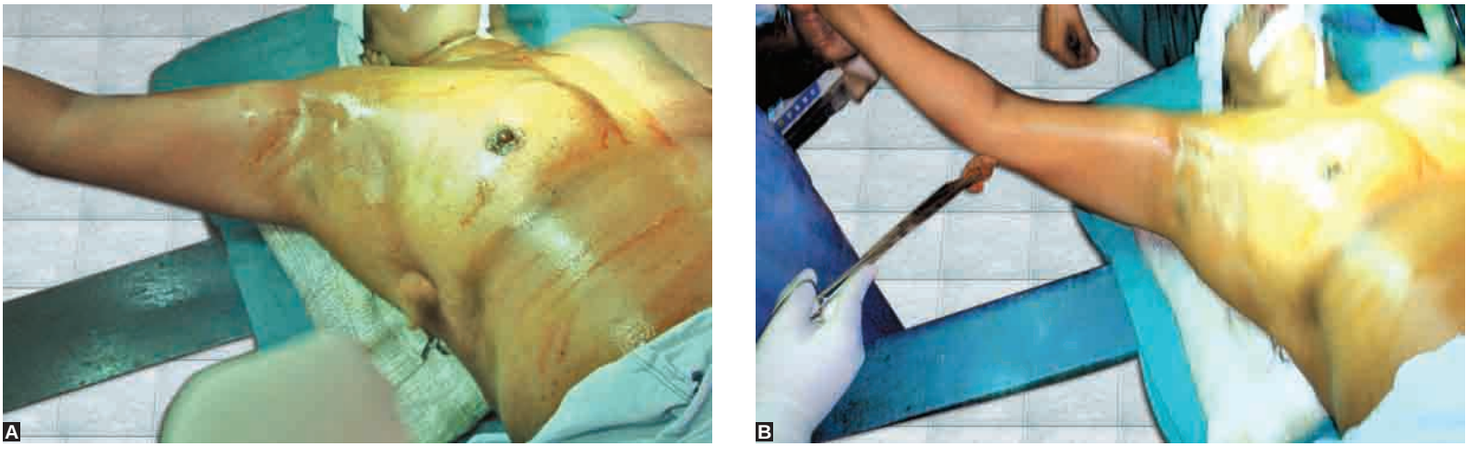


Figs 3-1A and B: Holding needle holder by fingertip pressure (ideal) and also by tight vise grip (acceptable method).

Anaesthesia and Positioning of the Patient

Surgeon or assistant should be present beside the patient while giving anaesthesia even though it is commonly not followed. Once anaesthesia is given, proper positioning of the patient depending on the surgery which he does should be done by surgeon itself. For example proper positioning for thyroidectomy, nephrectomy, sympathectomy, laparoscopic surgeries should be done and confirmed by the surgeon himself as it is important to have a proper position while operating **(Figs 3-2A to C)**. Surgeon should be physically and mentally comfortable while operating.

Figs 3-2A to C: During anaesthesia surgeon should be present beside the patient. After anaesthetist gives permission positioning of the patient done. Surgeon himself should do the positioning. He should be fully satisfied with the position of the patient. Proper positioning makes surgery easier.



Figs 3-3A and B: Cleaning the surgical field using povidone iodine. It is cleaned first at the site of incision; later outer area of the field. Three times cleaning should be done. Last one is used to clean mainly at the site of incision.

Cleaning and Draping the Surgical Field

Area of surgical incision should be cleaned with antiseptic solutions. Usually povidone iodine solution is used. Cleaning is started initially at the site of incision using antiseptic soaked gauze held in sponge holding forceps. Smooth soft straight strokes are used. Eventual cleaning is done on the places away from the line of incision on either side. Adequate wider area should be cleaned. Usually cleaning is done two times. Often two separate antiseptics are used each time like povidone iodine first and surgical spirit next **(Figs 3-3A and B)**. It is matter of surgeon's choice than any standard. Care should be taken while cleaning crevices like umbilicus or skin folds. After cleaning, draping is done using sterile surgical towels. Towels of different colours are used - green/blue/violet etc. Green is the commonly preferred colour. Sterile disposable plastic sticking sheets (*adhesive plastic drapes*) are also used in deeper part of the towel. Often incising area is covered with such sterile sticking plastic sheets and incision is made through this plastic **(Figs 3-4A to C)**. All these different methods are used to prevent sepsis. Towel clips are used in the corners to hold the drapes.

Making the Incision

Ideally incision should be marked using sterile marking ink. Its length, type, placing should be decided depending on the proposed surgical technique **(Fig. 3-5)**. Scalpel is used to make the incision. Depth control is better when belly of the scalpel is used.

Figs 3-4A to C: Draping is important to reduce infection. Adhesive plastic drapes are ideal. Incision is made through it. Photos show draping at abdomen, thorax, and back (spine).

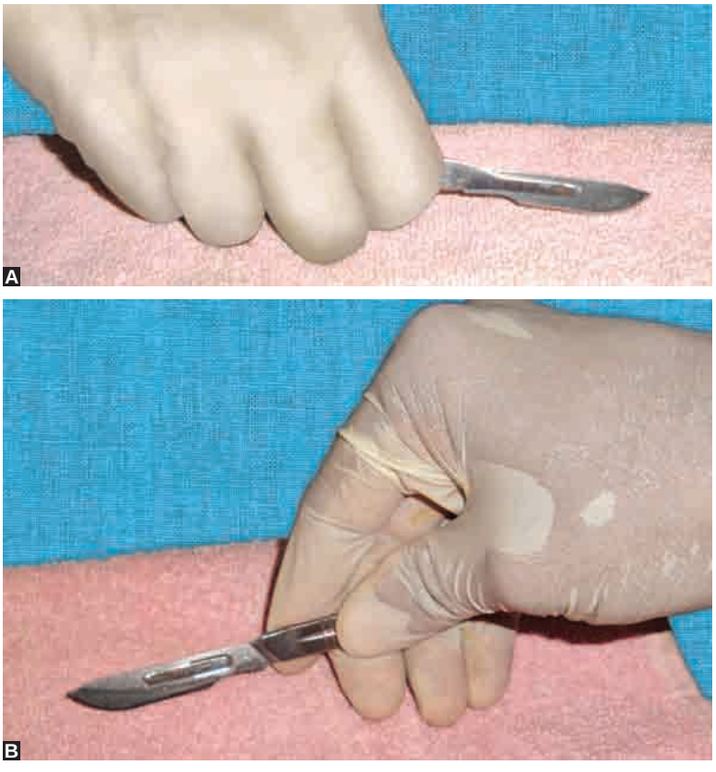
Fig. 3-5: Knife with blade should be given to the surgeon in a kidney tray. Same should be returned to scrub nurse. It should not be kept over the patient. It should be kept only in a kidney tray on a instrument trolley.

Fig. 3-7: Pen holding position.

Fig. 3-6: Dinner knife position.

- *Dinner knife position* is used while making lengthy incision. Sustained pressure by the index finger over the knife with depth control is the technique **(Fig. 3-6)**.
- *Pen holding/writing position* is used to make incision over the vessels/nerves/tumors. Skin flap or tissues without natural plane can be dissected using this method **(Fig. 3-7)**.
- *Fiddle bow position* is used to make incisions with less pressure on delicate tissues. It is with least pressure, fine dissection is done with firm grip **(Figs 3-8A and B)**.
- *Stab position of the knife* is used in draining an abscess or making an incision to pass drains. No 11 blade is usually used **(Fig. 3-9)**.
- *Grasping position* is used to make long sweeping cuts.

Incision should be in a single stroke cutting both skin and subcutaneous tissues. Repeated superficial flimsy strokes should be avoided. Once adequate incision is made small bleeders in the cut edges of the incision is cauterised using coagulation current. Many bleeding points stop spontaneously by pressure. Further incision is carried out with scalpel or cutting cautery. Cutting cautery transects the fat and tissues precisely but only partially haemostatic with least tissue trauma. Many surgeons prefer to use coagulation current to

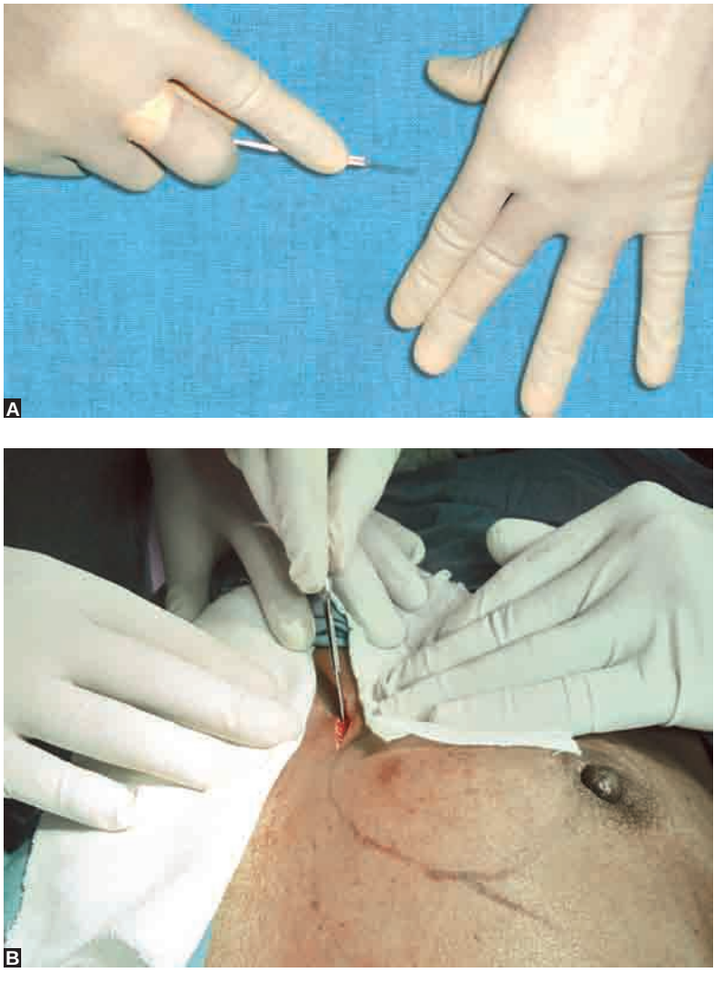


Figs 3-8A and B: Fiddle bow position.

Fig. 3-9: Stab position of knife for drainage of an abscess.

Principles in making incision (Figs 3.10A and B)

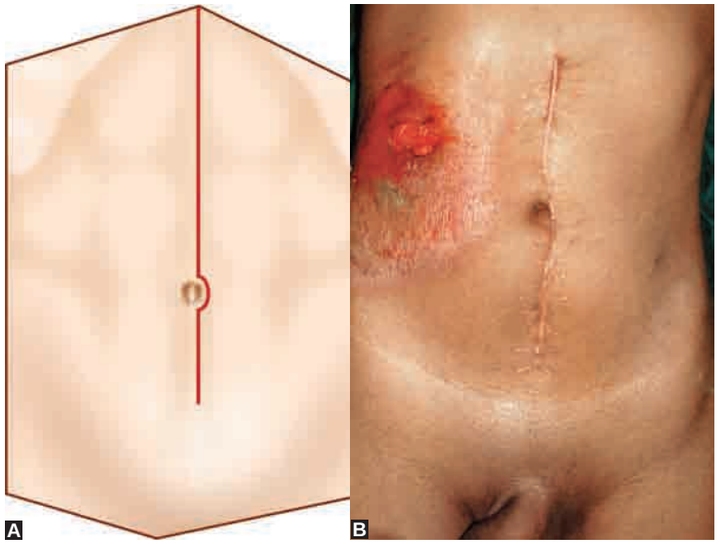
- Incision should be planned well prior to surgery for adequacy, for possible need for extension during course of the surgery, and indeed be cosmetically acceptable. Ideally incision site should be marked using sterile marker or methylene blue.
- Incision is done to access the deeper structure. It should be done parallel to crease lines. It should not cross across flexor aspects of the joints.
- It should be planned in such a way that scars are cosmetically accepted.
- Clean single stroke firm incision should be made with required depth. Repeated strokes and movements should be avoided. Blade should be at right angle to the surface.
- Knife should be perpendicular to skin to begin with blade pointing perpendicular to skin. But later blade should be parallel with curvature/belly of the blade on the site of the incision.
- While making lengthy incision like in abdomen, incision area should be stretched between thumb and index fingers of the other hand of surgeon.
- Another method is–using the fingers of left hand with the gauze, one lateral part of the marked incision line is held with traction; opposite side is similarly held by the assistant; deep stroke incision is placed using belly of the scalpel (22), cutting full thickness of skin and subcutaneous tissue, extending into the entire proposed length of the line of incision. It is commonly used in the abdomen.
- While making incisions care should be taken to avoid injuries to deeper structures like muscle/nerves/vessels/bowel.
- Patient should be symmetrically lying down on the operating table.
- In the abdomen with a previous laparotomy scar, present incision should be at a newer site. If skin is incised over the same scar, often excision of scar is needed. Dissection in the deeper plane and opening of the peritoneum should be started at fresh site so as to prevent injuries to deeper contents like bowel.
- Length of the incision should be adequate. There is no point in struggling in small holed blind surgeries.
- During surgery, if need arises, one should not hesitate to extend the incision.
- Use of diathermy in skin incision is controversial although cutting diathermy is used for this purpose. Thermal injury of the skin may result in poor scar.
- Incision should be parallel to natural lines/ Langer lines/hair lines/eyebrow.



Figs 3-10A and B: Methods of making incisions. Surgeon can stretch the skin between thumb and fingers with left hand and with the right hand incision is made. In second method, assistant holds the skin stretched by traction on each side by placing fingers of the hands over gauze and surgeon makes incision.

transect fat and fascial layers. It is good haemostatic but causes more tissue damage, oedema, infection. Blended cautery is ideal in such situation rather than coagulation cautery. Blended cautery cuts well with adequate haemostasis but with lesser tissue damage. Cautery is used for dissection in most places even in depth and all laparoscopic procedures. Good quality cautery, proper settings and earthing (in monopolar), precaution to avoid inadvertent injury of important adjacent structures are most important while using the cautery.

In the abdomen *upper midline incision* is commonly used extending below across *left of the umbilicus* **(Figs 3-11A and B)**. Linea alba is cut using scalpel or cutting cautery. Peritoneum is held between two artery forceps. It is felt with fingers to confirm that no abdominal contents are grasped. Peritoneum is cut using scalpel blade holding obliquely. Cut edges on either side are held using artery forceps. Long curved scissor (Metzenbaum) with closed blades is passed under the entire length of the incision to confirm that there no adhesions. Blades are opened and peritoneum is cut in the line of incision. Peritoneum is opened on left of the falciform ligament because this area is vascular. 5 mm wide of linea alba should be left attached to the umbilicus so that while closing proper bites are taken at this point to prevent incisional hernia at this site **(Figs 3-12A to C)**.



Figs 3-11A and B: Midline incision is universally used in the abdomen. Adequate incision is a must. Extension below is done from left of the umbilicus.

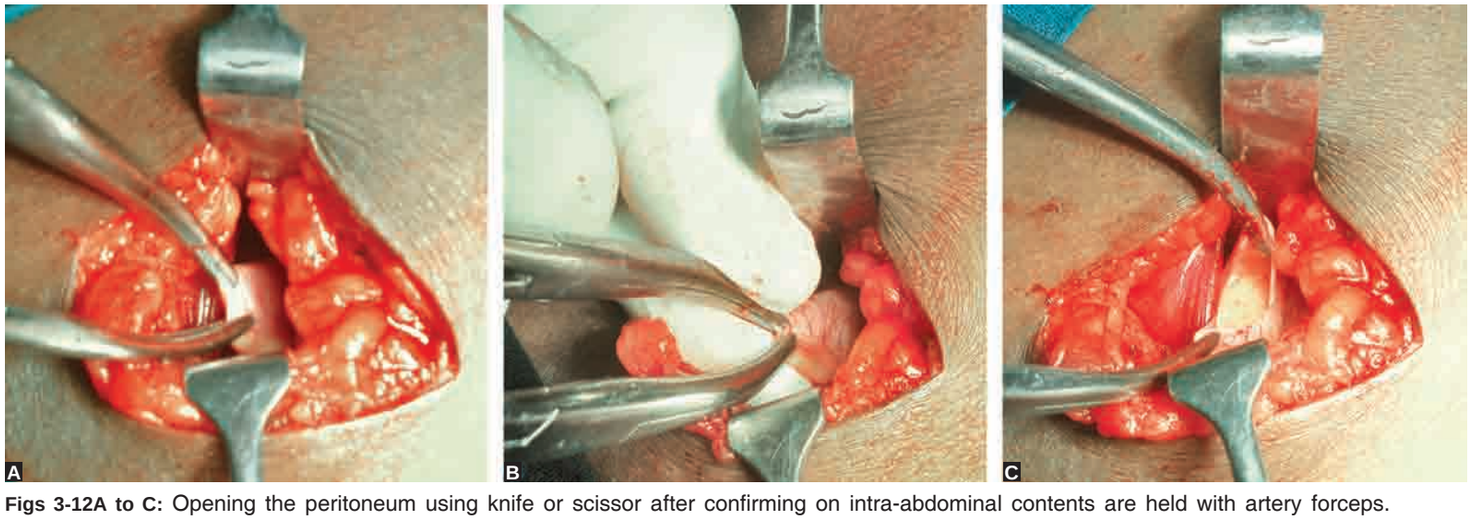
In the *lower midline incision,* lower part of the incision should be done carefully. Rectus sheath should be opened up to the pubis bone beyond the pyramidalis muscle. Preperitoneal fat is adherent to the peritoneum and urinary bladder in the lower most part. This part is vascular and thickened. This part of the peritoneum need not be incised as it will not improve the exposure further instead it will cause unnecessary troublesome bleeding.

Holding the Skin and Tissues

Skin is held using toothed dissecting forceps. *Fine Adson's toothed forceps* are available. Tough structures are also held using toothed forceps. Structures like subcutaneous tissue, fascia, bowel wall, vessel wall are held using non toothed forceps. Holding pressure and grip should be only optimum in such a way that after releasing it should not show the imprint of the forceps tip. Forceps is held over the serrations on the outer surface like as a pen holding fashion. It is the *fine grip* which holds the tissue rather than force. Haemostat (Artery forceps) is also used often to hold fascia, peritoneum, aponeurosis, etc. As much as possible tissues should be held using instruments to avoid unnecessary tissue trauma. But fingers must be used when you need '*tissue touch/tissue feel*', to confirm the surgical anatomy/to confirm the operability or extent of the pathology/to confirm the relation. *Finger dissection* is a well accepted surgical method but unnecessary usage should be avoided. Artery forceps should not be used to hold skin, bowel or delicate structures. Allis tissue forceps is used to hold skin flaps and tough structures. It is not used to hold bowel and delicate structures.

Retraction

Retraction of tissues in the depth is essential while doing surgery. Langenbeck retractor is used to retract skin and subcutaneous tissues. Different retractors are available to use in the deeper plane. Non-self retaining retractor (manual) when used needs the constant help of assistant. When self-retaining retractor is used, assistant's hands are free to help surgeon during surgery. Surgeon's both hands should be free to do the procedure. Often many general surgeons do surgery with one hand while retracting the tissues with other hand. This should be avoided as much as possible. But when traction to the tissue is needed then surgeon should hold or retract the tissues with traction to undertake further steps of the dissection **(Figs 3-13 and 3-14)**.



Figs 3-12A to C: Opening the peritoneum using knife or scissor after confirming on intra-abdominal contents are held with artery forceps.

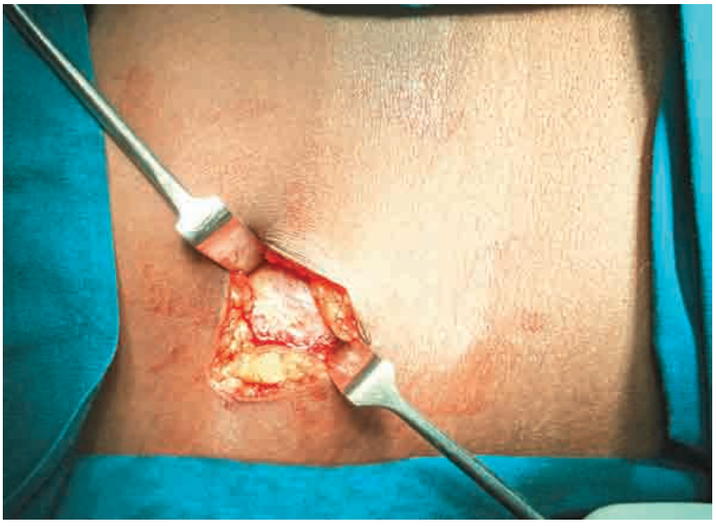


Fig. 3-13: After draping proper retraction is needed to continue with surgery. Assistant holds the retractors. Two hands of the surgeon should be free for dissection and proceeding with surgery.

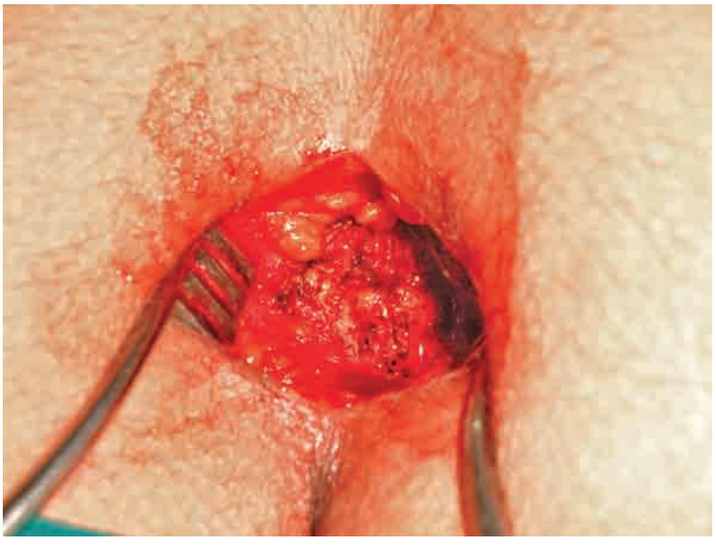


Fig. 3-14: Retraction of tissues is important using different retractors as needed.

Adequate incision of *sufficient length* and proper *stable exposure* are *the two basic essentials* of good surgical practice.

Exposure and Isolation of the Surgical Dissecting Area of Interest

Adequate exposure using proper incision, proper positioning, good retraction, by assistants, proper packing and keeping away other adjacent organs/tissues/structures. For example in open method of cholecystectomy with Kocher's subcostal incision, mops are placed medially over the stomach and below over the colon and above the liver to expose the field adequately.

DISSECTION

Dissection means identifying and separating the anatomical planes. Delineating right plane in right way is a real surgical craft. It comes by constant repetitive work, dedication and thinking. A beginner becomes master only once he masters this basic asset of surgical handicraft. Dissection should be least traumatic and with least blood loss.

Different methods available are–

Finger dissection: Left index finger is used for finger dissection. Gentle smooth finger strokes or sweeps are good way of dissection especially in the abdomen during Kocherisation, gastrectomy, adhesion removal, vagotomy, hiatus hernia surgery, pelvic surgery. However when there are adhesions blind finger dissections close to the vessels and forcible finger dissections are to be avoided **(Fig. 3-15A)**.

Scalpel dissection: It is ideal one to create a plane which is not natural. Scalpel is held in 45° angle to the line of incision. It is used to raise skin flaps in mastectomy, thyroidectomy. It is useful in dissecting dense scar tissue, tough structures. Scalpel is also used (no 15) in cutting the bowel during resection **(Figs 3-15B and C)**.

Peanut dissection (Kutner): It is very popular method of dissection in many place like dissection of Calot's triangle in cholecystectomy, urinary bladder dissection, to dissect the planes in pedicles during thyroidectomy, to skeletonise the lymphatics, to dissect the loose areolar tissue to achieve proper plane **(Figs 3-16A and B)**. It is small 1.5 cm wet gauze held firmly in a long artery forceps.

Large folded wet gauze (10 × 10 cm) in a sponge holding forceps is also used for dissection to push avascular loose areolar tissue while separating urinary bladder from uterine cervix; to elevate the peritoneum during lumbar sympathectomy, to separate stomach from pancreas posteriorly **(Fig. 3.17)**.

Scissor dissection: Closed blades of scissor is commonly used to dissect the tissues which also give proprioception feel of the tissues. Dense tissues are dissected and cut with scissors. Gentle precise controlled movements are necessary. It achieves a clean sharp dissection **(Figs 3-18A to D)**.

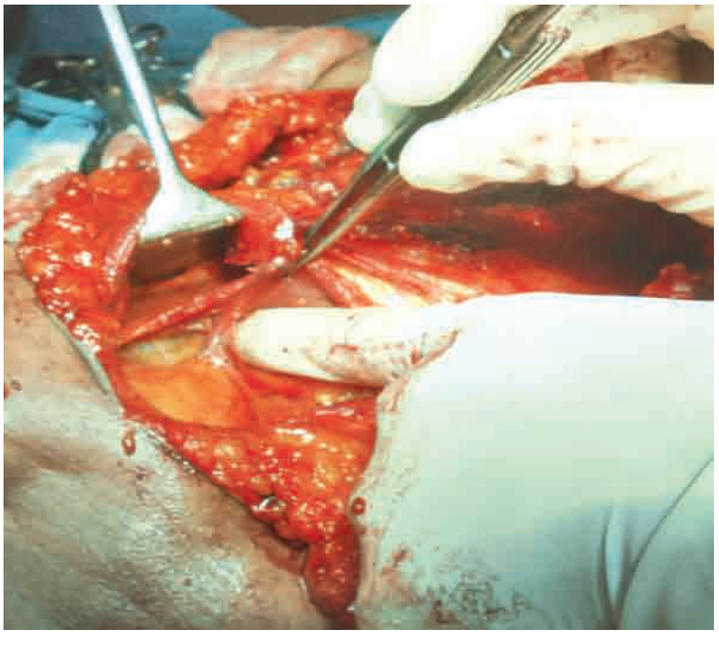
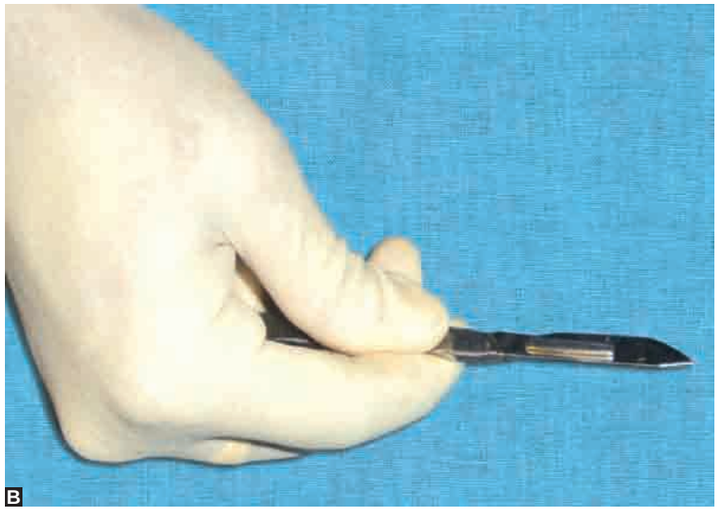
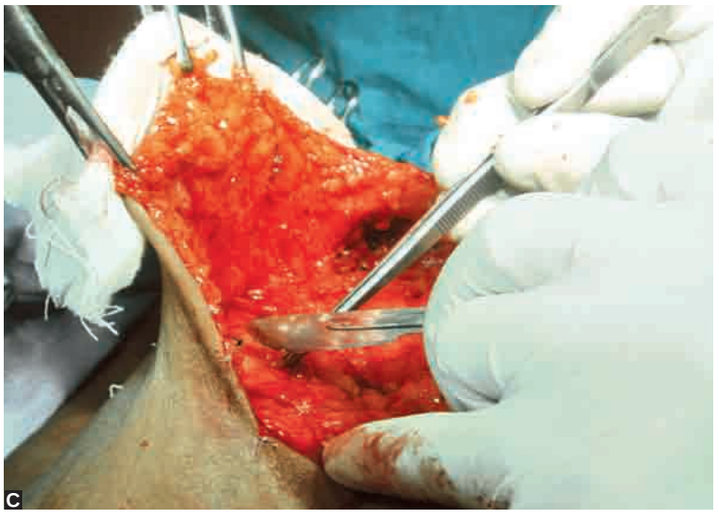
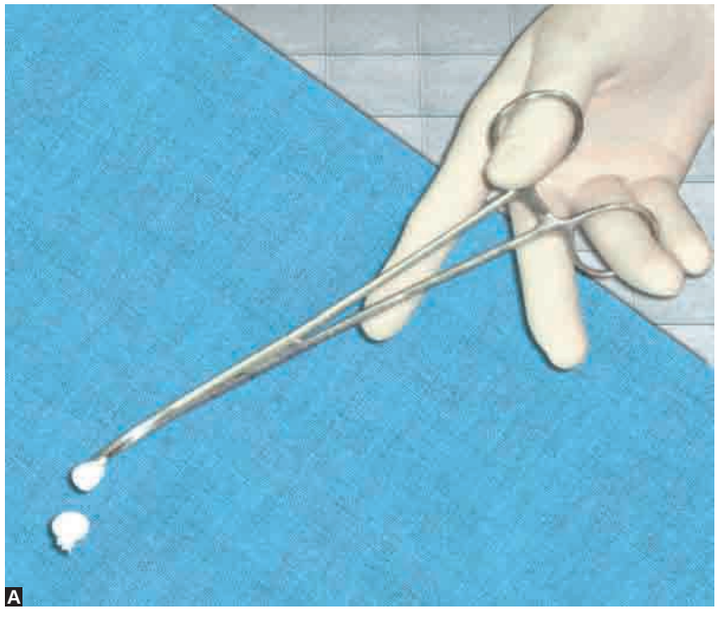


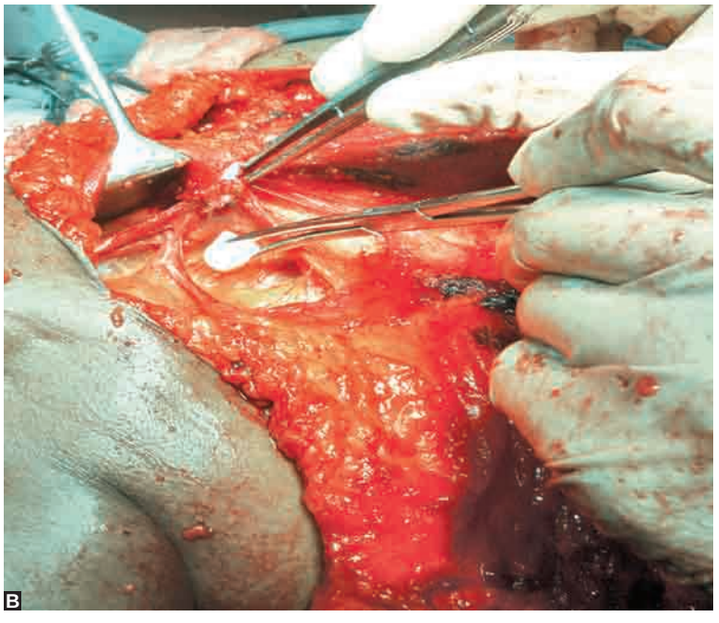
Fig. 3-15A: Finger dissection is one of the methods of dissection. It gives anatomical feel (tissue feel); depth can be assessed; extent of the pathology can be assessed; blunt dissection can be carried out. It should be gentle, careful dissection. Rough usage of finger should be avoided as it may injure adjacent tissues often causing unpleasant bleeding.





Figs 3-15B and C: Scalpel dissection is used commonly when there is no natural plane.





Figs 3-16A and B: Peanut dissection is commonly used to dissect loose areolar tissue.

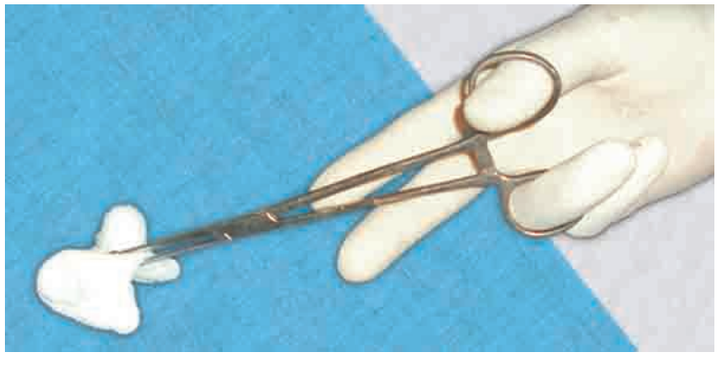
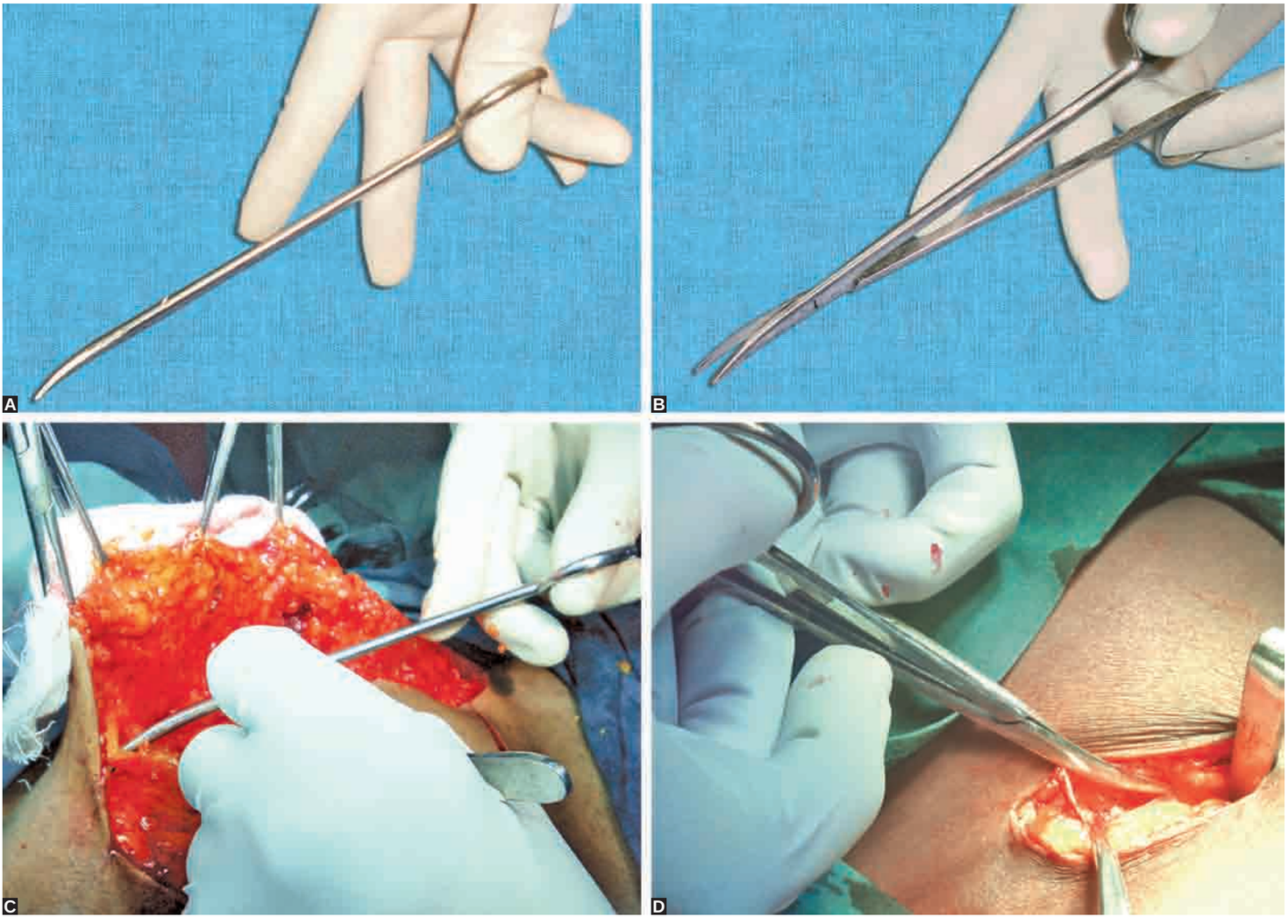


Fig. 3-17: Gauze dissection is used along loose areolar tissues; to separate urinary bladder from uterine cervix during hysterectomy, etc. It is used with gentle sweep movements over the tissues.

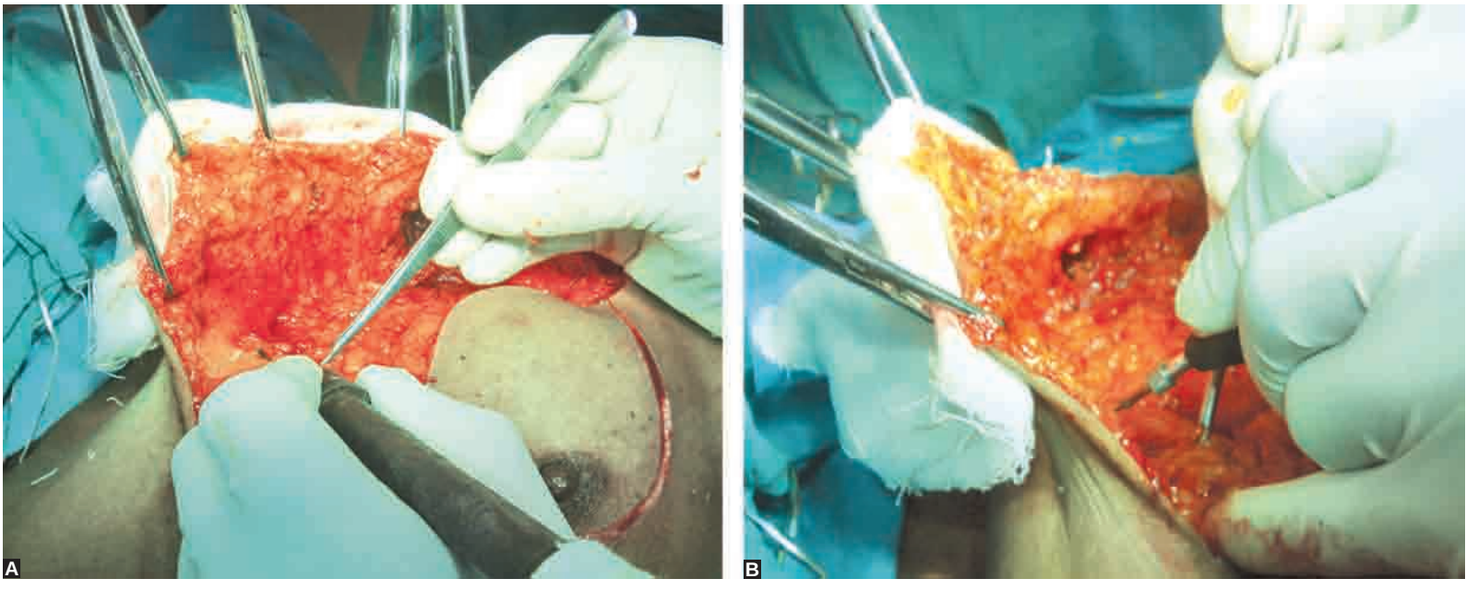
Cautery dissection: It is presently commonly used method of dissection. Cutting cautery is used for dissection. Coagulation is used in between as and when needed to control bleeding. It is not advisable to use coagulation current for dissection as it causes too much charring and tissue destruction. So infection and flap necrosis will be higher. Many surgeons are habituated to use coagulation current for dissection as it is easier and bloodless **(Figs 3-19A and B)**.

Note

Proper anaesthesia; good exposure; adequate retraction; meticulous dissection; patience; decision making skill on the operation table; skilled assistant; taking help of another surgeon without any ego–are the need for *successful surgery* and to become *successful surgeon*. ***'SEE AND CUT and CUT AND SEE'***



Figs 3-18A to D: Various methods of holding and using scissor during dissection. Scissor dissection is one of the good controlled methods of dissection.



Figs 3-19A and B: Cutting cautery is used for dissection. Coagulation current may cause charring. Coagulation is used to control bleeding. Cautery dissection here used to raise skin flaps in mastectomy.

SUTURING TECHNIQUE

Suturing is an art. It is technique of approximating tissues or ligating the vessels using specifically designed materials. Catgut and silk are good old suture materials (1887). Silk is non-absorbable and catgut is absorbable. Polypropylene, polyglactic, polydioxasone sutures (PDS) are newer sutures.

It is essential to avoid damage to suture strand when handling. One should touch strands only with gloved hand or closed blunt instrument. One should not crush or crimp sutures with instruments except when grasping the suture during instrument tie. Suture material should not be held using needle holder or artery forceps except during knotting **(Figs 3-20 to 3-23)**.

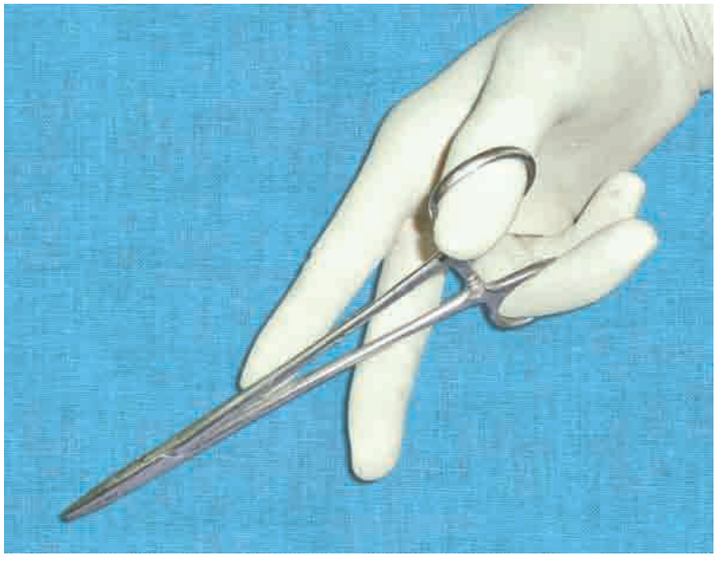


Fig. 3-20: Holding the needle holder properly and knowing its movement in rotational axis is important for proper suturing and knotting. It is the precise gentle rotation which is essential; not pushing flimsy movement.

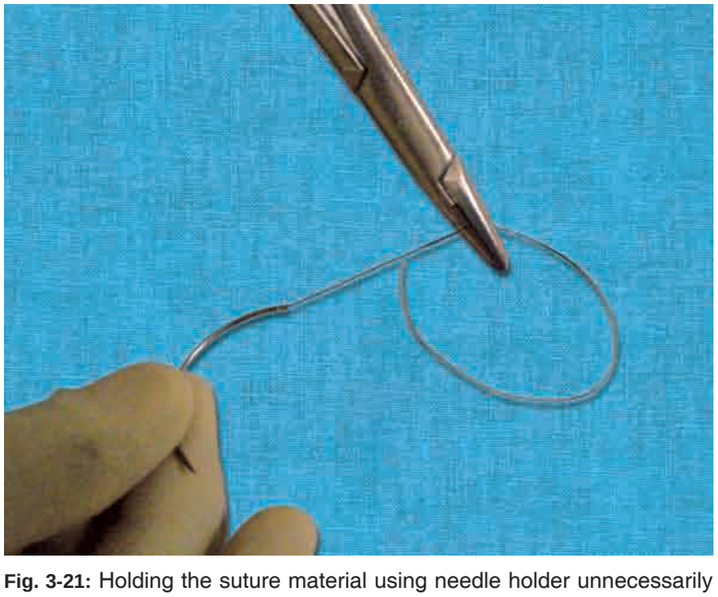


Fig. 3-21: Holding the suture material using needle holder unnecessarily should be avoided.

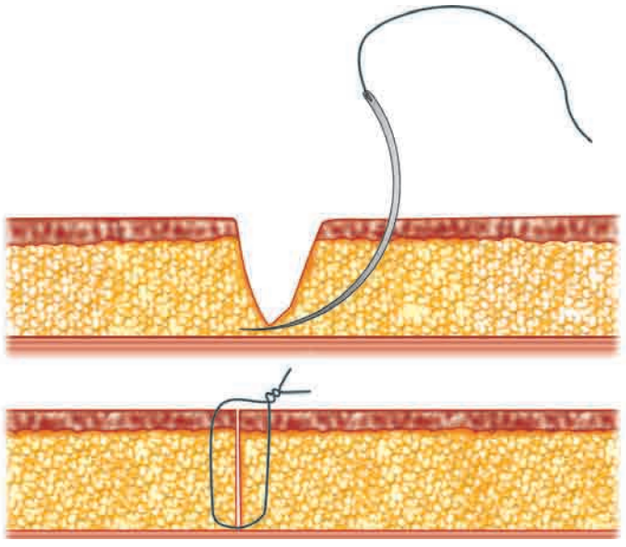


Fig. 3-22: While suturing needle bite should be taken correctly with adequate depth. Deeper part should be wider to have proper apposition.

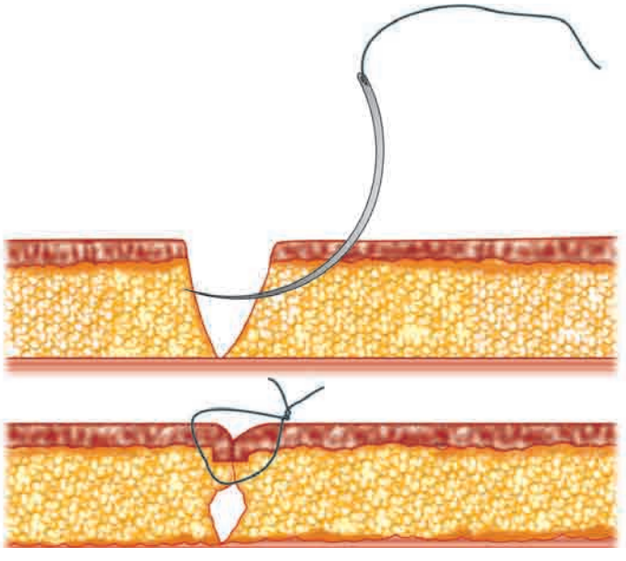
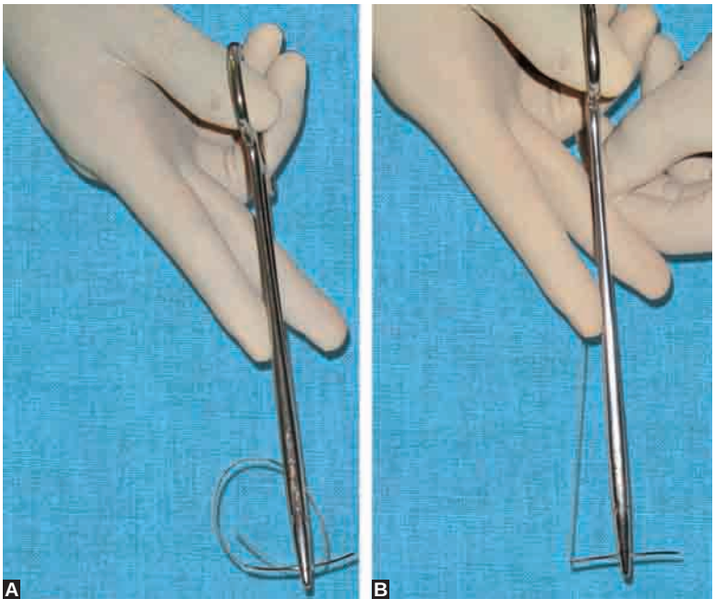


Fig. 3-23: Taking wrong bite of needle with inadequate depth, width and inequality will cause poor apposition and alignment and also creating dead space in the deeper plane causing seroma formation or poor scar later.

Proper selection of the needle holder, type of needles (size, curve, etc), and suture material is important. Needle is placed in the needle holder at the junction of *proximal 2/3rd to distal 1/3rd* of the needle holder to have optimum grip and precision. If held more proximal, then grip will be good but precision is inadequate. If needle is more distally placed, precision is good but with poor grip. Needle is held *half the distance from swaged end*. Grasping of the needle should be neither too tight nor too loose. Optimum *grasp* should be there. Alignment of needle holder jaw should be proper. Needle should not rotate during grasping. Needle and needle holder should function as a *single unit* **(Figs 3-24A and B)**.

Needle is passed through smaller thickness of the tissue. Excess tissue bite should be avoided. It is the smooth, rotation movement than the movement with force which is important. Proper sized needle



Figs 3-24A and B: Holding the needle with a needle holder.

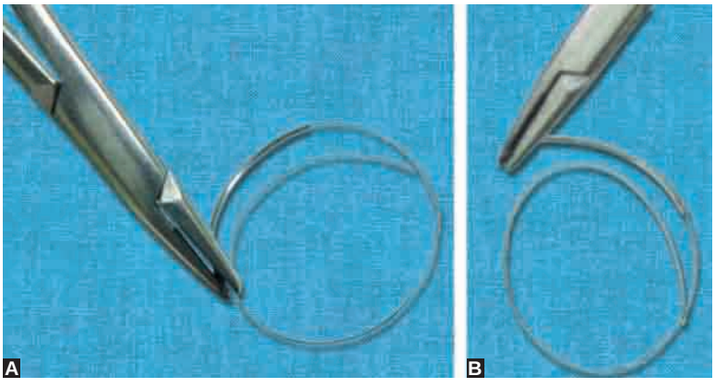


Fig. 3-25: Holding the needle tip with needle holder should be avoided. It is held only during knotting process.

should be taken depending on the thickness and texture of tissue/tissue resistance which is to be apposed. *Rotation force* should be in the direction of the curvature of needle. Twisting or bending needle tip should be avoided. Holding the needle tip with instrument will cause blunting or breaking of the tip and if such broken tip is entangled in the tissue it is very difficult to identify it **(Fig. 3-25)**.

Cutting needles are used for skin, tough structures, mucoperiosteum. *Round bodied needles* are used for smooth tissues like fat, peritoneum, muscle, bowel, vessel anastomosis, etc. Usual *width of the tissue* taken is 5 mm. But finally it depends on the thickness, tissue strength and condition to which patient is getting operated upon. In retention sutures of abdomen or Smead - Jones closure width taken is 3 cm. Distance between each bite is important. It should not be too closer or too far. In the skin 1 cm gap sutures are sufficient. In the bowel 5 mm gap sutures are needed to have complete sealing of the bowel edge and also haemostasis. Tissue should be handled carefully. Only required tissue should be grasped. Bulk grasping should be avoided. Smaller sized suture is better **(Figs 3-26 and 3-27)**.

Size of the suture material is decided in relation to the strength of the tissues. Usually 3 zero is used. Thicker tissues may need 2 zero sutures. Abdominal wall closure needs 1 or zero or 1 zero suture material.

Ideally interrupted sutures are better. It holds and apposes well. It maintains the blood supply of the tissue edge. But in many places like gastrojejunostomy continuous sutures can be used.

It is better to take bite from each edge of the tissue *separately* even though it looks more time consuming. When both edges are held together and needle is forced through them, there are chances of having lateral movements which can cause tear at the first point of entry of the needle resulting in poor apposition of the tissue. It can be used safely if the edges are close enough without tension and if one can avoid lateral movements while taking bite of second edge **(Fig. 3-28)**.

Learner *should practice* holding the tissues with instruments than hand. It is common that beginner prefers to use hands than instruments as it is easier, but holding tissues with instruments is better. In certain occasions hand is used to hold the tissues; otherwise by enlarge instruments are used.

Type of suture material used depends on the tissue and condition for which suturing is done. Once wound attains maximum strength sutures are no longer required. Slow healing wounds need non-absorbable sutures. Rapidly healing wound need absorbable sutures. Rapid healing, least irritation is achieved by smaller sized, monofilament, inert suture material. In bowel absorbable suture material used–3 zero is ideal; often 2 zero is also used. Silk is also used in many centers. Interrupted sutures are better especially in oesophagus, colorectum, and contaminated field. Continuous sutures are used in stomach and jejunum. Single layer is well accepted; it gives wider lumen; maintains blood supply. Double layer using silk/linen for outer seromuscular; full thickness Connell/Gambee sutures for inner layer using absorbable sutures like 3 zero vicryl is also equally good. It is time consuming, may lessen the luminal diameter. But it is more secure. In biliary tree and urinary system rapidly absorbing sutures like 3 zero vicryl are used. Patient age, nutrition, immunosuppression, malignancy, sepsis, acute nature–are other factors which decide the type of suture material used **(Fig. 3-29)**.

Note: After suturing needle should be returned to scrub nurse with needle holder.

Different Types of Suturing

Simple everting suture: It is used in skin. Bites at deeper plane should be wider than superficial plane. Edges should be everted once this stitch is placed **(Fig. 3-30)**.

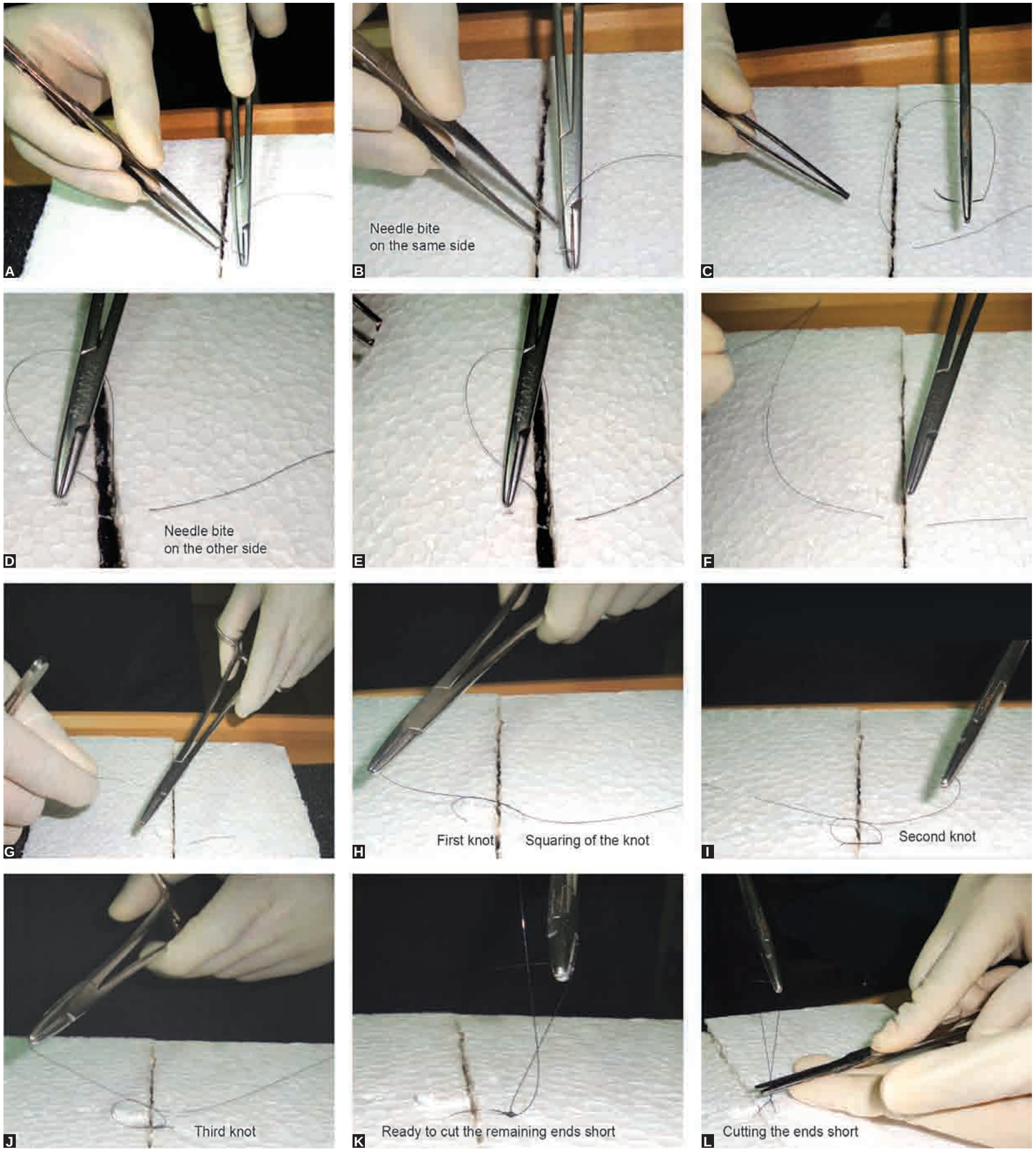
Simple interrupted fascial suture: It is used in abdominal wall like in closure of *Mc'Burney* incision by taking about 5-8 mm of tissue bite **(Figs 3.31A and B)**.

Vertical mattress suture (Stewart): Deep bite is taken from one edge; passed through deeper part of opposite edge and brought out on the opposite edge surface; again close to the superficial margin of opposite side bite is taken and is passed through similar edge of same side to bring out as mattress suture **(Figs 3-32 to 3-34)**.

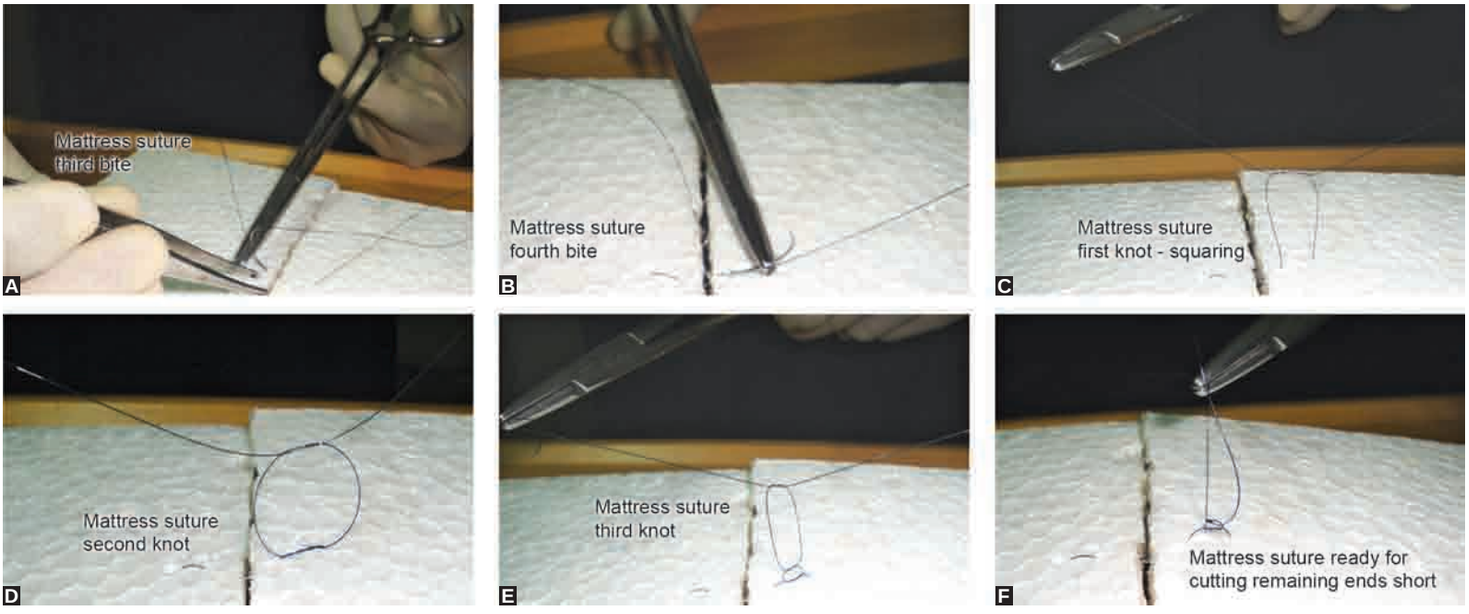
Horizontal mattress suture: It is not commonly used in skin. It is often used in retention sutures (tension sutures), fascial closure, and ventral hernia repair, to achieve haemostasis. Here bite is taken like a square with two time bites on each side one below the other **(Fig. 3-35)**.

Haemostatic figure of eight suture: It is basically used for haemostasis. It is used in circumcision to ligate frenular artery, bleeders withdrawn into the soft tissues. Vicryl or polypropylene (2 zero/3 zero) is used.

Continuous over and over simple suture: It is continuous suture used in peritoneum, fascia, aponeurosis. Vicryl is used usually.



Figs 3-26A to L: Instrument suturing and knotting—simple suture.



Figs 3-27A to F: Method of placing mattress sutures and knotting with squaring.

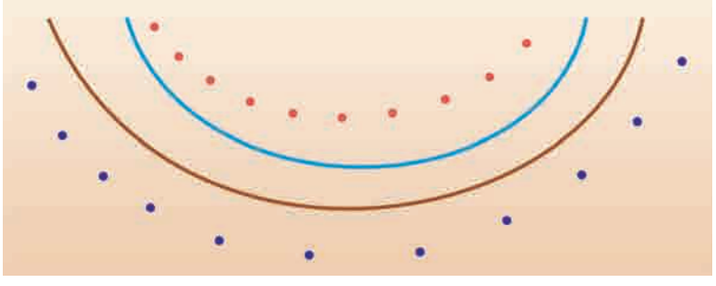


Fig. 3-28: By marking the corresponding points of each edge of the wound before suturing, makes it easier to take bites at proper anatomical level to achieve good wound alignment and apposition without causing disparity.

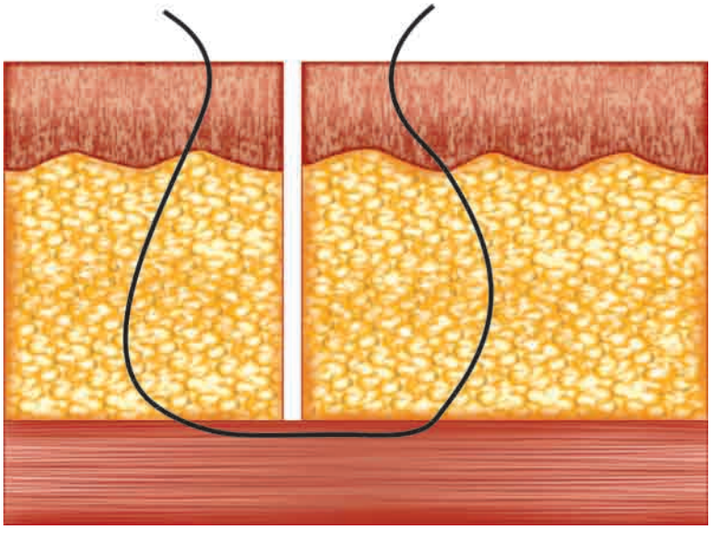


Fig. 3-30: Bite should be equidistant on both edges of the wound to achieve eversion of the wound edges. Inversion of the edge should be avoided.

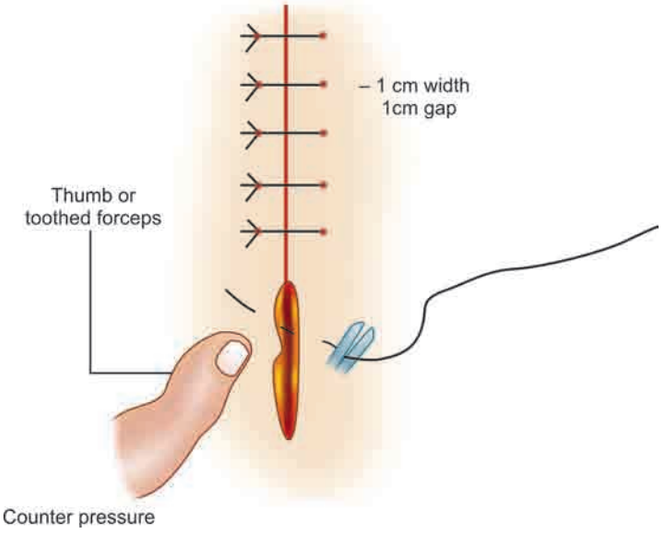
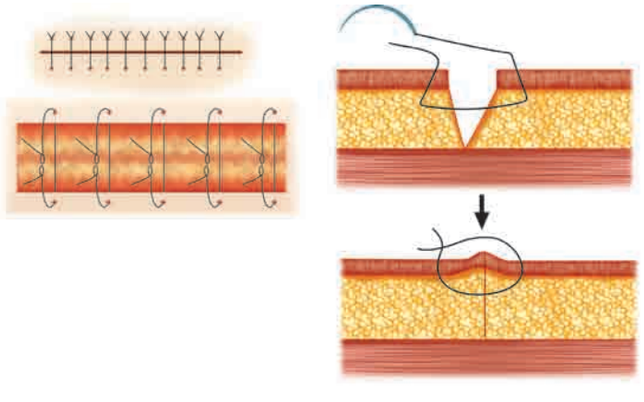


Fig. 3-29: Equidistant, proper correct bite, counter pressure using thumb or toothed forceps on the opposite edge, rotation precise gentle movements are the basic principles of suturing.



A B

Figs 3-31A and B: Simple interrupted suture.

Fig. 3-32: Vertical mattress sutures.

Fig. 3-33: Scar of interrupted sutures–vertical mattress sutures.

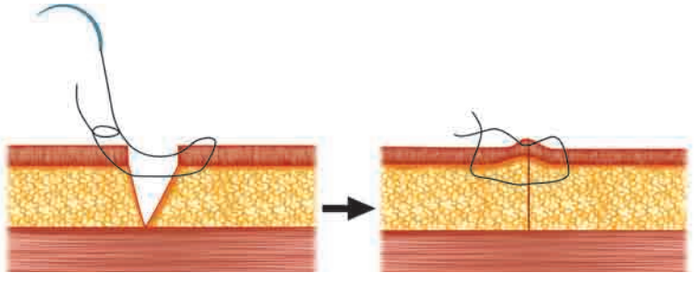


Fig. 3-34: Vertical mattress suture (Stewart).

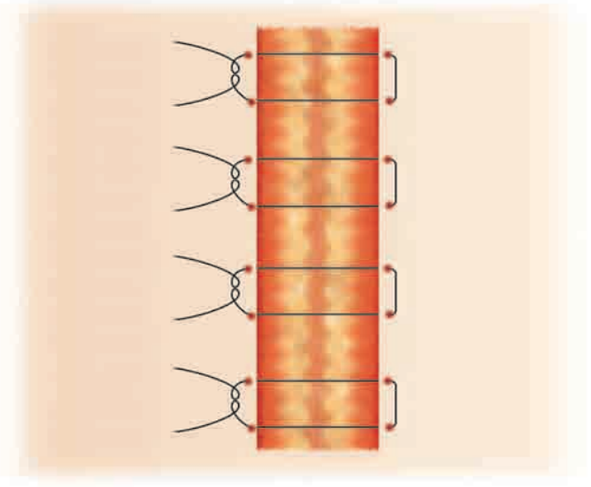


Fig. 3-35: Horizontal mattress sutures.

Subcuticular suture: It is used in skin closure. Needle bite is taken initially at one corner; it is continued by taking bites at the white dermis each side alternatively to reach the other end of the wound; which is then brought out through the corner of the wound. Usually absorbable polyglycolic acid is used (3 zero) using curved cutting needle **(Figs 3-36A to D)**. It is difficult to place subcuticular sutures using round body needle. Absorbable suture is not removed. Nonabsorbable monofilament suture can also be used. Its ends are left long or tied loosely over gauze. It is removed in 10 days. Often there may be difficulty in pulling out the sutures. Subcuticular suture gives cosmetically better scar. But if sutures thicker than 3 zero is used it will cause inflammatory reaction in the apposed wound causing no cosmetic benefit. Subcuticular sutures should not be used in trauma, infective areas, and emergency surgeries. There is controversy whether it has got advantage over interrupted sutures using fine material except in avoiding (in absorbable subcuticular)/easier (non-absorbable subcuticular) suture removal.

Skin staplers: It is stainless steel staplers applied using specialized disposable devices to the skin. It is quicker and apposes well. It is used in major surgeries. It saves time compared to suture closure of the skin. Two wound edges should be held in proper alignment before applying skin staplers. Removal needs special instrument. It gives good cosmetic result **(Figs 3-37A to D)**.

Continuous locking sutures (Continuous blanket sutures): It is not commonly used in skin. It is used in closure of fascial layer. It holds well and is haemostatic. It is commonly used in closure of rectus sheath. Nonabsorbable suture material is usually used. It does not cause bunching of the wound **(Fig. 3-38)**.

Continuous over and over suture: It is continuous sutures taken at equidistant. It should not be very tight as more tightening may cause strangulation of the wound edge; it may cause bunching of the wound; but it saves time **(Fig. 3-39)**.

Continuous 'mass closure' using one or zero monofilament nonabsorbable suture material commonly used in closure of abdominal incisions especially midline. Bites are taken at 1 cm width from wound edge; with each bite at 1 cm interval. Single strand or loop suture material can be used for this. This method is commonly used **(Fig. 3-40)**.

Note: *Jenkin's rule*–Length of the suture material used is 4 times the length of the wound.

The three point suture: It is used in suturing triangular flap/flaps to have correct apposition. Dermal bites should be at the same levels on both edges **(Fig. 3-41)**.

Retention sutures (Tension sutures): It is even though practiced in many centers, ideally it should be avoided. It is used during closure of laparotomies done for acute conditions like peritonitis, obstruction wherein patient's general condition is not good; layer by layer closure may cause acute wound failure with burst abdomen; when quick closure is a need of the day. Its use is getting replaced by *Smead-Jones*

Figs 3-36A to D: Technique of subcuticular suture placing.

Figs 3-37A to D: Skin stapler is used to close large surgical skin incision. It is faster and cosmetically accepted.

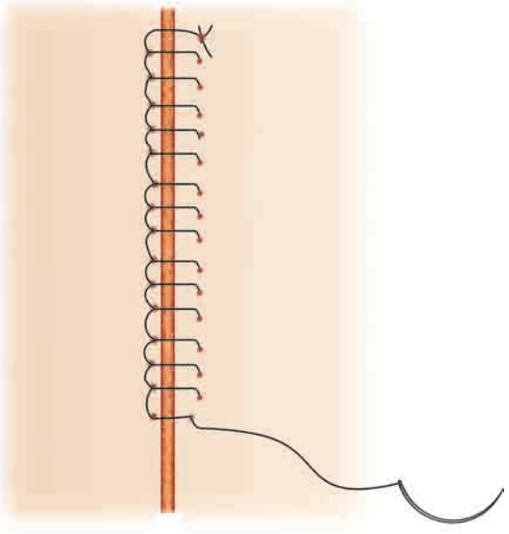


Fig. 3-38: Continuous locking suture.

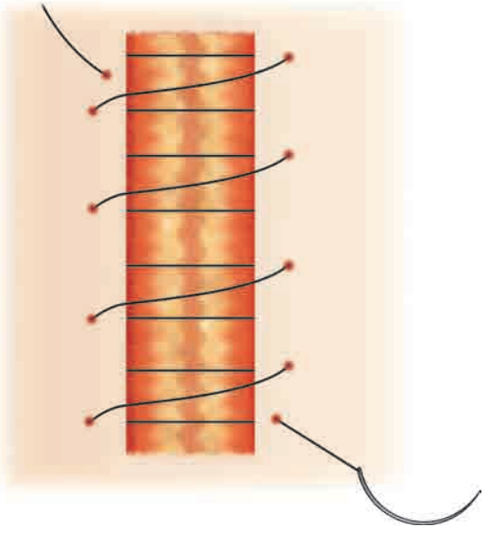


Fig. 3-39: Continuous over and over suture.

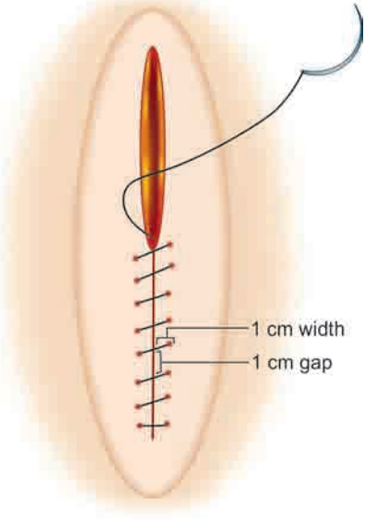


Fig. 3-40: Continuous mass closure of the abdomen.

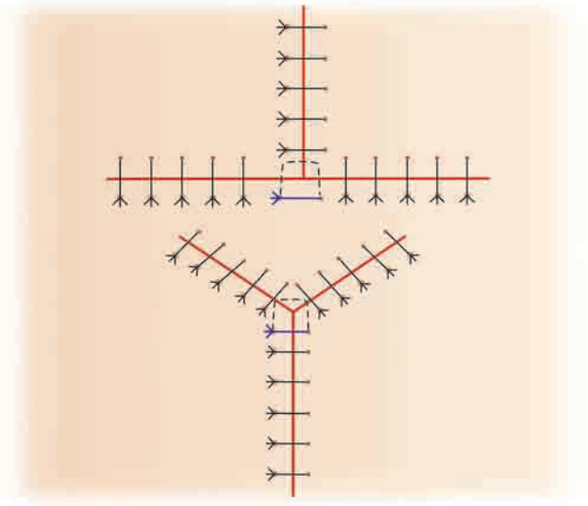


Fig. 3-41: Three point suturing is used in apposing junction of the triangular flaps.

sutures or interrupted single layer deeper sutures. Retention sutures are taken as full thickness sutures placed 3-5 cm away from the wound. Large curved cutting needle is used. Number zero or one monofilament suture material like polyethylene is used. First bite is taken away from the wound from skin to peritoneum into the peritoneal cavity; needle is then brought back 3-5 cm away from the opposite edge of the wound; suture material is passed through a supportive sterile tube (cut drip set tube) of 2-3 cm length; near the edge of the skin of the existing side needle and suture material is passed; similar bite is taken on the same side of skin edge; suture is passed through one more sterile tube of 2-3 cm size and is kept ready for knotting after completion of placing all sutures. Each suture is placed with a gap of 1.5 to 2 cm. Knotting is started from one corner; but if closure is difficult then central knots is put first. While knotting in deeper plane, bowel and omentum should be guarded with finger or placing mop or using a special curved bow-like instrument (*Sergeant Instrument*) so as to prevent entangling or injuring these structures. Sutures are cut once all knots are tied on one side of the wound. Skin may be apposed using separate sutures **(Fig. 3-42)**.

Fig. 3-42: Sergeant retractor used during closure of the abdomen to prevent abdominal content coming out.

In *vertical mattress retention sutures,* tubes cross the wound. *In horizontal mattress retention sutures*, bites are taken like a square and sterile tubes are placed parallel to the wound (not crossing). In this type number of sutures needed is less than vertical type. Distinct advantages of horizontal mattress retention suture type are not clear but it is said that it is stronger than vertical mattress retention suture. But chances of bowel or omentum getting trapped are higher in this **(Figs 3-43 and 3-44)**.

Modified Smead-Jones closure: It is interrupted specialised suture used in the closure of abdomen as single layer excluding the skin. Linea alba is held with Allis' forceps. *Number one* polyethylene or PDS suture material is used. First bite on one side taken 3 cm away (width) from the margin from outside to inside; it is then passed through the corresponding opposite edge with 3 cm width from inside to outside; later again one small loop of 5 mm width from the edges of each side of the wound from first bite site to second bite site is taken; suture is knotted on the free edge of the first bite side. Full thickness bite holds the suture and maintains the tension in the wound. Smaller loop keeps the linea alba in apposed place. Large curved *Ferguson needle* is better to place these sutures. Each suture is placed at 2 cm interval. This is the type of suturing used at present in acute abdominal conditions instead of the retention sutures. Here also it is better to place all sutures under proper vision and knotting is done at the end **(Fig. 3-45)**. At least four knots should be placed. Excessive tension should be avoided. In upper abdomen peritoneum need not be included in the bite; but in lower abdomen as linea alba is indistinct, peritoneum is included in this.

LE Hughes double near and far suture: It is similar with same indications as Smead-Jones, with double near and far sutures placed to have a strong loop with knot on one side **(Fig. 3-46A)**.

Single layer seromucosal suture of bowel: It is now well practiced method of suturing of the bowel. Interrupted seromucosal sutures using three zero/two zero vicryl or PDS takes up well. Nonabsorbable silk or linen also can be used. These nonabsorbable sutures are good old suture materials which are even now well accepted. Only drawback presumed is formation of suture granuloma at the anastomotic site **(Fig. 3-46B)**.

Gambee single layer full thickness (all layers) sutures using vicryl are also used in bowel anastomosis. It can also be used as continuous sutures especially during gastrojejunostomy. *Continuous suturing* is quicker; alternate bites should be locked to prevent purse string effect; anterior layer is closed with inverting sutures. *Interrupted suture* is more stable and stronger with less chances of anastomotic disruption. It also maintains the blood supply better than continuous sutures. Width of suture bite taken should be less over mucosal part than seromuscular part. Bites are taken 3 mm from the cut edge of the serosa; each bite is taken in a 5 mm gap **(Fig. 3-47)**.

Lembert suture: It is the commonly used seromuscular suture. Silk 3 zero or vicryl 3 zero is used. Deep seromuscular suture including submucosal layer is taken at a point 5 mm from the cut edge of the serosa; this bite emerges at same line closure at 2 mm from the cut edge of serosa; bite is taken on the opposite part of the bowel at 2 mm from the serosal cut edge as seromuscular which emerges at 5 mm point away in the same longitudinal line and knot is placed. It can be used as continuous suture also **(Fig. 3-48)**.

Cushing suture: It is similar to Lembert suture wherein seromuscular bites are taken parallel to the cut edge of the serosa (at 2 mm from the cut edge). Thickness of tissue taken is 5 mm. Both interrupted and continuous sutures can be taken **(Fig. 3-49)**.

Halsted suture: It is actually seromuscular horizontal mattress suture. Care must be taken to avoid excessive tension over the suture line as this may lead into ischaemia of the anastomotic site **(Fig. 3-50)**.

Fig. 3-43: Vertical mattress retention sutures. It is full thickness single layer suture.

Figs 3-44A and B: Horizontal mattress suture.

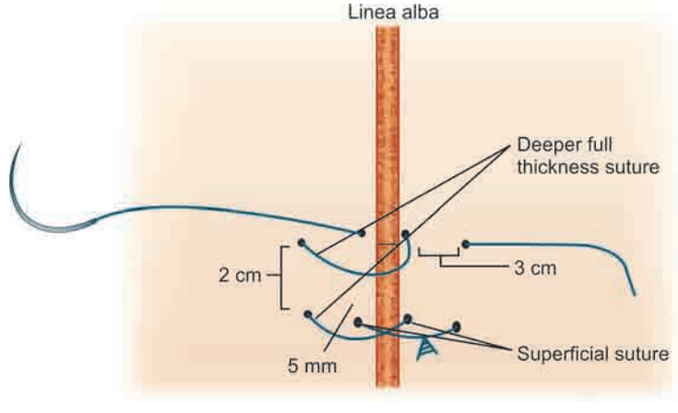


Fig. 3-45: Modified Smead Jones sutures. These sutures are better than placing retention sutures.

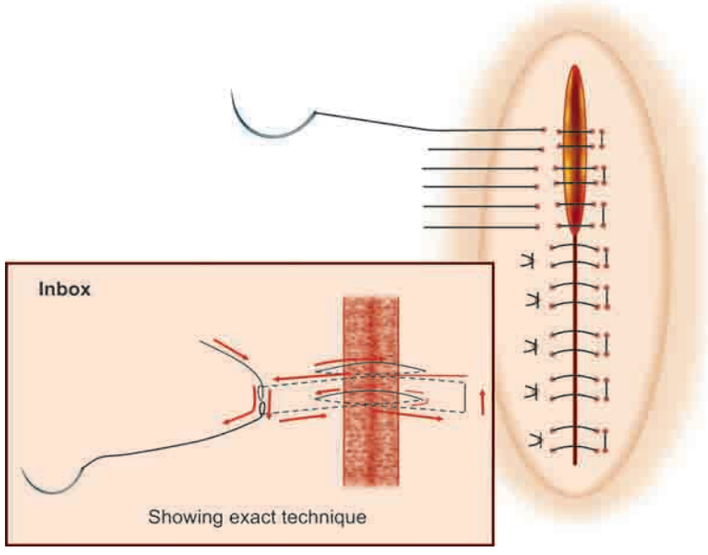


Fig. 3-46A: LE Hughes double near and far suture.

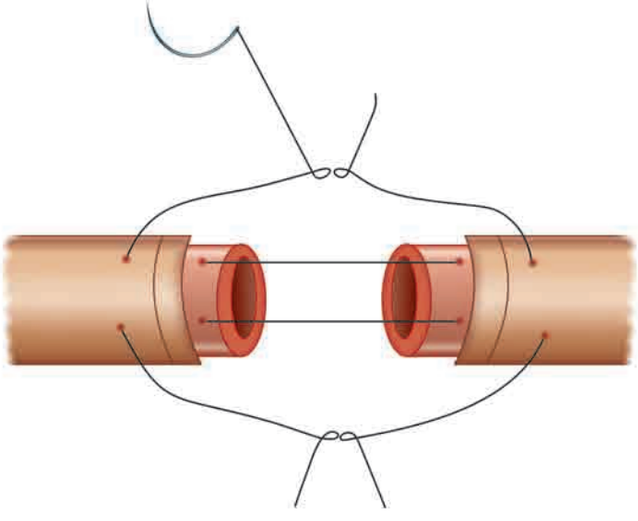


Fig. 3-46B: Single layer seromucosal layer suturing of the bowel.

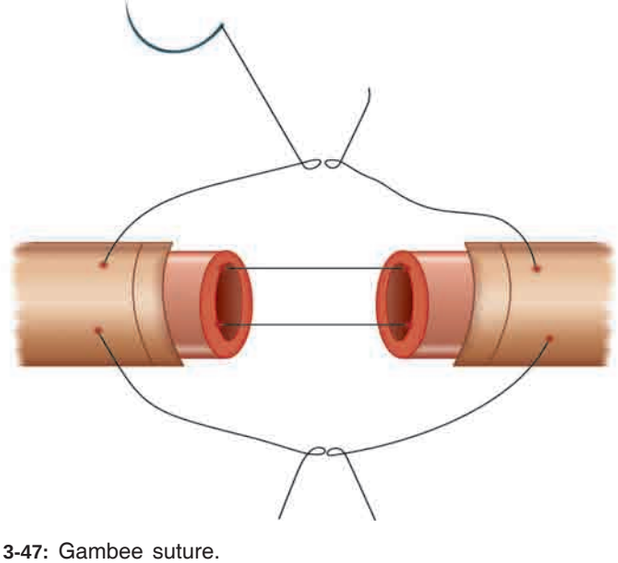


Fig. 3-47: Gambee suture.

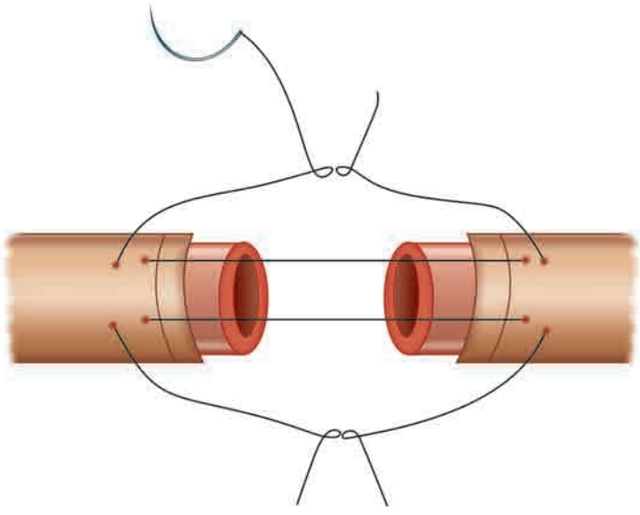


Fig. 3-48: Lembert suture.

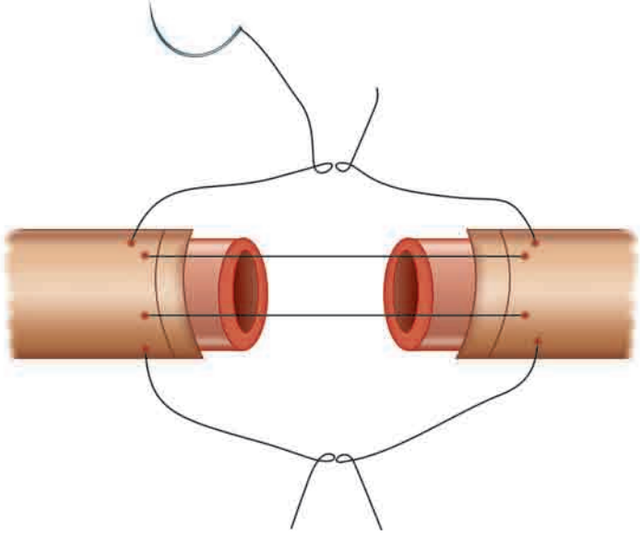


Fig. 3-49: Cushing suture.

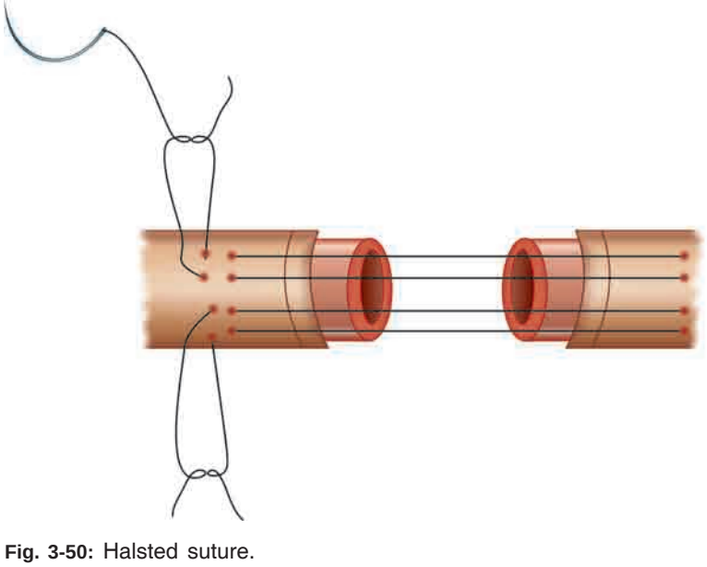


Fig. 3-50: Halsted suture.

Connell suture: Here suture material passes through all the layers of the intestine from serosa to mucosa; again brought out through all layers of the intestine on the same side from mucosa to serosa; passed over opposite segment of the bowel; passing from serosa to lumen/mucosa and from mucosa to outside towards serosa; again coming towards same side to repeat the technique. It is very good technique to invert the mucosal part of the anterior layer. It is commonly used in double layer anastomosis but can be used in single layer anastomosis **(Fig. 3-51)**. Connell suture apposes well; achieves good mucosal inversion. But it is *not adequately haemostatic* and so bleeders on the cut edge of the bowel should be ligated or cauterized individually.

KNOT TYING TECHNIQUE

Principles

The knot must be simple, firmly tied and should not slip. Knots must be as small as possible and ends should be cut as short as possible in the tissues. Skin sutures which are to be removed should be kept around 1 cm length so that removal is easier. But keeping too long sutures will abut into adjacent knots causing problem. In tying the knot one should avoid friction between strands to avoid weakening of the suture; one should avoid damage to the suture while tying knot. Excessive tension while tying knot will lead to suture breakage or tissue damage. Strength should be optimum; neither too tight nor too loose. Beginners tend to put too tight knots. Too tight sutures may cause tissue strangulation. After tying the first loop tension should be maintained on the strand to avoid loosening of knot. Final throw should be as nearly horizontal as possible. The surgeon should not hesitate to change stance or position in order to place secure flat knot. Usually three knots are sufficient. First knot is the best knot. In retention sutures or if polypropylene is used as suture material, then maximum 4/5 knots has to be placed. Any additional knots will not help in stability of knot or do not add to the strength of a securely tied square knot.

First throw/knot should be gently pushed and guided using index finger **(Fig. 3-52)**.

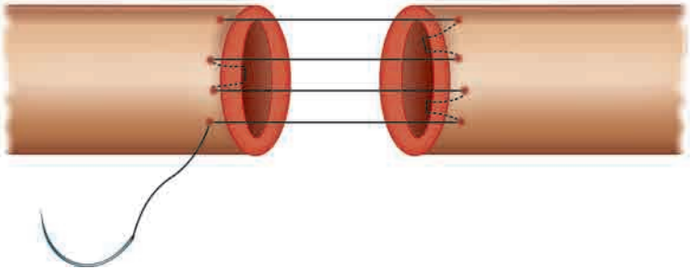


Fig. 3-51: Connell suture for bowel anastomosis.

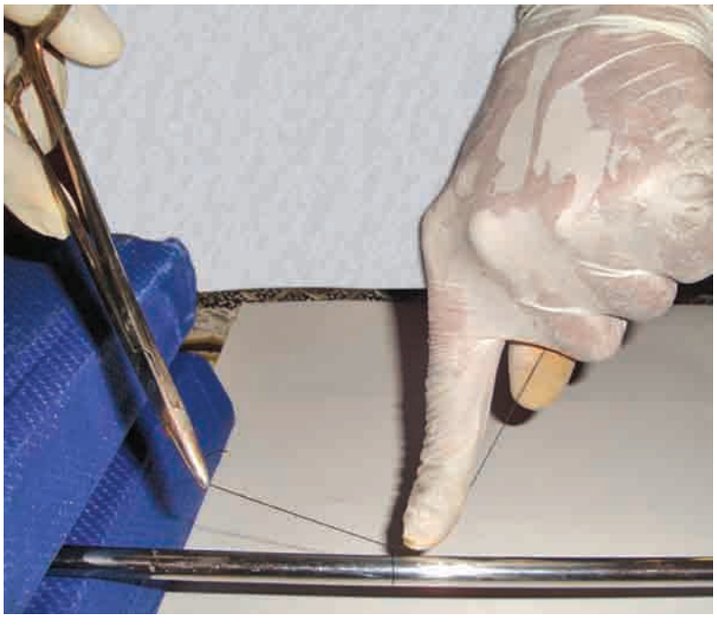


Fig. 3-52: First throw/knot should be gently pushed and guided using index finger.

Remember about suturing

- Width of the bite of suture on each side of the wound edge should be equal–coarse adjustment.
- Gap between the sutures should be equal. It may be 1 cm gap in skin; 3-5 mm gap in bowel; 1-2 mm gap in vessel.
- Slight eversion of the wound edge causes proper apposition.
- Deeper bite in the tissue by the needle should be wider than superficial to achieve adequate eversion.
- Inversion of edges may cause overlapping, delayed healing, delayed wound gap and poor scarring.
- Knots should be on one side of the bites on the corner of the optimal side which is the wound edge which is on lower level–gives fine adjustment.
- Bites should be adequate and deep enough; superficial unequal bites will cause improper apposition.
- Thumb can be used to push the skin against the needle bite from opposite side.
- Suturing is done from more mobile edge of the wound towards relatively immobile side.
- Flap of the tissue/skin when sutured, knot should be on the opposite side of the edge of the flap.
- Vertical mattress sutures give a good eversion.
- Improper alignment of the wound edges in a curved or lengthy wounds can be prevented by placing the key sutures at salient points which are identified by holding the edges taut using skin hooks or marking corresponding points on each edge to have proper adjustment and to prevent distortion.
- Wound tension should be distributed equally.
- Optimum tension at suture line will not cause blanching of the skin and will only leave thin/least suture mark whereas more tension with abnormally tight suture will blanch the skin causing obvious suture mark.
- Least tissue trauma, atraumatic handling, optimum precision are the need.
- Suturing and knotting is an art; a craft; is a fine work.
- Slow, precise, first bite should be careful and best bite; rapid, clumsy bite is not a good bite; one should avoid repetition.
- Matching landmarks on either sides of the wound should be identified properly.
- Suturing is easier with multifilament suture material like silk than monofilament suture material. Silk has got best handling ability, knot holding property, least memory. Suture insertion and passage through tissues is easier with silk.

Different Knot Tying Techniques

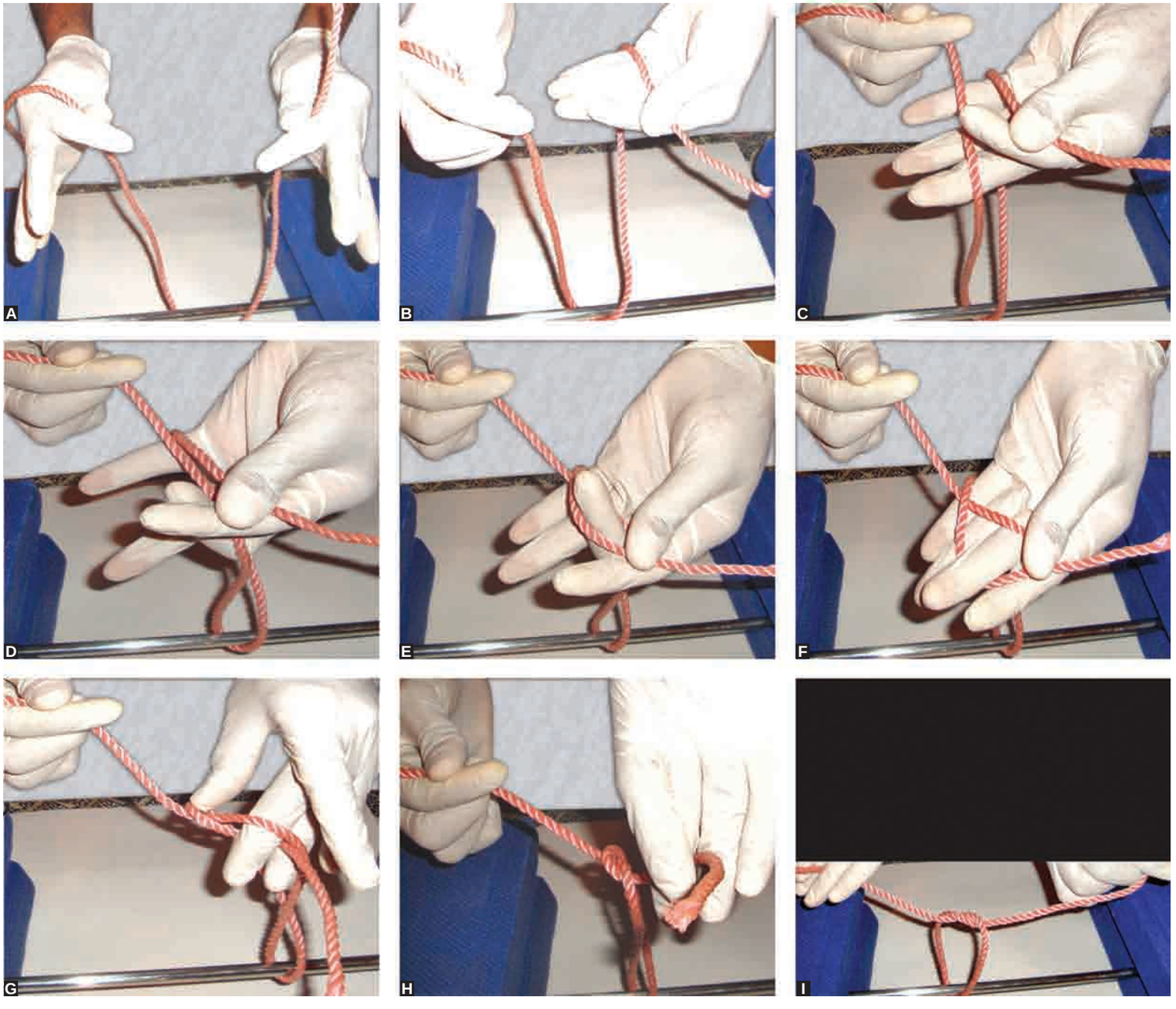
Hand Knot Tying

Two hands and single hand techniques are used. Two hands technique is ideal. *Aberdeen hand knot* is also used to end the continuous suture.

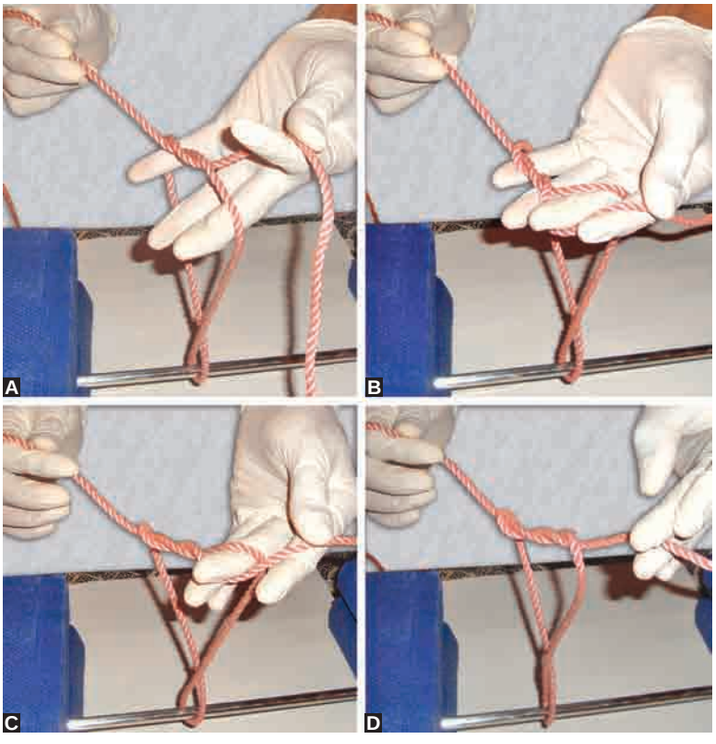
Two hands technique is commonly used. It is done using left hand in right hander; end of the thread/suture material is held between thumb and index finger of left hand; this part of the thread will pass behind the little finger of left hand, encircling it, and coming forward towards between thumb and index finger. Opposite end of the thread which is held in right hand is looped in front across middle finger; middle finger stretching and holding this right hand loop will be flexed at the distal interphalangeal joint and looped around the left hand thread end to create first knot which is held between apposed middle and ring fingers. These two fingers with the thread are pulled towards left to release the knot; knot is squared by directing the left hand towards the opposite side; knot is tightened by gentle push using pulp of left index finger. Further two knots are also placed similarly **(Figs 3-53 and 3-54A to D)**.

Single hand technique is done using left hand index finger. Thread is held similarly but between left thumb and left middle finger; looping is done using left index finger. This method is used whenever thread is small or there is less space in the area. It is little cumbersome to do compared to two hands technique **(Figs 3-55A to H)**.

Two hand technique and single hand is also done in another method: With the left hand between thumb and index finger one end of the thread is held (held proximal to the pulp these two fingers) with loop coming in front from below; other end of the thread holding in right hand is passed across index finger of left hand coming from behind up and forward close to the other end of the thread in left hand; apposed pulps of the thumb and index finger is looped around it and left hand thread tip is passed between these two finger pulps to achieve the



Figs 3-53A to I: Hand knotting using two hands technique.



Figs 3-54A to D: Two hands technique use and placing surgeon's knot with two loops/throws in the knot with squaring.

knot. Further knots are repeated similarly. Surgical knots can also be placed. Knots can be placed in similar way by single hand technique **(Figs 3-56A to S)**.

Aberdeen knot is used in continuous sutures at the end. Thread end is passed through the loop created in earlier last bite/turn; end is passed through this loop to create a new loop; once it is repeated 4-5 times thread end is pulled firmly tightly to tighten the knot. It is used while closing linea alba/rectus sheath using nonabsorbable continuous sutures **(Figs 3-57A to M)**.

Instrument Knot Tying

This is the basic essentiality for surgery. Different types of knot tying are there. Needle holder is held with one hand; long limb side of the suture is held with other hand; instrument (needle holder) is looped (throws) around the suture usually twice for surgical knot (first knot ideally should be *surgical knot*–means two loops are taken); instrument is crossed to opposite side to square the knot and gently knot is tightened; tightening of the knot should be adequate enough means neither too tight to strangulate the tissue nor too loose so as to create a gap; this first knot is *essentially the knot* in knotting; gentle traction should be held to the strand to avoid loosening of the first knot; two ends of the suture should be pulled in opposite direction with equal gentle traction. Second knot is taken as a single loop which is usually taken from behind the suture material (opposite direction and squared in opposite direction) and is tightened; third knot is again single loop (or often double loop like surgeon's knot) taken from front of the suture material (alike first knot single or double loop) and is tightened. One has to remember that usually three firm proper knots are sufficient. It is always considered that even though first knot is the holding knot total two knots (only one additional knot) are *insufficient* and *so three knots* are a must **(Figs 3-58A to K)**.

Only in suture material like polypropylene which has highest *memory* (recoiling tendency and so poor knot holding ability) five knots are put. Any further knots put will not help in strengthening the knot further; so it is waste of energy by the surgeon and unnecessary creating bunch in the knot. After placing first knot it is always better to fix the knot with surgeon's index finger to confirm the adequacy of tightness of the knot **(Figs 3-59A to H)**.

Instrumental knotting is more precise than hand knotting; as it creates optimum regulated tension at the suture line; and knot guidance and placement is better with instrument.

Laparoscopic Knot Tying

Problems with laparoscopic suturing are–lack of tissue perception, depth; limitation of movement of the instruments; difficulty in suturing and knotting inside; restricted space of working; need for high skill level by the laparoscopic surgeon.

Prerequisites for laparoscopic suturing

- Perfect health–mentally and physically.
- Hand-eye coordination.
- Visual perception, ability to concentrate and dedication, determination.
- Precision, proper camera operator.
- Learning curve, repetitive training, motivation, discipline, willpower.
- Proper instruments and their usage.
- Triangulation of two working instruments are important.

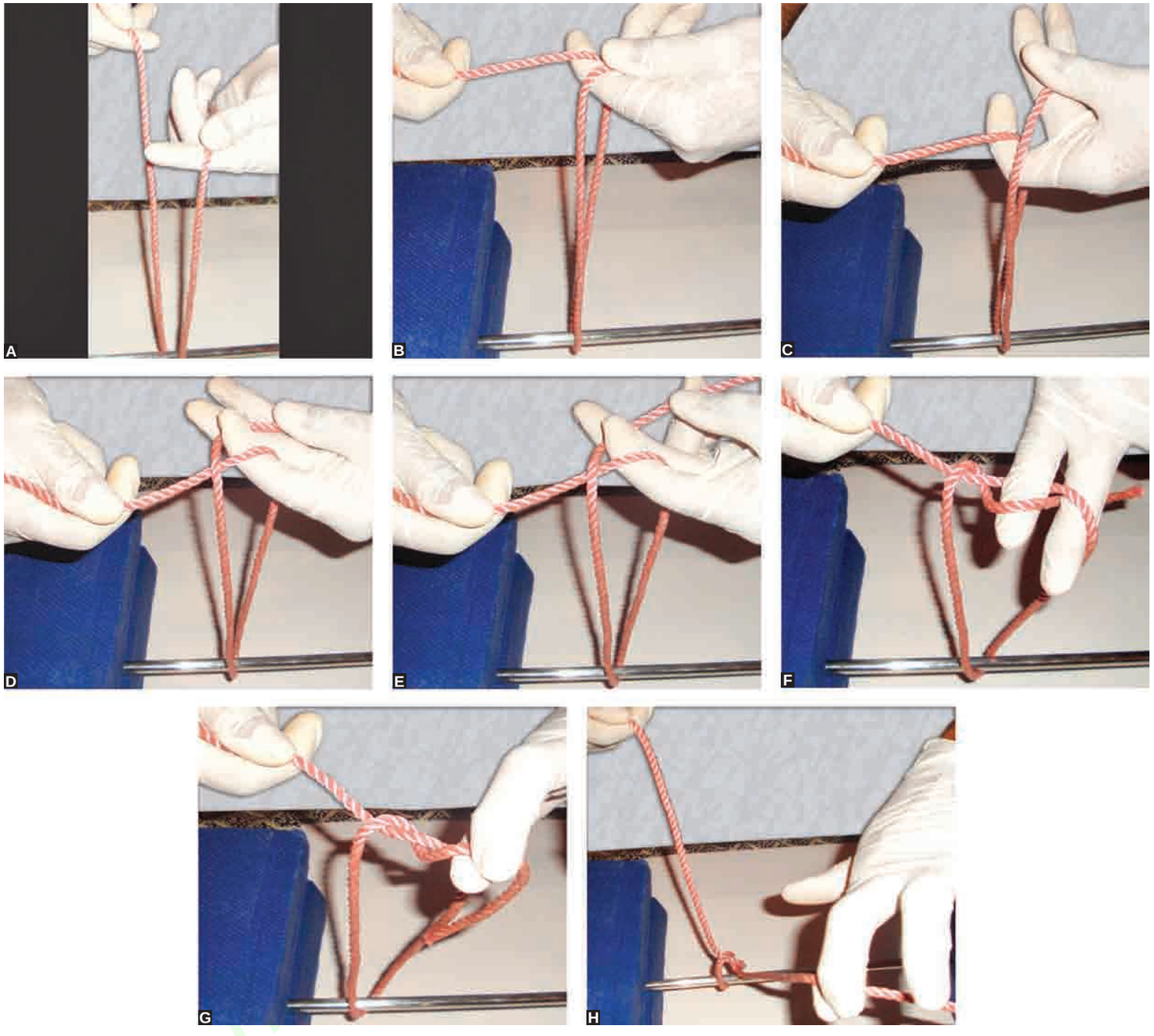
Types of Laparoscopic Suturing/Knotting

(A) *Intracorporeal suturing and knotting*–It is technically demanding one. Fine needle with suture is used. *Ski needle* with rounded curved tip and triangular straight shaft is used. Needle is held at triangular shaft so that needle will not swivel. *Dundee 'Ski' needle* with flattened proximal cross section instead of triangular makes improved locking and fixation of needle into needle holder without much difficulty, which makes positioning of the needle easier **(Fig. 3-60)**. Standard curved needles are also commonly used but with swiveling problem. Polyfilament, coloured (black or fluorescent white), and 3 zero suture materials are ideal. Polyfilament material holds well with easy knotting ability.

Excellent needle holder is an asset for intracorporeal knotting. Semm, Wolf, Ethicon, Cook, MBG are different needle holders available. Szabo and Berci needle holder gives 360° rotation with precise manoeuvring. *Self righting needle holder* with a notch inside allowing self positioning of the needle is also available.

Needle with suture material is placed inside the peritoneal cavity through–5 mm reducer cross 10 mm port; direct percutaneous (only straight needle); Reich method through 5 mm port (5 mm port is removed, gently needle with 5 mm needle holder is directly pushed along the track of the removed port into the peritoneal cavity under laparoscope guidance and 5 mm port is again slid into the abdominal cavity across needle holder); through 10 mm port directly. Needle entangling in the tissues, needle cutting, separation of the suture material from the needle, injury to the vital organs are the problems which may occur while introducing the needle.

Entrance bite and exit bite in the tissue should be taken separately. Knot is formed by either through 'C' loop or 'O' loop. *Square knot, square slip knot* (square knot untumbled to form slip knot), ligature slip knot, surgeon's knot are placed. Jamming slip



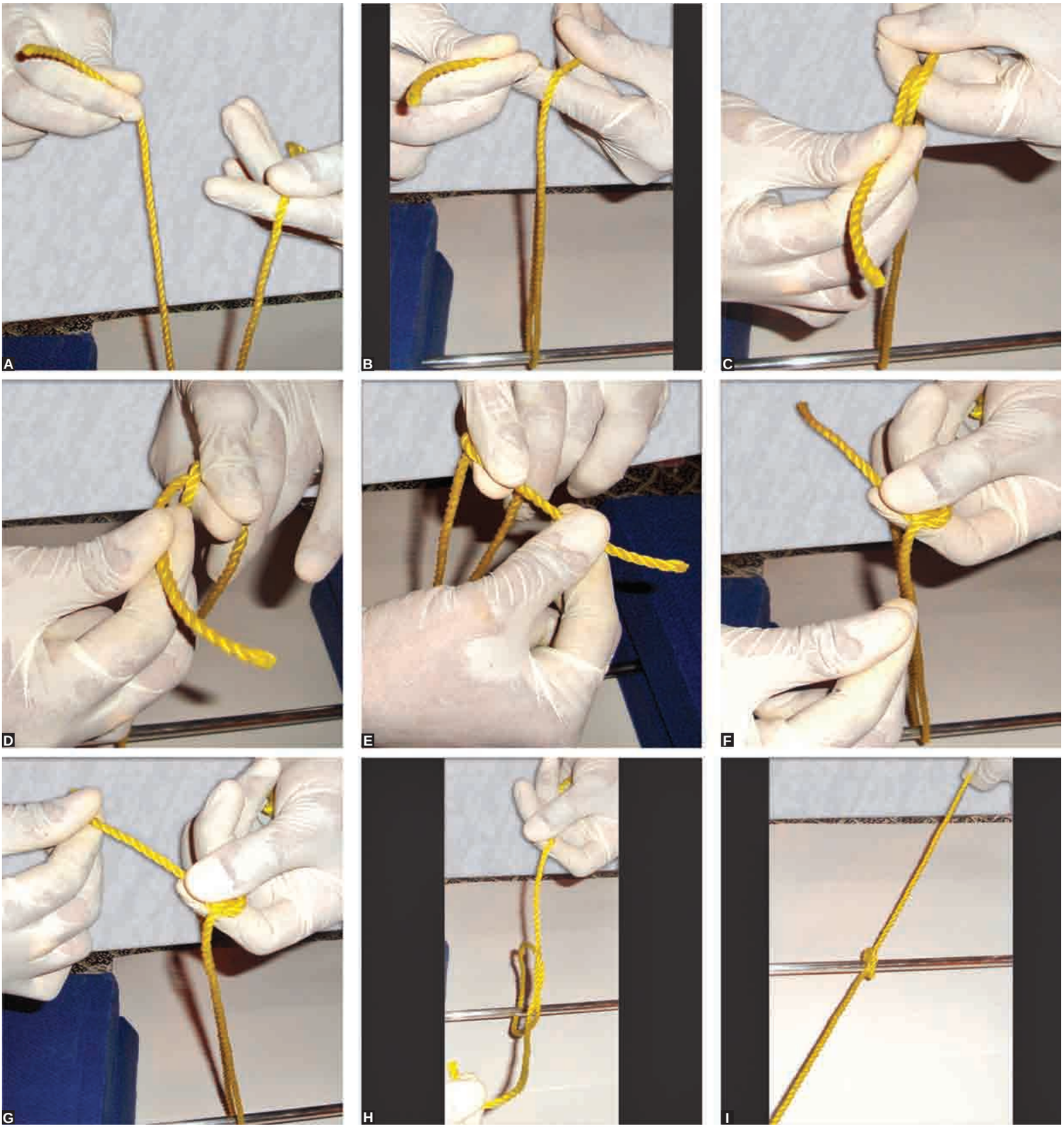
Figs 3-55A to H: Making knot with single hand technique. Even though surgeon should learn this technique as it is used when suture ends are short. It is not necessary to use this technique for fascination purpose. It is always better to use two hands technique which is more comfortable.

knot, Aberdeen knot (terminal knot) are other knots which can be placed. *Intracorporeal twist technique* is another method used in laparoscopic suturing. One end of the suture is rotated over the needle holder with suture tip holding for three loops; other grasper/needle holder holding other end of the suture is released to hold tip of the looped suture material; needle holder of the looped suture releases the tip of the looped suture and is allowed to hold and create a loop of the free other end of the suture which after releasing the loop across this loop forms a knot; further pull releases the loop achieving a firm knot **(Figs 3-61 to 3-63)**.

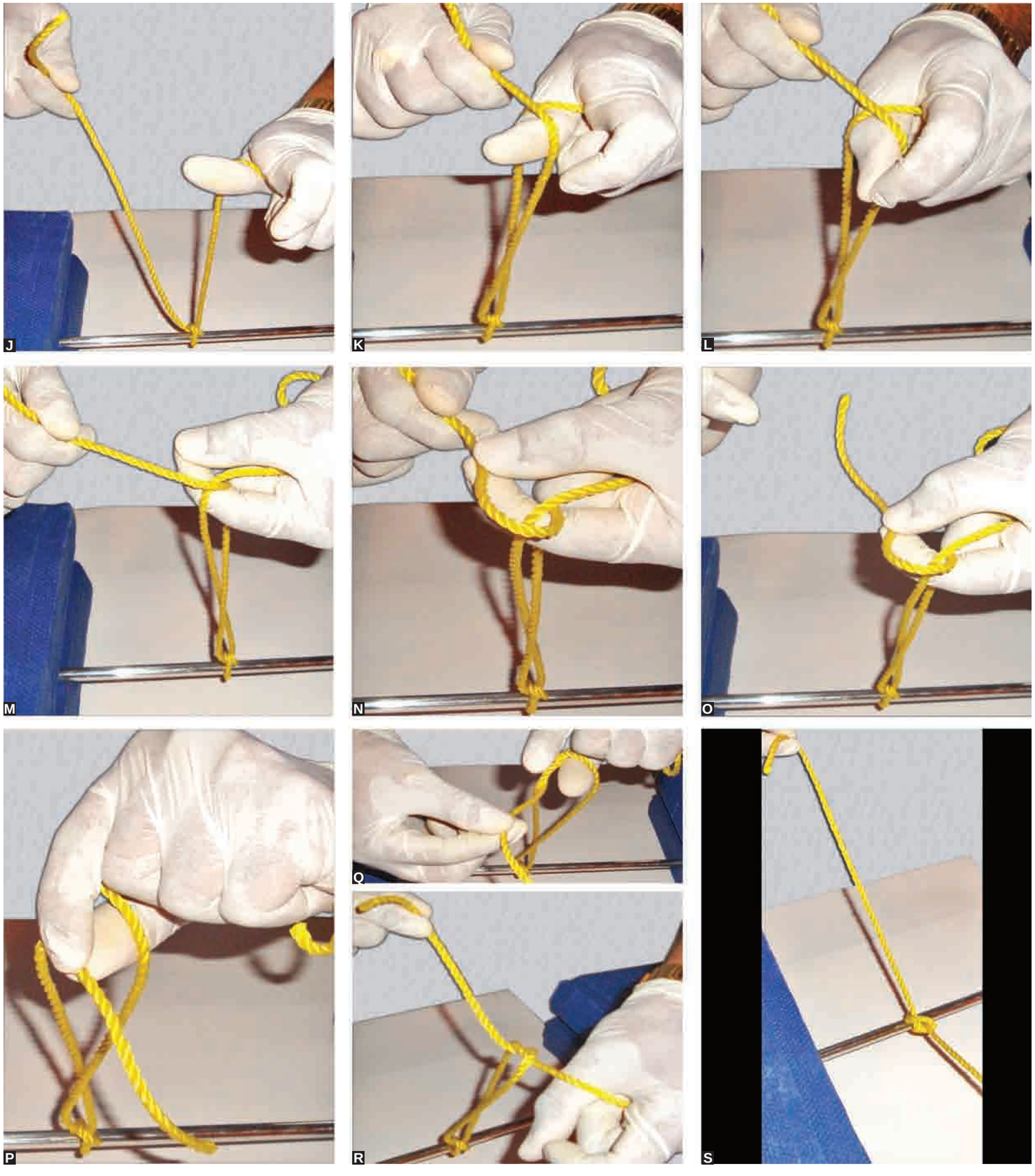
Jamming slip knot is a starter knot used in continuous suturing. After double looping through needle holder, little away from the end, the suture is grasped to form a loop to which knot is slipped and further knots tighten it. This knot near the end of the suture material acts as a first knot of the continuous suture which avoids intracorporeal knotting and hastens the suturing **(Fig. 3-63)**.

B. *Extracorporeal knotting:* It is commonly advocated in laparoscopy as it is convenient, safe and effective. Long 90 cm suture is used; needle with suture may be passed through tissue inside under laparoscopic vision and brought out through the 5 mm/10 mm port. Similarly ligature also can be looped around the specific structure and ends of the suture are brought out for knotting. After placing extracorporeal knotting, it is pushed to the required site through a knot pusher. Additional knots similarly can be placed. Different types of extracorporeal knots are–

1. *Roeder's knot* (By Roeder used for tonsillectomy in 1918): Semm used this in laparoscopy. Catgut is commonly used. Silk also can be used. Initial half knot (single loop) →3½ turns over the loop →second half knot →pushing towards first loop →tightening

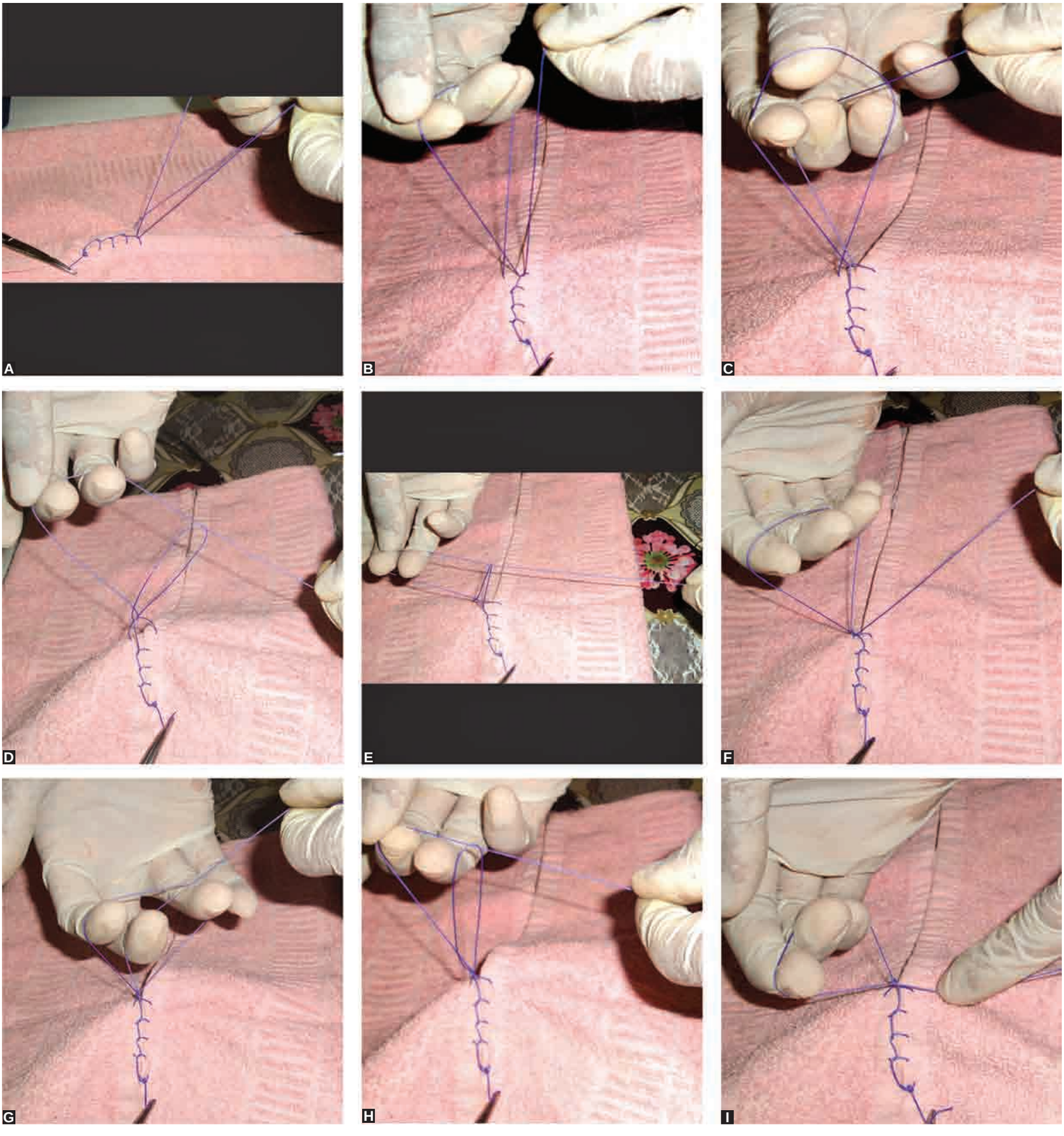


Figs 3-56A to I

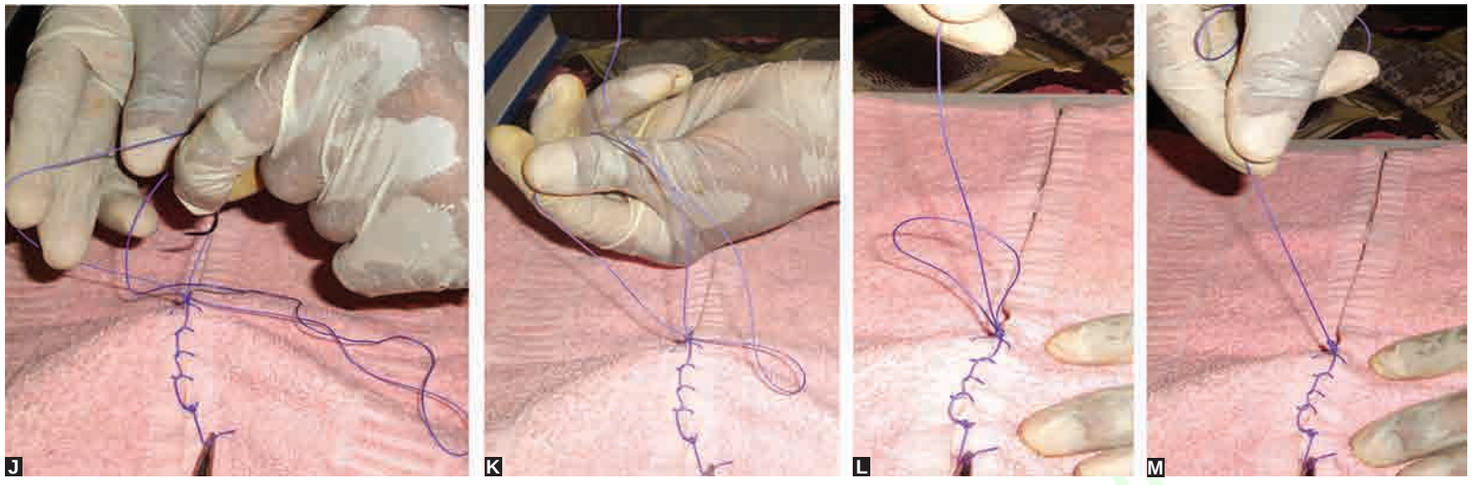


Figs 3-56J to S

Figs 3-56A to S: Two hands technique hands knotting using mainly thumb and index finger; here apposed thumb and index fingers move across loop to create knot.

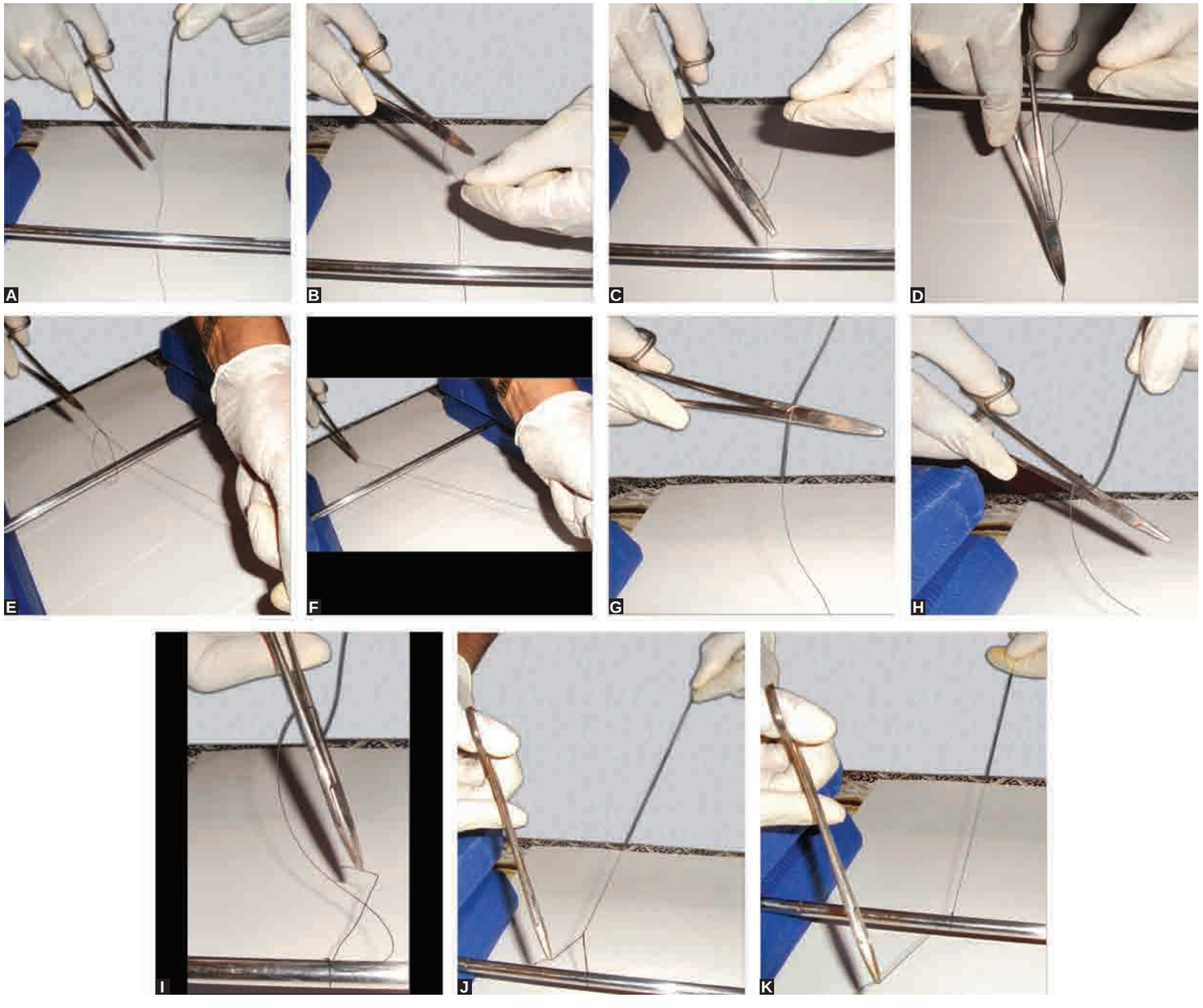


Figs 3-57A to I

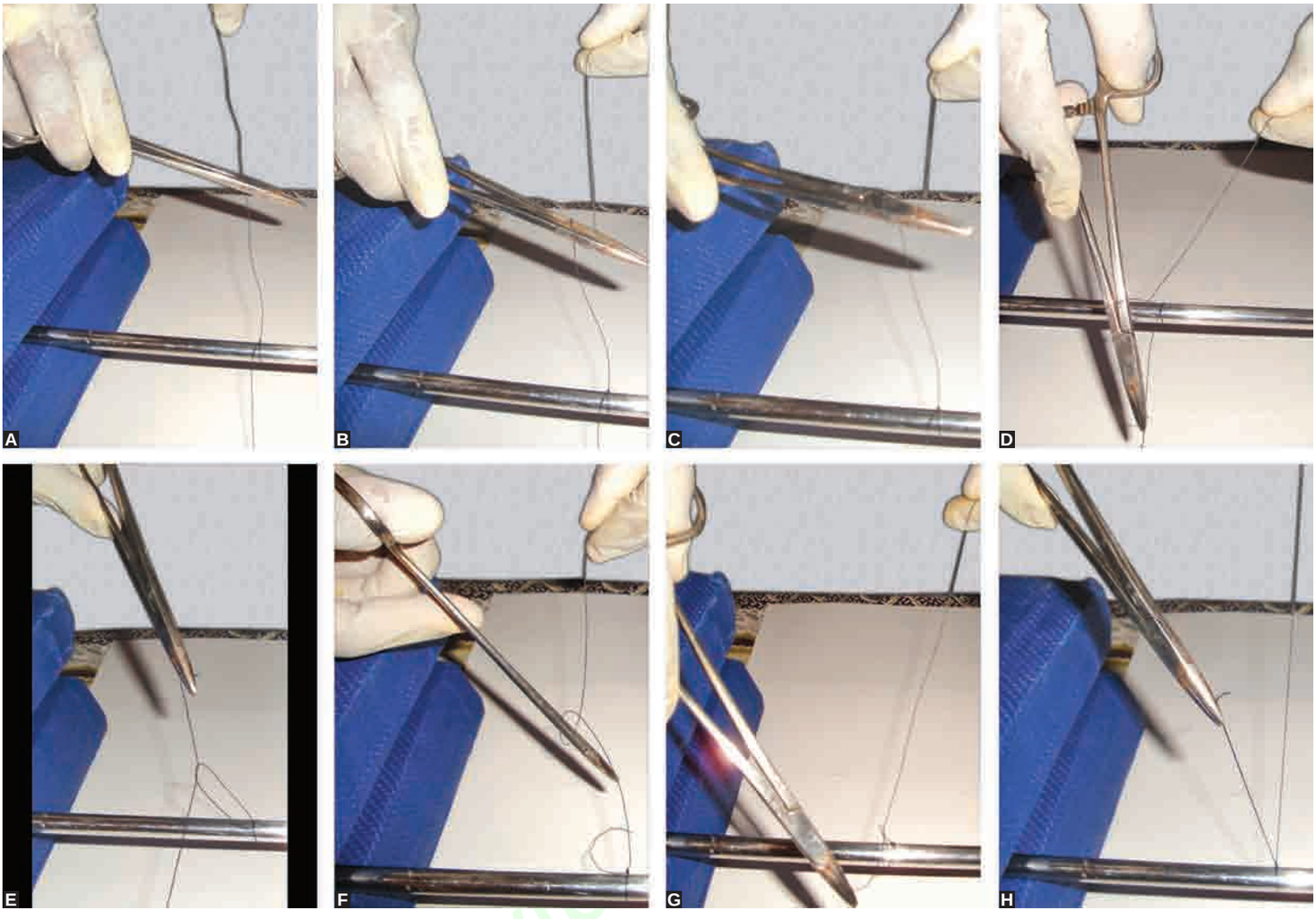


Figs 3-57J to M

Figs 3-57A to M: Photos showing how exactly Aberdeen knot is placed. Usually used at the end of linea alba suturing.



Figs 3-58A to K: Placing reef knot using needle holder instrument. Knot should be squared for proper secure knot to get.



Figs 3-59A to H: Instrumental placing of surgeon's knot (double throw of first loop with squaring)

Fig. 3-60: Dundee Ski needle.

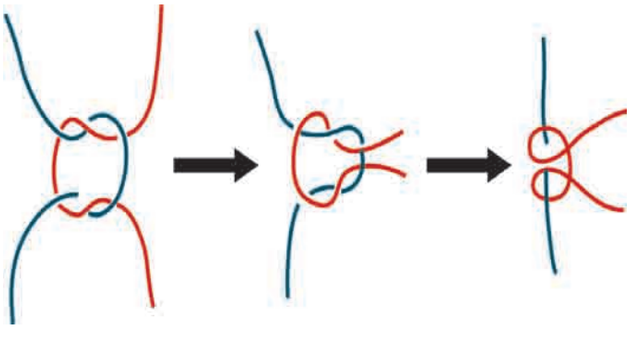
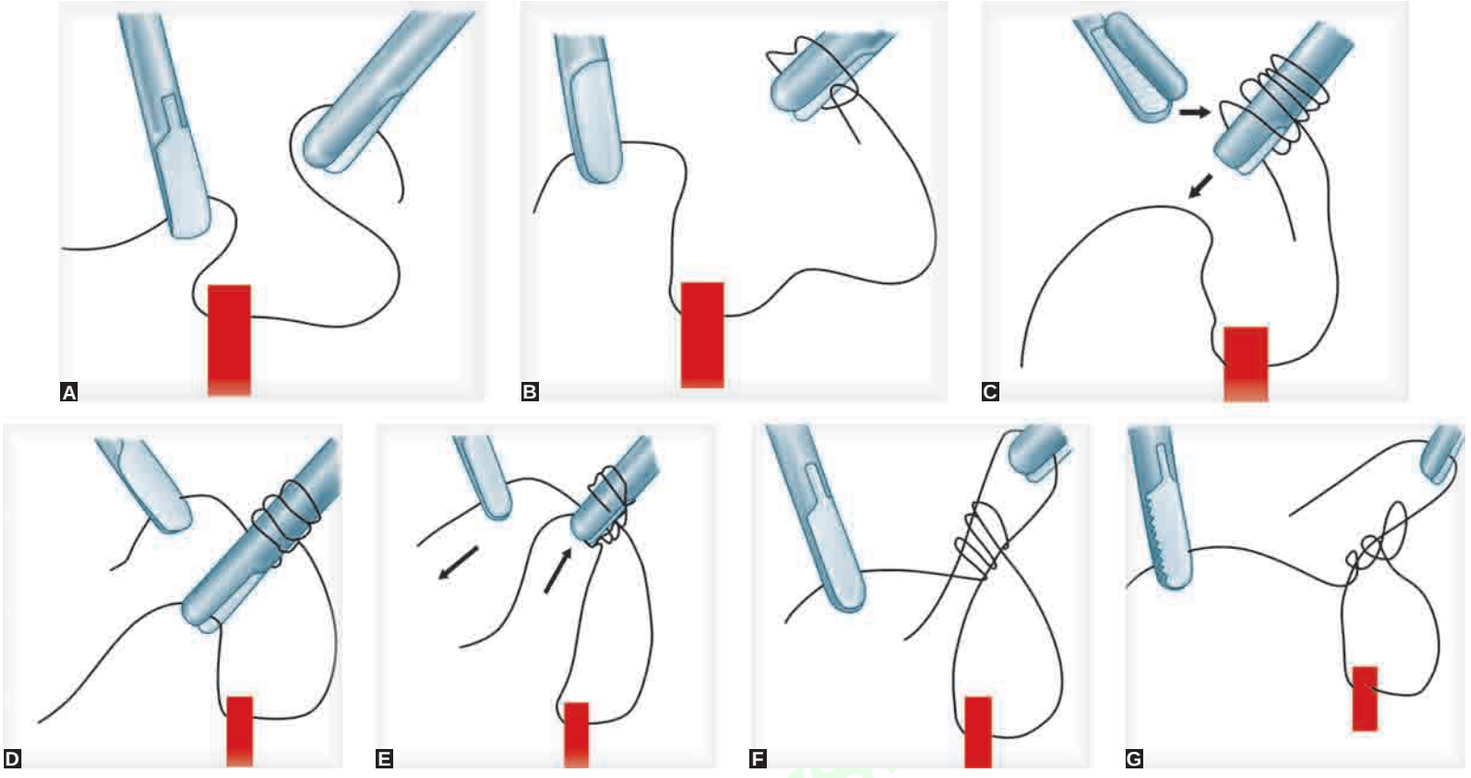


Fig. 3-61: Square knot untumbled to form slip knot–square slip knot. It has got ability to secure the knot in difficult places. It can be placed using monofilament suture material. It maintains adequate tissue tension. It is pushed in place by sliding.

creates good Roeder's knot which can be slid over the suture material easily →pushed after loop is passed around the structure like base of appendix using knot pusher **(Fig. 3-64)**.

2. *Melzer knot* (Melzer Germany 1991): It is modification of Roeder's knot. Here double initial half knot (double loop) →3½ turn over the limbs of the loop →double second half knot →staking of turns and pushing to tighten the knot →ready for use with a loop. It is used with PDS and is *stronger* than Roeder's knot **(Fig. 3-65)**.
3. *Tayside knot*: Initial half knot →4½ turn loop on standing part →tail is passed through first loop →tail is again passed through the first loop →tail is pulled to tighten the knot and ready for use. It is modified Fisherman's utility knot (Scotland) **(Fig. 3-66)**.
4. *Duncan slip knot:* Half hitch is added to the loop after 3½ turn **(Fig. 3-67)**.
5. *Texas Endosurgery Institute Knot (TEI Knot):* It is useful for many suture materials like PDS but it is difficult to do and several methods are present.

C. *Pre-formed slip knots*–Endoloops. It is prelooped sutures which are commonly used in appendicectomy, cholecystectomy or ligating blood vessels. Chromic catgut is the material commonly used here. It is introduced and placed using 5 mm endoloop pusher. Disposable pushers with pre-knotted endoloops are available. Metal knot pusher is not disposable (reusable) with a Roeder's knot.



Figs 3-62A to G: Intracorporeal twist knotting.

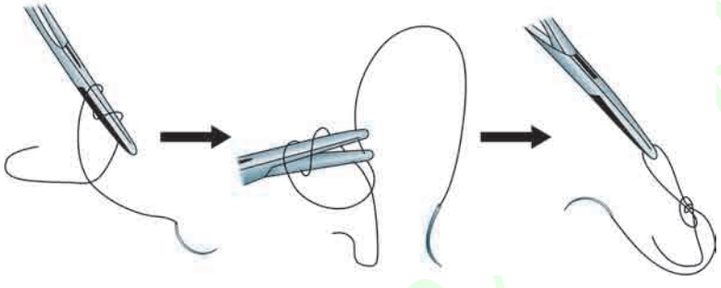


Fig. 3-63: Jamming slip knot.

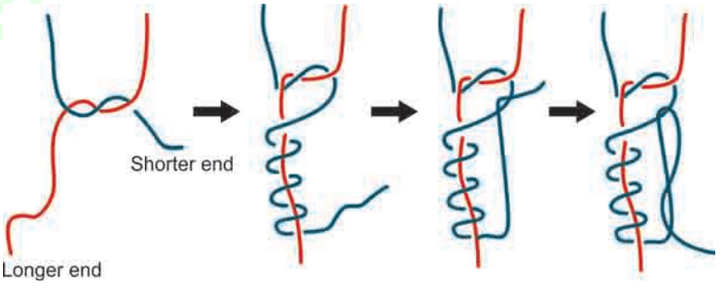


Fig. 3-66: Tayside knot.

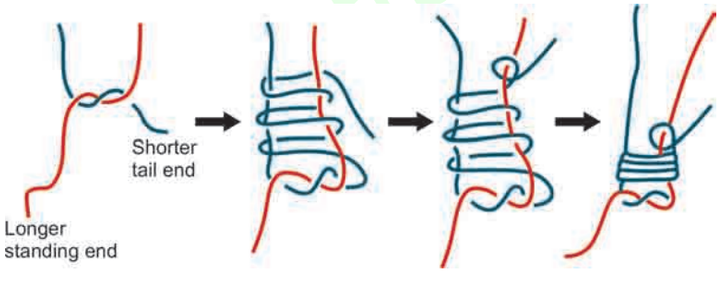


Fig. 3-64: Roeder's knot.

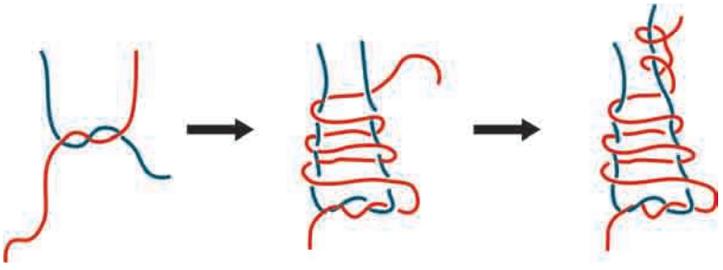


Fig. 3-65: Melzer knot.

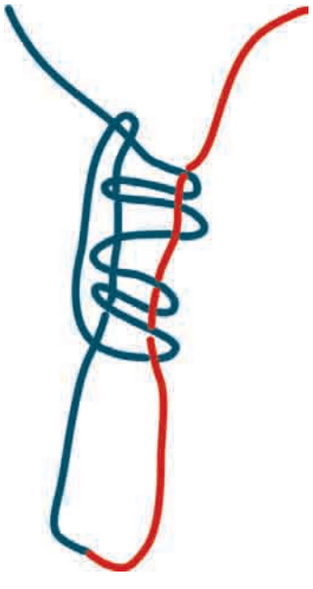


Fig. 3-67: Duncan slip knot.

Different Knots

1. *Reef knot* with squaring is ideal knot and commonly used. Correct squaring is essential. If it is not done knot gets spoiled and loosened **(Fig. 3-68)**.
2. *Granny knot* is not safe when second loop is taken from the same side **(Fig. 3-69)**.
3. *Surgeon's knot* with one extra loop in the first knot with squaring. It prevents loosening and slipping of the knot and maintains strength and tension required with the tissue and so becomes a more secure knot **(Figs 3-70A and B)**.
4. *Modified fisherman's knot:* First knot has got three loops/throws with surgeon's knot with squaring; second knot is squared single loop; third knot is squared double throw surgeon's knot **(Fig. 3-72)**.
5. *Triple modified reef knot:* It is the reef with three knots instead of two. It is actually the commonly used knot **(Fig. 3-71)**.

Dog-Ear

After excision of a circular lesion while closing the wound, the ends of the wound gets elevated like pronouncement called as 'dog-ear'. If this is sutured as it is, it causes a prominence resulting in unsatisfactory cosmetic scar. Such wound is sutured until dog ear is formed; later dog-ear is excised with lengthening of the wound; suturing continued to create lengthier clean sutured wound eventually leading into a scar **(Fig. 3-73)**.

Principles in knotting

- Optimum grip; optimum control; optimum precision–is essential.
- Hold the suture with needle holder only during knotting (not in other time).
- Knot must be as small as possible.
- In skin after knotting ends of interrupted sutures are cut neither too short nor too long; usually 1 cm of length kept is equivalent to gap between sutures. In deeper plane it should be kept short.
- One should avoid friction between strands while knotting. This can be minimised by holding sutures loosely; not tightly like a string. If so it will cause sawing effect and reduces the strength of the suture.
- Holding the suture with excessive tension will break the suture and traumatise the tissues. Folding with minimum tension allows free movement of the suture for finer suturing.
- First knot is the important knot; after placing first knot gentle traction to the strand is needed to avoid loosening of the first knot. Two ends of the suture should be pulled in opposite direction with equal gentle traction.
- Knotting is for proper apposition and approximation of the tissues; not for strangulation; so too tight suture should be avoided. Optimum tension should be used. It comes to a surgeon by repeated practice and experience. Surgeon should adjust his stance and position to place the knot properly.
- All knots ideally should be squared for stability by pulling in opposite direction.
- Friable edges of the wound cause poor knot holding and placement.

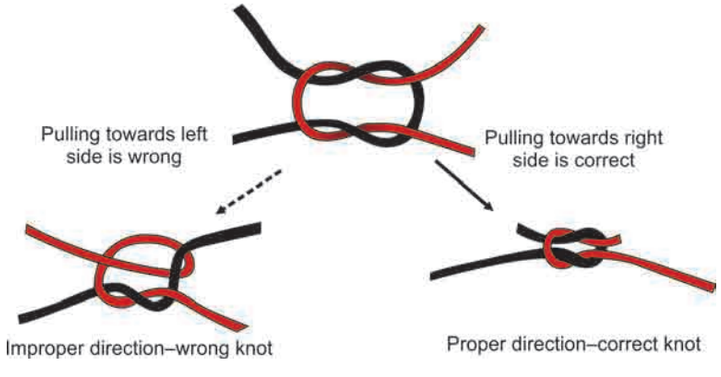

Pulling towards left side is wrong
Pulling towards right side is correct
Improper direction–wrong knot
Proper direction–correct knot

Fig. 3-68: Reef knot.

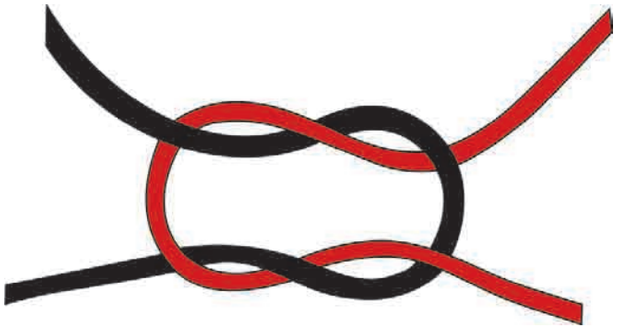
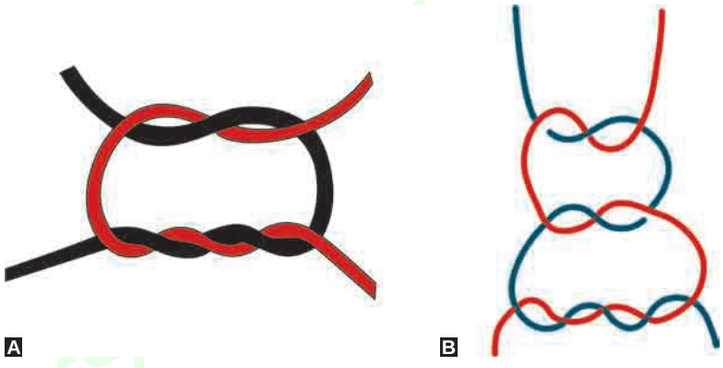


Fig. 3-69: Granny knot. It is not commonly used.



Figs 3-70A and B: Typical surgeon's knot is taking two loops/throws in first knot with squaring. It holds well without slippage.

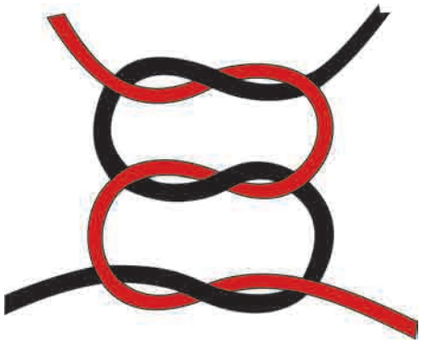


Fig. 3-71: Reef with three knots is used here which is more secure.

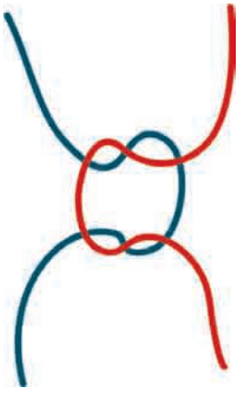


Fig. 3-72: Squaring of knot should be done to make it secure, especially first throw/knot should be squared.

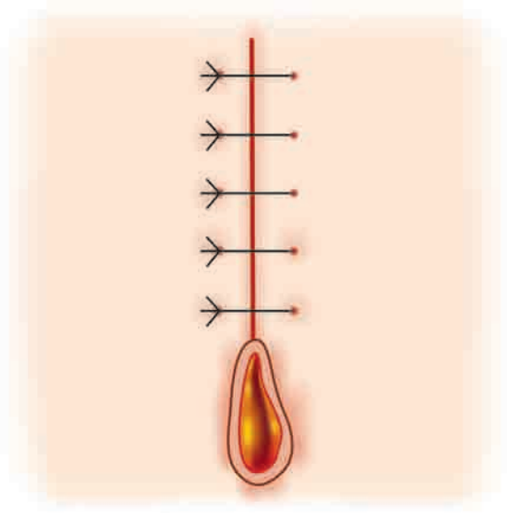


Fig. 3-73: Dog-ear often develops at the end of the wound. It is rectified by cutting excess skin and suturing creating a lengthy scar.

SUTURE REMOVAL

Suture cutting scissor is used with sharp tips. Suture is cut on one side deep to the knot; it is pulled using forceps *towards the wound line* so that to prevent entering the exposed part of the suture to get into the deeper part of suture line during removal and also to prevent wound dehiscence. Cut suture if pulled away from the wound line, chances of wound dehiscence is likely. Surgeon should use wrist and finger movements. B P handle with *11 number pointed sharp blade* also can be used. Patient should be always in lying down position. Suture removal is also an art **(Figs 3-74A to E)**.

HAEMOSTASIS

Control of bleeding is essential part of the surgical technique. Small oozing gets controlled on its own by natural haemostatic methods. All other bleedings may be small or large vessel bleeding needs proper secure control before further proceeding with surgery. There are many methods to control bleeding.

Figs 3-74A to E: Suture removal is an art. It is done with all aseptic precautions. Suture is cut behind the knot and suture holding at the knot using dissecting forceps or haemostat, it is pulled towards the wound so that wound dehiscence will not occur and outer part of the suture material is not dragged inside the track during removal to reduce the possible chances of infection along the track.

Gauze/Mop Pack

Wet gauze packed over the diffuse area with pressure over it controls the diffuse bleeding. Size of the gauze needed is decided based on the area of ooze. Small gauze/large gauze/mop/mops can be used. Small saline wet gauze is used in small area like raising thyroid flap. Large gauze may be used in wider area with fat disposition like raising flaps in mastectomy. Mops are used in the abdomen and in brisk torrential bleeding like liver injury. Often mops are kept in place to develop adequate tamponade and haemostasis and are removed in 24–48 hours once patient is well stabilised. During surgery when sudden bleeding occurs by inadvertent cutting of the vessel, hurried applying of the haemostat should be avoided as it is blind application. Instead it is better to pack the area with mop with firm pressure, after few minutes mop is removed gently to identify the point of bleeder which is held using a haemostat **(Fig. 3-75)**. Suction device should be used to keep field clean and clear to identify the severity and point of bleeding. *Note:* Mopping is the essential part of the surgery. *Rubbing* over the tissues using mop *should not* be done.

Use of Haemostat

Usually medium sized curved haemostat is used. In the depth large sized artery forceps can be used. Occasionally right angle forceps also is used. Mosquito forceps is also used for small bleeders like in head, face and neck surgery. Commonly bleeder should be identified precisely and caught with the artery forceps like a point. When identifying is difficult due to retraction or presence of fat, convex part of the artery forceps is used to hold the tissue with the bleeder. Again unnecessary holding of extra tissues should be avoided in this method as it may lead into deeper tissue destruction. After applying the haemostat it should be confirmed that bleeding has stopped by mopping and suction. While placing the ligature around the haemostat tip of the haemostat should be pointing forward (assistant should hold the haemostat gently and carefully and surgeon will place the ligature). Always make sure that haemostat is not catching the vital adjacent structure which may be incorporated in ligature **(Figs 3-76A to F)**.

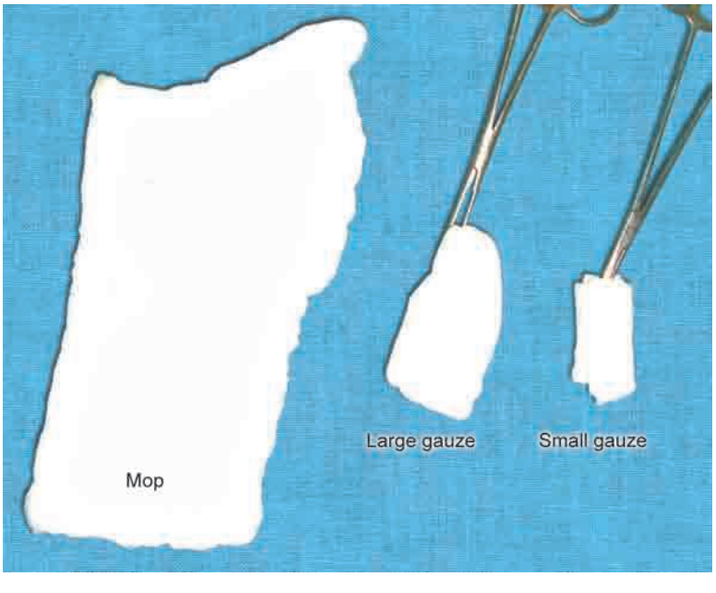


Fig. 3-75: Packing is common method to control bleeding temporarily. Small gauze, large gauze or mop/mops are used depends on the area, depth and severity of bleed.

In scalp bleeding or scalp incision galea should be held with straight or curved artery forceps/haemostat at many points and turned back over the skin to stop bleeding.

Bleeding area can be lifted with non-toothed forceps and underneath tissue can be cross clamped with haemostat.

Use of Ligature

Ligation of bleeding vessel is essential in many places. Small vessel is cauterized after holding with haemostat. Wider vessel should be ligated. Polyglycolic acid 2 zero or 3 zero can be used. Silk also can be used as it holds well with good strength. Once surgeon places the first knot, assistant *gently* releases the haemostat and removes it. Haemostat should not be released suddenly.

Mounted tie is used for small or medium vein ligation. Here two ligatures are placed with 0.5or 1cm gap around the vein using two haemostats and tied securely. Vein in between is cut safely. If it is artery two ligatures are placed proximally and one ligature distally before cutting in between. Larger vein ligation also needs double ligation proximally **(Fig. 3-77)**.

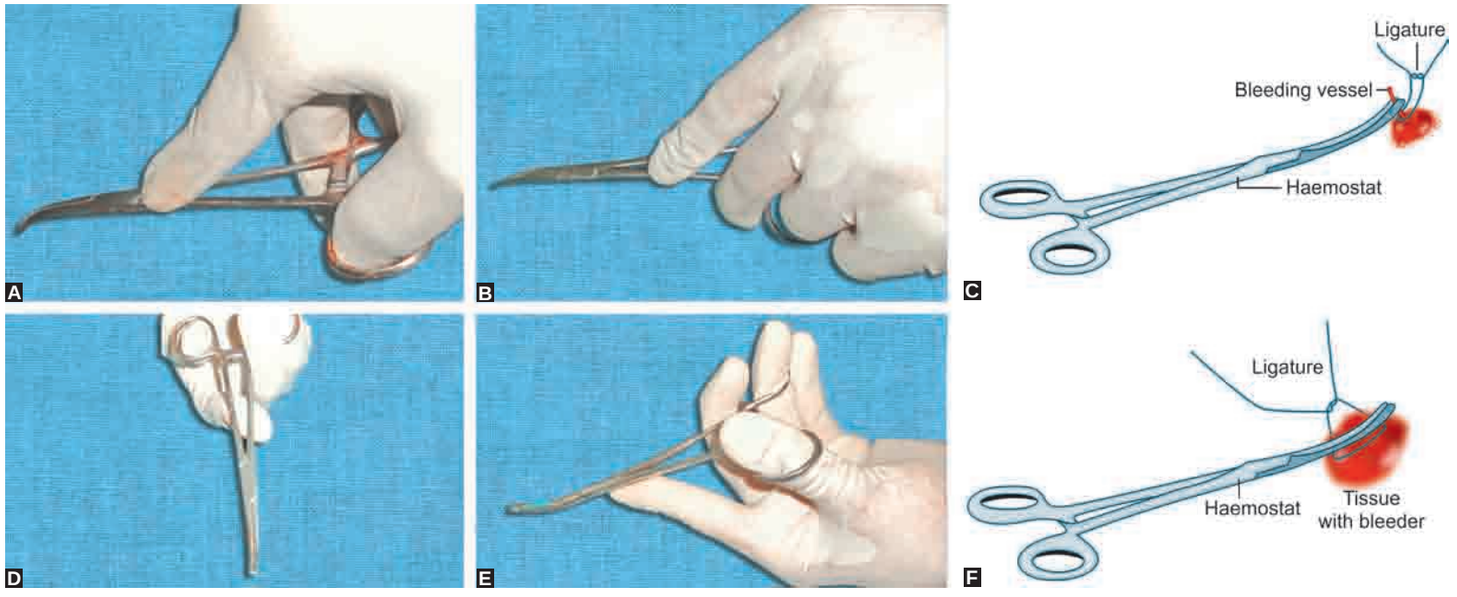
Ligating the larger vessel like left gastric artery, branches of mesenteric vessel and superior thyroid artery needs additional care as slippage in reality is a definitive risk. In such occasions ideal method could be to dissect the vessel from adjacent tissue and fat for 1.5 cm (*skeletonisation of the vessel*) length and ligating it. Ligation of such vessel needs special care. Initially vessel is cross clamped using *Mixter/Miegster* clamp. Using long haemostat lengthy ligature (silk or polyglycolic acid) is passed around the Mixter clamp and tied using hand knot. One more ligature is placed again 2 mm proximal to earlier ligature. Stump of the vessel should be around 1 cm beyond the distal ligature **(Fig. 3-78)**.

Often in resection of the tissue like gastrectomy, mastectomy, colectomy, intestinal resection, main vessel (gastric artery/gastroepiploic artery/mesenteric vessel branch) is isolated and dissected for about 2 cm length and ligature is passed using Mixter clamp as a feeding ligature and tied. Proximal two ligatures are placed at 2 mm apart. Distal ligature is placed away at 1.5 cm gap. Vessel is cut using curved scissor or with no. 15 blade (part behind the vessel should be guarded by placing flat surface of the dissecting forceps or any other instrument) leaving 1 cm vessel proximally and 0.5 cm vessel distally. Two firm proper proximal ligatures are sufficient even though many surgeons have got the habit of placing 3 or more proximal ligatures. Only one proximal ligature is technically sufficient but is not advisable; so two proximal ligatures are probably ideal **(Fig. 3-79)**.

Transfixation Ligature

Transfixation prevents the slippage of the suture. It is used in big vessel ligation or when oozing tissues are held and ligated. Gastric vessels, mesenteric branches, in obese patients where ligature may not hold, in vessels in the depth–are the indications. It is better to use transfixation suture whenever surgeon feels that just ligature may not be sufficient to secure.

Needle with the suture is passed underneath the haemostat over middle of the grasped tissue, first knot encircles the half of the tissue on one side; suture is looped around on the opposite side of the grasped tissue and knot is placed. Once such *figure of eight stitch* is completed then only haemostat is released by the assistant. Further knots are placed over it. Still safety of the ligature can be achieved by passing the needle *second time* underneath the tissue again before knotting **(Fig. 3-80)**.



Figs 3-76A to F: Haemostat is used in two ways. Holding is done on the tip when bleeder point is visualised and is ligated. If tissue is bleeding, tissue is held over the convex part of the haemostat and ligated.

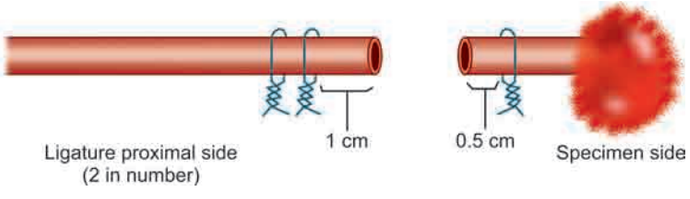


Fig. 3-77: Vessel is cut between knots with adequate gap in between to prevent knot slippage. Ideally proximal two ligations and distal one ligation are needed.

Underrunning of the Tissue

It is not possible to catch the area and control the bleeding if bleeding point is not identified and is not pointed. Any blind struggle to hold the area with haemostat will aggravate the bleeding without achieving any thing. In such occasion it is wiser to place continuous locking sutures in tissue bed where bleeding occurs using 3 zero polyglycolic acid/silk/polypropylene sutures. Repeated mopping and suction of the area is essential. However surgeon should take care and be aware of presence of some major vessels and vital structures in that deeper plane. Depth control in these sutures is also important. Usually bleeding stops by placing few locking sutures. Locked loops should be held by the surgeon himself so that tearing through the tissues by the suture material is avoided and gentle traction to lift the tissue to facilitate further bites is achieved.

Diathermy

Diathermy is most commonly used tool for haemostasis at present. Monopolar cautery or bipolar cautery is used for haemostasis. It is high density current which is made to pass into the tissue in need (target tissue) to cut or control bleeding (coagulate).

In monopolar cautery current passes through a grounding electrode kept behind thigh/buttock of the patient. Monopolar device delivers two types current–cutting and coagulation. *Cutting* is continuous, high frequency low voltage current causing rapid heating of tissue leading into tissue disintegration and cutting. Haemostasis is not adequate

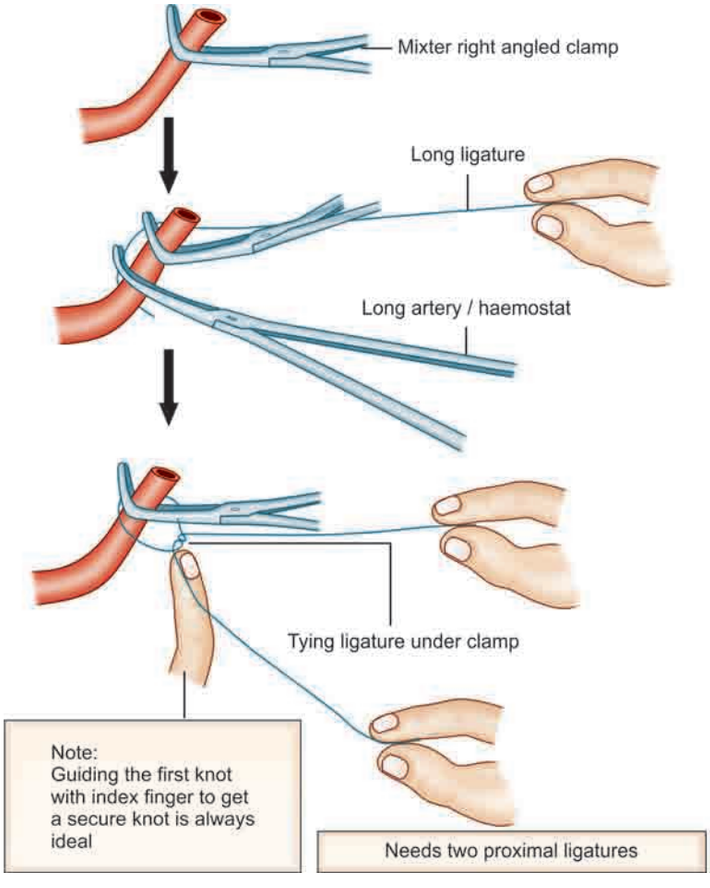


Fig. 3-78: In the depth vessel should be dissected first properly. Mixter/ Miegster clamp is applied. Ligature is passed underneath using long haemostat. Ligature is placed by firm knot which is directed using index finger.

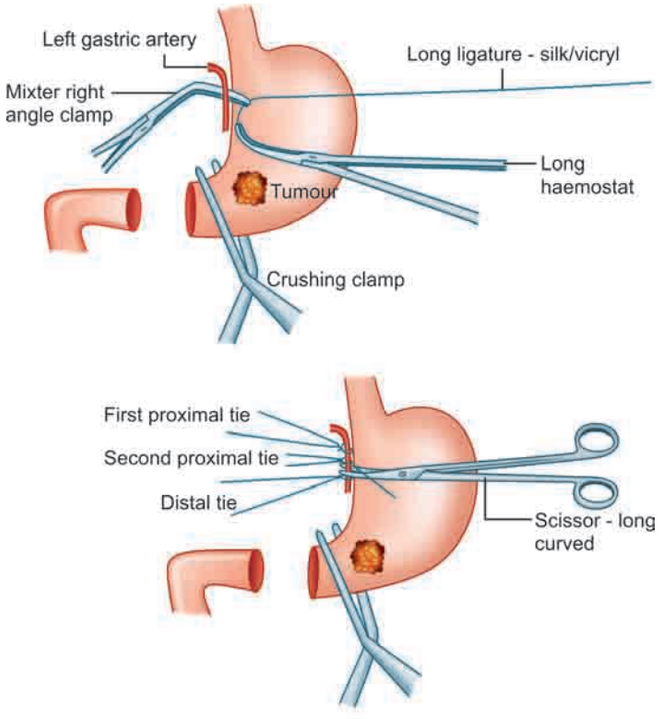


Fig. 3-79: Once adequate length of the vessel is dissected properly from surrounding tissues, using Mixter clamp ligatures are placed–two proximally; one distally. Vessel in cut between proximal and distal ligatures.

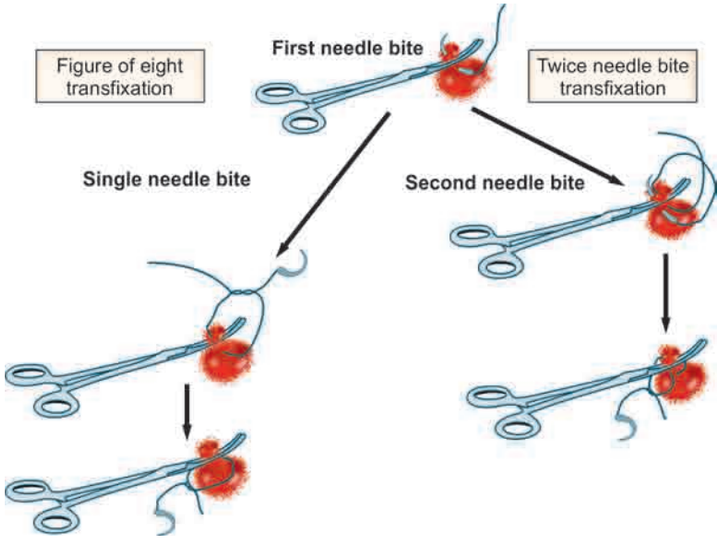


Fig. 3-80: Transfixation suture. It is done by two methods. Single bite, figure of eight suture or double bite transfixation is used. Both hold knots in place with minimal chance for slippage.

in cutting cautery. *Coagulation* is pulsed wave, low frequency, high voltage current causing slow tissue heating, protein coagulation and vessel sealing. Coagulation in *fat tissue causes more charring* as fat is poor conductor of electricity, destruction and more prone for infection of the wound. Coagulation cautery may cause lateral heat significant enough to cause heat injury to adjacent vital structure/tissue. It is often dangerous in bowel, bile duct, major vessels. Burn injury due to default in earthing plate can be dangerous. Proper earthing and connections should be checked by surgeon himself. It is legally important also. Bleeding point is grasped using specialised fine non-toothed forceps called as cautery forceps. Cautery blade is touched to the instrument and cautery peddle is pressed to achieve desired effect of coagulation. Tip of cautery blade can be touched directly over the oozing tissue area to achieve haemostasis. Use of cautery should be avoided in epidermis and dermis as it causes severe thermal injury. Vessels more than 2 mm diameter cannot be cauterised. If attempted it may cause more bleeding; or may temporarily seal the vessel but later disruption can occur to cause re bleeding in postoperative period.

In bipolar cautery, current passes from one blade of the bipolar forceps across the grasped tissue in between towards other blade directly without earthing. It causes heating only in between blades of the bipolar forceps. Lateral heat and adjacent tissue injury is less. It is much safer to use bipolar cautery to prevent hazardous injury to adjacent vital structures (bowel, CBD, IVC, Major artery/vein). It causes coaptive coagulation. It is not used for cutting. It is very useful in laparoscopic surgery. Earthing plate is not needed in bipolar cautery. Bipolar coagulation is slower compared to monopolar coagulation. It often checks the surgeon's patience.

Ligasure/Ligaseal/Ultrasonic Shears/Laser/ Harmonic Scalpel (Focus)

These are the different energy sources presently available to control bleeding which coagulate and seal wider vessels even up to 5-7 mm diameter. It is very useful in hysterectomy, colectomy, gastrectomy, resections, pancreatic surgery, thyroidectomy and advanced laparoscopic surgeries.

Haemostatic Clips

Haemoclips are applied directly over the vessel circumferentially. It is useful in thyroidectomy, gastrectomy, colectomy, oesophagectomy, etc. It should not be applied blindly without visualising the vessel/ bleeding vessel. Improper application may cause uncontrolled bleeding. Before applying it direction of the clip, structure underneath should be assessed properly. It may injure adjacent structures, or lacerate the vessel clipped if not placed properly. Precise gentle placement assures the haemostasis and speeds the surgery. Haemoclips are used in open as well as laparoscopic surgery.

Tourniquets

Tourniquet means to turn (Greek). It is used to cut off the blood supply to a limb temporarily so that a bloodless field is created while performing the surgery. Limb should be exsanguinated before applying/inflating the tourniquet. It is done using a bandage or pressurised Rhys–Davis exsanguinator. A tourniquet is applied in midthigh above the elbow in upper limb. It should not be closer to joints. It is not applied over the forearm or leg. It is applied over layers of gauze/cotton, but not over bare skin. Pressure used in upper limb is 250 mmHg; in lower limb is 300 mmHg. In general 50 mm Hg above the systolic pressure of the patient used in many places, even though it may be inadequate as fluctuation in blood pressure can occur during procedure (in children it is 150 mmHg for upper limb and 250 mmHg for lower limb). *Uses* - To attain bloodless field in limb surgeries of upper and lower limbs, orthopaedic surgeries, soft tissue tumors, amputations. It is used (rubber tourniquet) to get assess to veins for IV injections and IV sampling. Tourniquet is used in diagnostic tests for varicose veins, purpura (ITP), etc. It is used as a first aid in bleeding conditions of limbs, snake bite (it is controversial). Tourniquets are also often used for small procedures in fingers and toes. *Types:* (1)

Rubber tourniquet - Simple red rubber catheter is used for drawing blood, to have access to veins. (2) *Pneumatic tourniquet* - Used in limbs, will give the arterial pressure and also acts as a tourniquet. (Sphygmomanometer cuff is simpler and easily available type). (3) Esmarch rubber *elastic bandage tourniquet* **(Fig. 3-81)**. (4) Specialised sophisticated tourniquets are available which gauge pressure, timing accurately **(Figs 3-82A and B)**. *Contraindications:* In all peripheral vascular diseases and atherosclerosis; infection; DVT; crush injuries; sickle cell disease. *Complications:* Crushing effect on muscles in thigh may lead on to crush syndrome; tourniquet palsy (radial nerve) in upper limb; infection; improper application of tourniquet will lead to more bleeding; forgetting the removal of tourniquet or using more time to release may compromise the blood supply of the limb leading to severe ischaemia and gangrene.

Note: Tourniquet time for upper limb is one hour and for lower limb is two hours.

Fig. 3-81: Esmarch rubber tourniquet.

Figs 3-82A and B: Automatic gauged pressure tourniquet.

Control of Sudden Severe Bleeding during Surgery

It is often encountered problem in major surgery like pancreatic surgery, nephrectomy, splenectomy, oesophagectomy, biliary surgeries, surgeries in neck, and surgeries for malignancies. Methods used to control haemorrhage temporarily are–(1) *Finger pressure* and packing: Applying pressure directly over the site is the ideal method as immediate pressure instead of struggling to catch the bleeder using haemostat. *Pringle manoeuvre* by holding the foramen Winslow between thumb and fingers is one of the methods to control bleeding in liver. Iced sterile saline pack can be used in kidneys to reduce the metabolic activity and so to increase the compression period. (2) Usage of clamps carefully with proper suctioning: Satinsky clamp and other vascular clamps are soft and stable which can be applied effectively across a bleeding major vessel like portal vein/IVC/major artery. (3) Proximal and distal control using vascular clamps or umbilical tapes in major vessels like aorta. (4) Extend the incision to expose the area adequately. Visualisation, suction should be optimized. Adequate number of blood should be arranged for transfusion. Needed assistants may be increased. If felt surgeon should not hesitate to call another experienced surgeon for help. (5) Permanent control of bleeding by vascular suturing using fine 4 zero polypropylene sutures or other definitive procedures. (6) Monitoring the patient for DIC, coagulation changes, further bleeding, sepsis, cardiac arrest, ARDS, respiratory problems, metabolic consequences.

Other Methods

Topical agents–They are collagen or cellulose matrix which stimulates clot formation over the oozing surface. They also

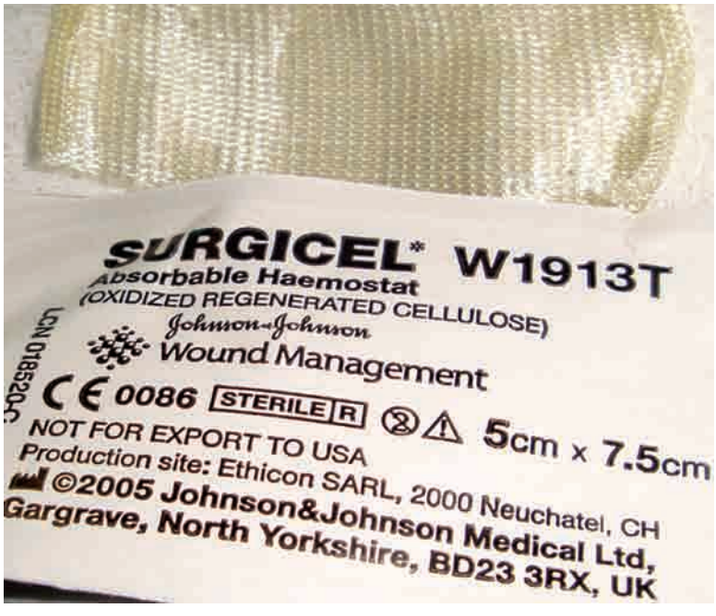
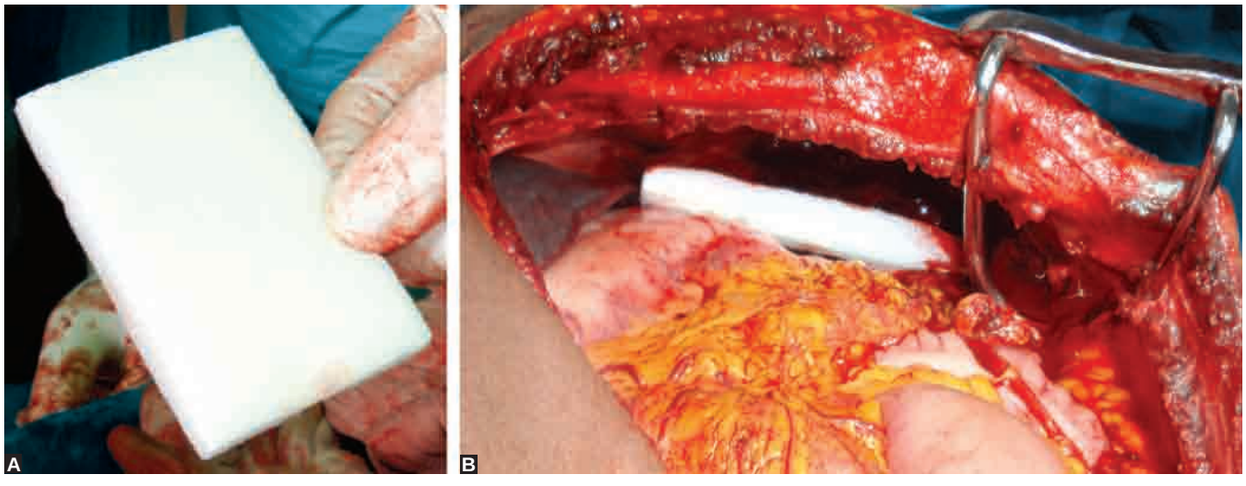


Fig. 3-83: Surgicel.

prevent disruption of clot already formed. *Microfibrillar collagen powder* (Avitene) can be sprinkled over bleeding surface through forceps. It is used when oozing surface is irregular. But it is costly. *Oxidized cellulose* (surgicel) is placed over the bleeding area **(Fig. 3-83)**. *Gelatin* sponge, topical thrombin, gelatin matrices (floseal), topical cryoprecipitate, topical EACA (Epsilon amino caproic acid), alginate materials, temporalis muscle patch (neurosurgery) are other materials used. *Bone wax* is bees wax with almond oil; it is used in bleeding bone marrow.

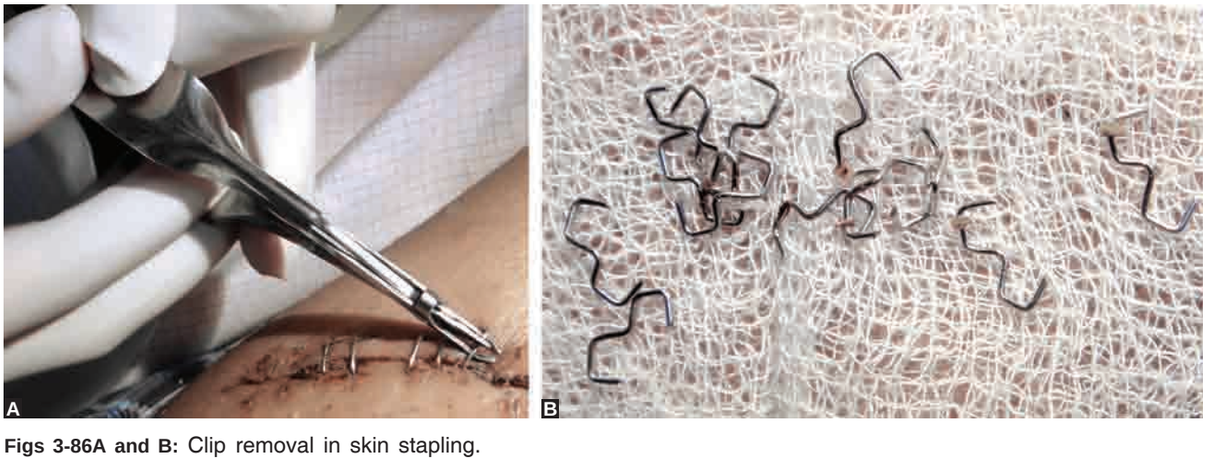
Endoscopic control of haemorrhage using laser, sclerotherapy, clips, etc. are tried. Angiogram and therapeutic embolisation using coils, gel foam, clot is used in bleeding duodenal ulcer, colonic bleeding.

Endostaplers and endoclips are used in laparoscopic surgery safely.



Figs 3-84A and B: Gel Form.

Fig. 3-85: Cutting the end of the knot.



Figs 3-86A and B: Clip removal in skin stapling.

Chapter

4

Day Care Surgery, Ambulatory Surgery, Outpatient Surgery

DEFINITION

It is a confusing entity with so many words with difficult understanding. It is fast developing and so equally important.

Day care surgery or ambulatory surgery is discharge within 23 hours of admission (USA); or surgery done without night stay (UK). It is often also called as *ambulatory surgery/minimal stay surgery*.

Even though all are similar technical meanings are little different.

Day care surgery means patient is fit to return home in 23 hours usually with or without overnight stay. *Ambulatory surgery means* patient recovers after surgery and returns home in the same evening. *Office surgery means* patient recovers from surgery and returns home in few hours. *Outpatient surgery* is different from day care surgery in that patient is not previously fully assessed in outpatient surgery. Only minor procedures are done in this. Patient is not admitted in out patient surgery. In day care and ambulatory surgery patient is admitted in the hospital.

Day care surgery has been defined by *the Royal College of Surgeons* as when the surgical day case patient is admitted for investigation or operation on a planned non-resident basis and who do not require facilities for recovery. This definition excludes upper and lower GI endoscopies, outpatient procedures such as flexible cystoscopy, and minor superficial surgery under local anaesthetic, none of which require full day case facilities for recovery.

It is a *unique upcoming field* in surgery wherein surgeon, general practitioner, nurse at care centre, anaesthetist work in hand so that hospital stay and cost is reduced. Patient who has prepared prior by all evaluation methods comes to the hospital, undergoes surgery/procedure, gets discharged at evening.

The cases are usually carried out under local, regional or general anaesthesia (monitored anaesthesia). Facilities and standards of care in the day care surgical unit must be alike to those provided for inpatient. The patient is to be formally admitted to day care unit, full work up and documentation is done and there should be facilities to observe the patient for 12 hours.

INTRODUCTION

In 19th century (1903) Glasgow surgeon James Nicoll did many day care surgeries in children. Dr RM Waters of Sioux City of Iowa in 1918 did first day care surgery under general anaesthesia. Dudley Street ambulatory surgical centre started in Providence Rhode Island in 1968 by Charles Hill. Society for Ambulatory Anaesthesia has established in 1984 for safety and undertaking of ambulatory surgery.

Ambulatory surgical set up may be:

- Hospital integrated.
- Hospital separated but accessible to the hospital.
- Satellite ambulatory unit.
- Free standing unit–totally independent.
- Office based unit–mainly in USA (20 % surgeries) but are said to be inadequately equipped.

Levels of ambulatory surgery are:
Minor (LA); Major (GA/Epidural); Inpatient ambulatory surgery.

Assessment done prior to surgery are by*—pre-anaesthetic clinics* with system evaluations; *health questionnaire* by surgeon and physician; *telephonic interviews*.

Patient selection, patient information, patient acceptance are important parts in day care surgery.

Procedures done in day care surgery set up are:

Excision of deep swellings; lymph node excision biopsy; therapeutic endoscopies; all procedures for haemorrhoids; hydrocele surgery; circumcision; hernia surgery; gynaecologic procedures; minor amputations; orthopaedic procedures like reduction, minor plating and screwing of bones, arthroscopies, surgeries of peripheral joints, surgeries for carpal tunnel syndrome, ear surgeries, small laryngeal and nasal surgeries, many ophthalmic surgeries like cataract surgeries, laser, etc.

Inguinal hernia, femoral hernia, small umbilical hernia, excision of skin tumours, many plastic surgeries are done in day care surgery.

Basic requirements are–in house anaesthesiologist; recovery room; theatre and recovery room/ward nurse; all essential surgical set up including monitor, ventilator.

The procedures that can be undertaken as day care surgical procedures are as per the BADS or Audit Commission of UK which came up with 'Basket of 20' surgical procedures to provide a more consistent measure of performance. The 25 procedures included as found updated in the report of the Audit Commission of UK, 2000 are as follows: (Updated report, 2001) —

1. Orchidopexy. 2. Circumcision. 3. Inguinal hernia repair. 4. Excision of breast lump. 5. Anal fissure dilatation or excision.

6. Haemorrhoidectomy. 7. Laparoscopic cholecystectomy. 8. Varicose vein stripping or ligation. 9. Transurethral resection of bladder tumour. 10. Excision of Dupuytren's contracture. 11. Carpal tunnel decompression. 12. Excision of ganglion. 13. Arthroscopy. 14. Bunion operations. 15. Removal of metalware. 16. Extraction of cataract with/without implant. 17. Correction of squint. 18. Myringotomy. 19. Tonsillectomy. 20. Submucous resection. 21. Reduction of nasal fracture. 22. Operation for bat ears. 23. Dilatation and curettage/hysteroscopy. 24. Laparoscopy. 25. Termination of Pregnancy. *The British Association of Day Surgery (BADS)* has recommended inclusion of another fifty procedures under the name of Trolley of procedures.

Selection criteria are–

American Society for Anaesthesiologist (ASA) category I and II patients can be taken up for day care surgery. ASA III/or beyond are contraindicated for day care surgery.

ASA (American Society of Anesthesiologists) grading of the patient for surgery

1. Normal individual
2. Mild–moderate systemic disease-Diabetes and hypertension under control
3. Severe systemic disease–uncontrolled diabetes and hypertension
4. Incapacitating systemic disease
5. Moribund status

Class E—Emergency surgery

Exclusion criteria for day care surgery are

- ASA grade beyond III or more.
- Obesity (BMT>35).
- Hypertension–not controlled.
- Surgery requiring more than one hour.
- Surgery with anticipation of major fluid/blood loss or needs postoperative critical care.
- Preterm babies and infants less than 3 month's age.
- Patient living in far and not easily reachable or able transport easily.
- Unstable psychiatric illness. If proper caregiver is not available.
- Uncontrolled diabetes, alcohol abuse, COPD, severe asthma, epilepsy.
- Pregnancy.

Final evaluation is done just prior to the date of surgical procedure. Patient should be assessed by surgeon, anaesthesiologist, and a physician. Once evaluation is done surgery should be undertaken ideally within 2 weeks.

Haematocrit, ECG, renal function tests–Blood urea and serum creatinine, blood sugar level, chest X-ray are to be taken. Other relevant investigations are done depends on specific diseases patient is having or suspected like cardiac (Echocardiography, cardiologist opinion) and respiratory diseases.

Patient should be asked to stop smoking at least 2 weeks prior to surgery.

Type anaesthesia should be decided by surgeon and in house anesthesiologist. Local anaesthesia is commonly used at present for small procedure like tapping, excisions, circumcision and hydrocele. Open inguinal or femoral hernia surgery is commonly done at present under local anaesthesia unless hernia is irreducible/large or patient is contraindicated for local anaesthesia. Laryngeal mask airway (LMA) or combined oropharyngeal airway are commonly used. Minimal or no premedication is the usual practice in day care surgery.

Laparoscopic hernia repair (TEP/TAPP) is also can be done under day care surgery but under general anaesthesia.

Proper written consent for anaesthesia, procedure, day care surgery with consent for possible needed admission if at all due to some complications should be taken.

Spinal or epidural anaesthesia also can be used in many procedures.

List of day care surgery for the day should be decided previous day after collecting clear information from the patient about him being coming for surgery without fail. Some inadvertent reasons if patient fails to turn up, then person on waiting list can be called upon for surgery if he is prepared and ready to do so.

TECHNIQUE

Technique is same as like any theatres. There is no deviation in principles and methodology of the procedure.

Sutures can be interrupted or absorbable subcuticular. Dressings are placed. Patient is asked to remove dressing in 3 days and is allowed to take bath normally in 3 days.

Ward nurse will monitor the patient properly about the recovery and should document it. Once she is sure of proper recovery then patient is discharged with proper intimation about oral drugs, diet, and rest in the house, to call and attend immediately in dire problems. Usually patient is discharged in 6 hours if procedure is done under local anaesthesia; in 8-12 hours if procedure is done under general/epidural/spinal anaesthesia. Clear cut discharge criteria should be followed and should be decided by anaesthesiologists and surgeons. *Aldrete scoring system* is used for fitness for discharge and safe transfer of the patient to the house.

Care Once at Home

This is equally important as patient has undergone surgery just few hours back. It is mainly be the patient, family members.

Patient should take rest that date (night) once he reaches home; diet should be initially liquid and later normal diet. Patient should be informed about one or two episodes of possible development of vomiting postoperatively due to anaesthesia which usually subsides eventually.

Informed caregiver mostly one the close family member is essential part of the day care surgery.

All instructions should be given properly in *a written form* clearly in understanding simple way.

Driving, decisive works, exercises should be avoided for 24 hours.

Any additional instructions should be taken as when needed over the phone by the patient.

Follow up by telephone in 12 hours, 24 hours and 48 hours should be done by the day care center (by nurse or anaesthetist or surgeon) as a mandatory.

Patient should be called for suture removal and if needed postoperative evaluation depends on the condition to which patient undergoes surgery.

General practitioner/family physician of the family/patient should aware of the patient undergoing surgery; he should visit give care to the patient. Extra responsibility comes to general practitioner.

Present Trend for Day Care Surgery

It is rapidly emerging field in surgery–in different specialties also. It *reduces cost*, mental agony to patient and family members. *Minimal hospital stay* makes it acceptable to the patient. 30% (in USA) - 40% (in UK) cost savings occur by day care surgery.

70% surgeries in USA and 60% surgeries in UK are done by day care surgery, and 20% surgeries in India.

Home diet given with care and feeling of away from hospital makes better recovery.

Infection rate comes down drastically in day care surgery because of avoidance of hospital acquired resistant infection.

Day care surgery probably reduces the disability.

Postoperative nausea and vomiting (50%); postoperative pain and postoperative drowsiness/dizziness (50%) are the *common complications* in day care anaesthesia.

But proper selections, proper follow up, immediate reaching facility to the hospital is done as day care procedure in case of emergency mainly *postoperative bleeding*, often vomiting, dehydration due poor intake, pain, discomfort and sedation–are the prerequisite cares.

It is developing field which needs modern anaesthetic and surgical set up with outstanding team and set up.

Alertness; ambulation; analgesia and alimentation–*basis for* day care surgery.

Chapter 5

Instruments

Surgical instruments are essential for any surgery, whether minor or major. All instruments should be sterilized prior to use to prevent infection.

Parts of an instrument (Fig. 5-1)

- Two finger bows for holding
- A ratchet or lock
- A pair of shaft or body
- Joint either box type (with a slot) or pivot (attached by a screw)
- Pair of blades at terminal part

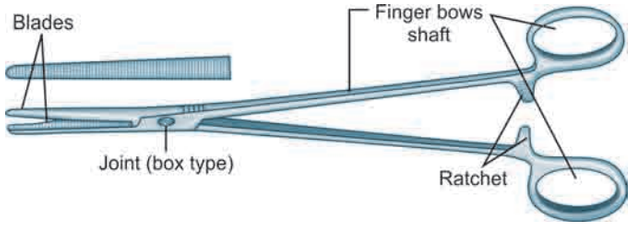


Fig. 5-1: Parts of an instrument.

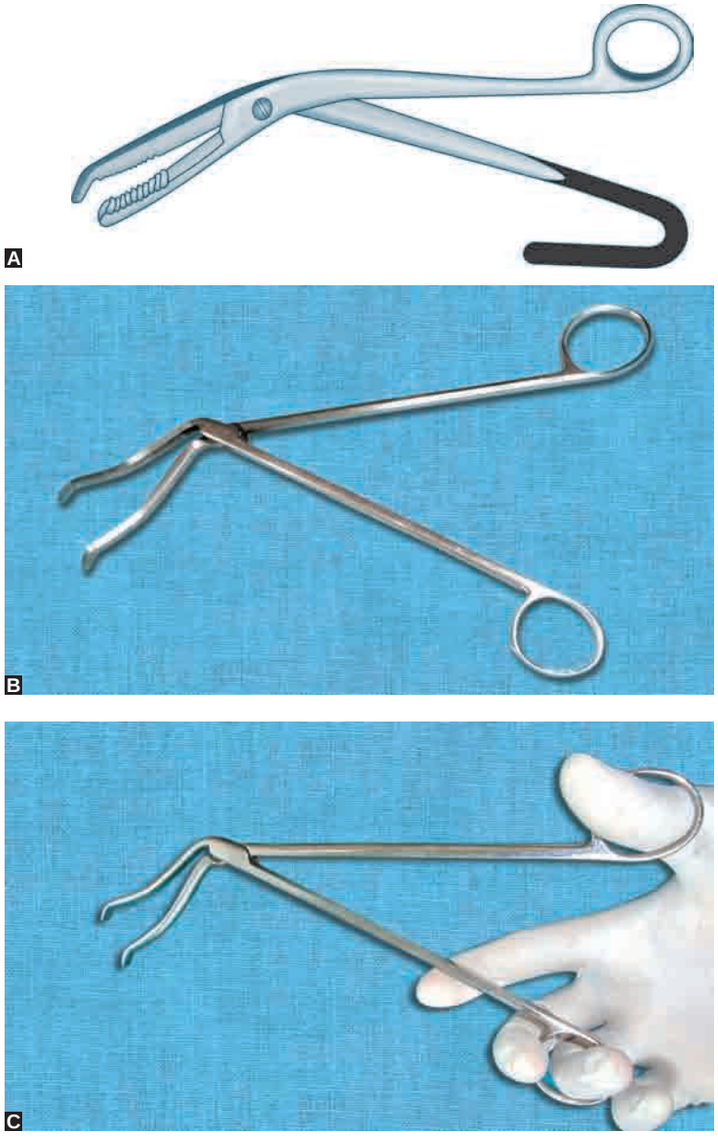
CHEATLE'S FORCEPS

It is used to pick sterilized articles like instruments and drapes so to avoid touching the instruments while transferring them from one tray/table to other. It is kept dipped in antiseptic solutions like savlon/cidex. It does not have lock. It is heavy metallic forceps with curved blades with serrations. One blade of the proximal handle has got rounded ring for inserting finger and other blade may be having ring or often has got free hook to have proper grip **(Figs 5-2A to C)**.

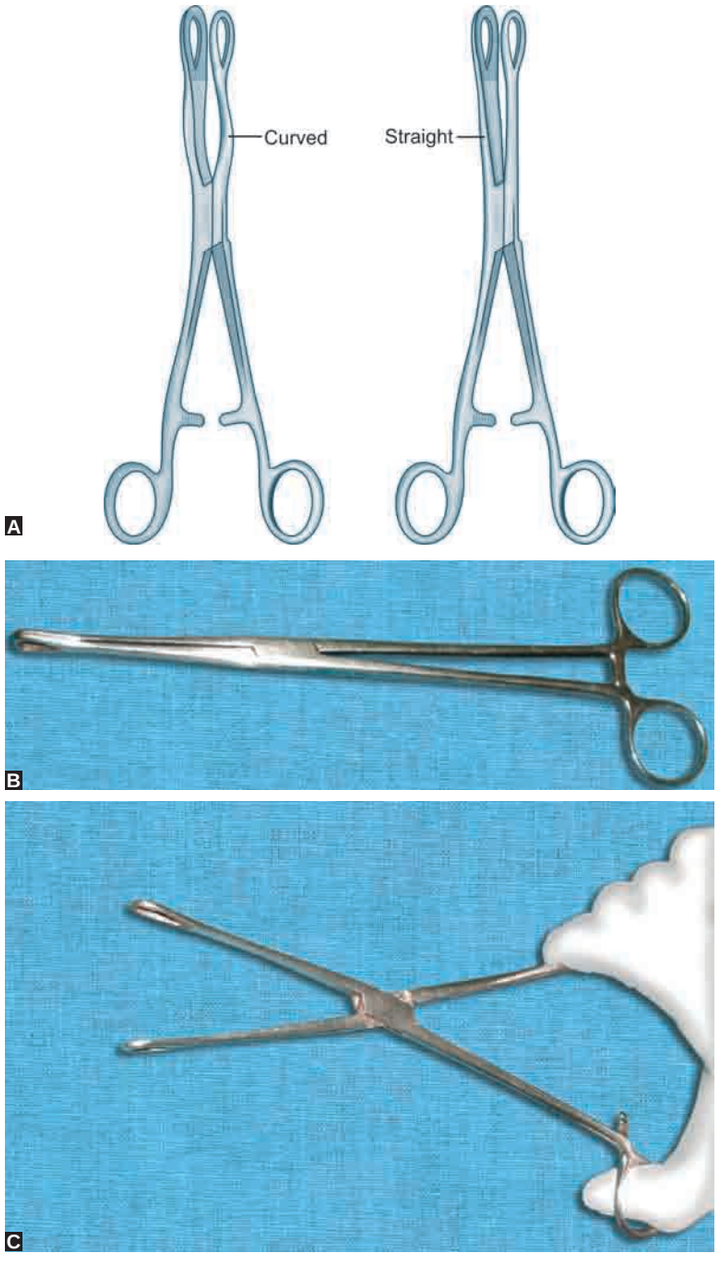
SPONGE HOLDING FORCEPS (RAMPLEY'S)

It has got fenestrated, serrated flat round distal end. It is 22.5 cm long; has a ratchet and two long blades **(Figs 5-3A to C)**.

It is used to clean the operative field. Because of the length, the surgeon's hand will not get contaminated while cleaning the patient, it is also used to swab the cavities, to mop the oozing area, to hold gall bladder or cervix or tongue or bowel or stomach during surgeries, for blunt dissections or as ovum forceps. It can also be used to dry the operative field using gauze. It can be used for blunt dissection with a wet firm swab held on the tip in vagotomy, sympathectomy. It can be used as haemostatic with a large gauze at the tip. It is used to hold Hartmann's pouch in open cholecystectomy. It is used to clean the vaginal cavities.



Figs 5-2A to C: Cheatle's forceps.



Figs 5-3A to C: Sponge holding forceps—(Rampley's) both curved and straight and also photo of the same.

MAYO'S TOWEL CLIP

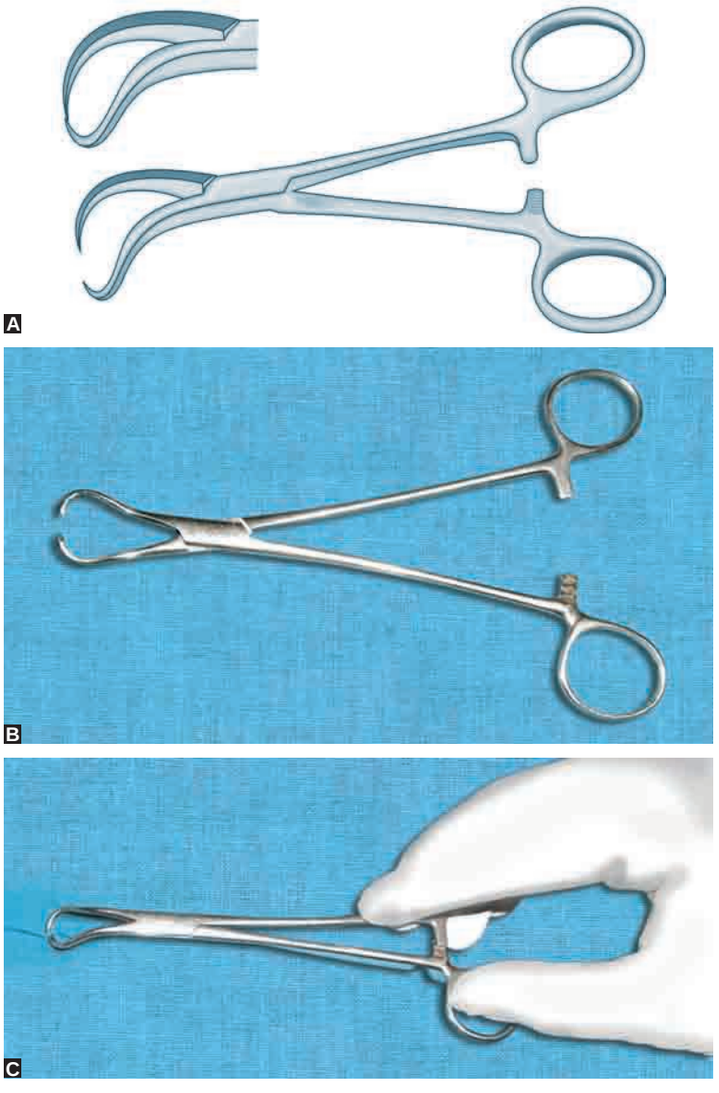
It is used to fix drapes in operative field. It is light but strong with small curved blades. Curvature helps to hold entire thickness of drapes firmly and easily. Two sharp teeth one on each blade cross each other but do not approximate (cross action tip) **(Figs 5-4A to C)**.

It is used to fix suction tubes, diathermy wires and laparoscopic cables on operative table.

It is used to fix ribs in flail chest.

It can be used to hold cord in hernia or to hold tongue if specific instruments are not available.

It can be used to hold dental wiring; patella during patellectomy; in faciomaxillary fractures.



Figs 5-4A to C: Mayo's towel clip.

BACKHAUS' TOWEL CLIP

It has got a ratchet catch, curved sharp ends which approximate each other, but do not cross each other (Approximating tip, but no cross action in tip) **(Fig. 5-5)**.

MOYNIHAN'S TETRA TOWEL CLIP/ FORCEPS

It is used to hold the cut edges of the skin incision to the four corners of the draped tetra towels so as to isolate the operative field. Isolation also can be achieved by suturing the drape margins to the subcutaneous tissue at different points or using adhesive plastic drape to skin through which the drape skin incision is made **(Fig. 5-6)**.

DOYEN'S TOWEL CLIP

It is a short instrument with curved ends with sharp points. Handles join at proximal ends. When handles are pressed tips open, when handles are released tips close and firmly grip the towel **(Figs 5-7A and B)**.

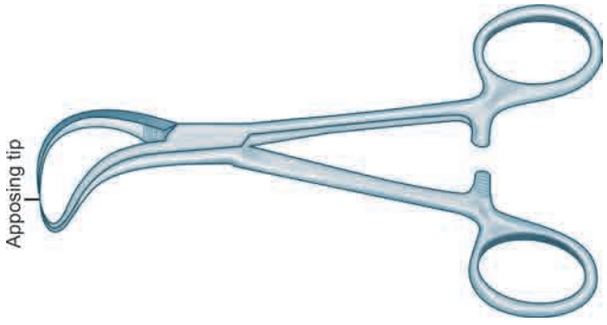


Fig. 5-5: Backhaus towel clip.

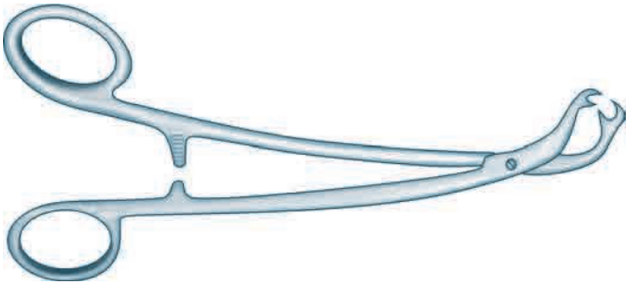
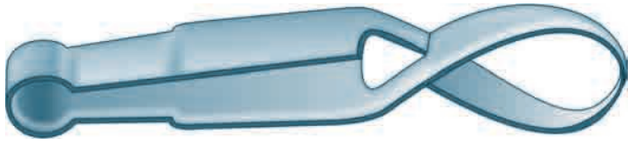
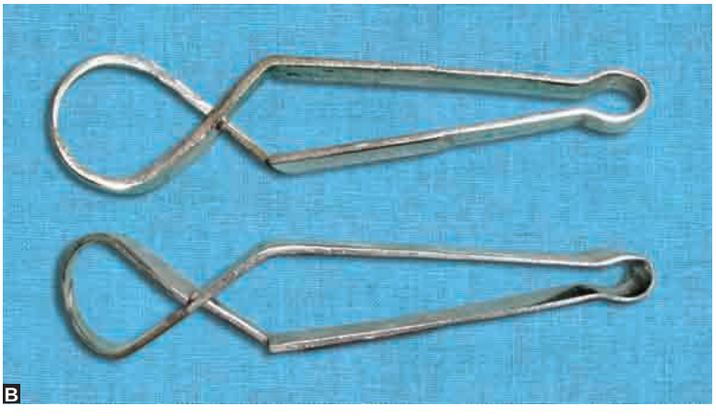


Fig. 5-6: Moynihan's tetra towel clip –it is with long blades with a curvature with two teeth in each blade (total four).





Figs 5-7A and B: Doyen's towel clips.

Towel clips

- Mayo's—cross action tip; no approximation.
- Backhaus'—approximating tip; no cross action
- Doyen's—tension blades open when pressed and vice versa
- Moynihan's tetra forceps/towel clip to isolate cut edge of the skin incision for isolation; has got two teeth on each blades
- Bull dog towel clip—has got cross section action with tapering points
- Gray's towel clips—not used now.

ARTERY FORCEPS (HAEMOSTAT)

Types (Figs 5-8 and 5-9)

Based on size—

- Small or mosquito artery forceps–*Mosquito forceps* is so called because of its fine tip which can even catch the proboscis of a mosquito.
- Medium sized artery forceps.
- Large artery forceps.

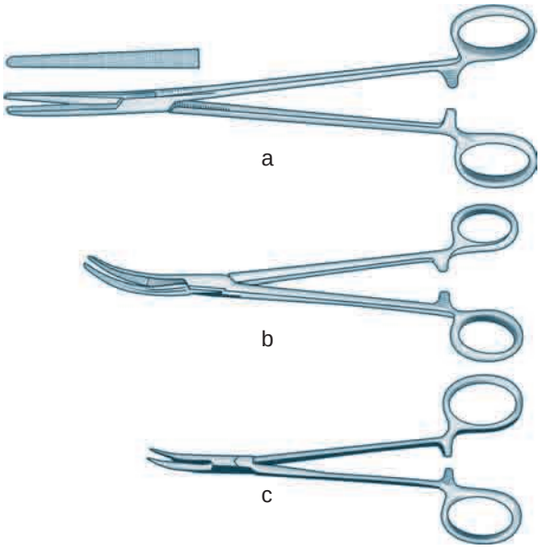


Fig. 5-8: Artery forceps: (a) Straight, (b) Curved, (c) Mosquito (Halsted).

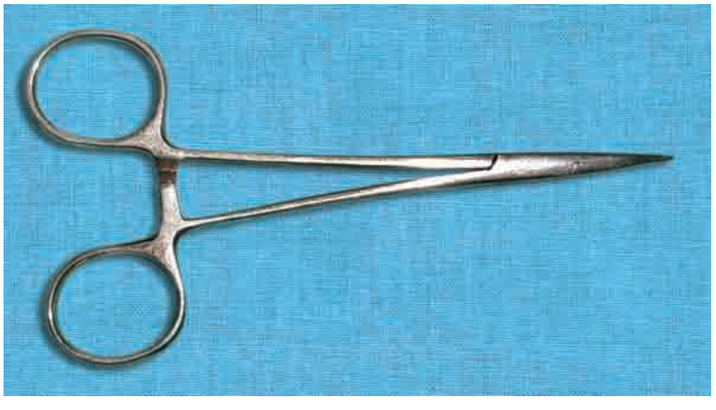


Fig. 5-9: Small sized curved Halsted haemostat–Mosquito artery forceps.

Based on shape—

- Straight artery forceps.
- Curved artery forceps.

Features of artery forceps—

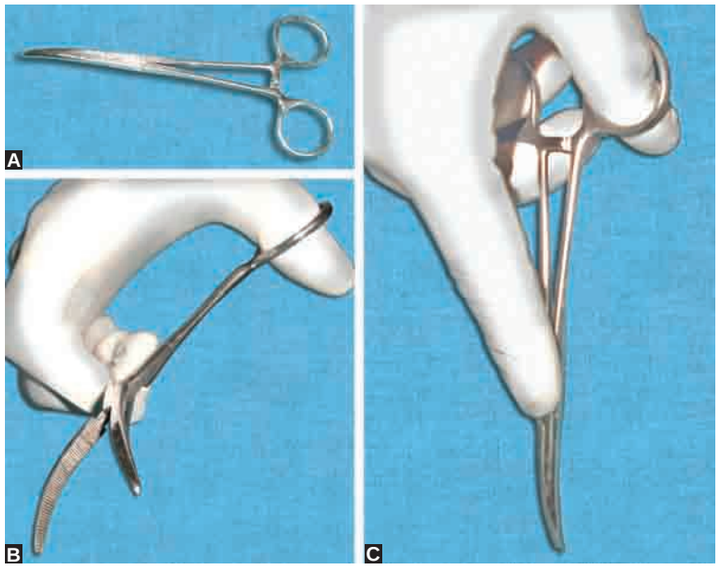
- Distal blades are having transverse serrations which are well apposed.
- Lock in the proximal part.

Uses—

- To catch bleeding points.
- To open the facial planes in different surgeries.
- To pass a ligature and to hold it

- To hold fascia, peritoneum, aponeurosis.
- To hold sutures.
- To drain an abscess like a sinus forceps.
- To hold gauze as pea-nut.
- To crush the base of the appendix.
- To clamp a catheter in between the hinge and ratchet of the haemostat.
- To catch prepuceal skin in circumcision.
- Mosquito forceps *(Halsted)* is used in paediatric surgery/microsurgery/cleft surgery/plastic surgery.

Instrument can also be used to catch arteries/veins/capillaries and so ideally should be called as *haemostat*. But common word used is artery forceps. Haemostat has got serrations on the distal half of the each blade (In pedicle clamp entire blade has got serrations) **(Figs 5-10A to C)**.



Figs 5-10A to C: Artery forceps showing its inner aspect with transverse serrations–Spencer-Wells haemostat/pedicle clamp. It is better called as haemostat. Many named artery forceps/haemostats are available with little different in features. More or less all serve similar functions. Serrations in entire length of the distal blades is traditionally a stout haemostat or pedicle clamp (Spencer-Wells) whereas traditional artery forceps has got serrations only near the tip/distal half of the inner blade. There is no need to remember such confusing entities even though these are facts.

Medium sized, curved half serrated haemostat, called as *Kelly's artery forceps* **(Figs 5-11 and 5-12)**.

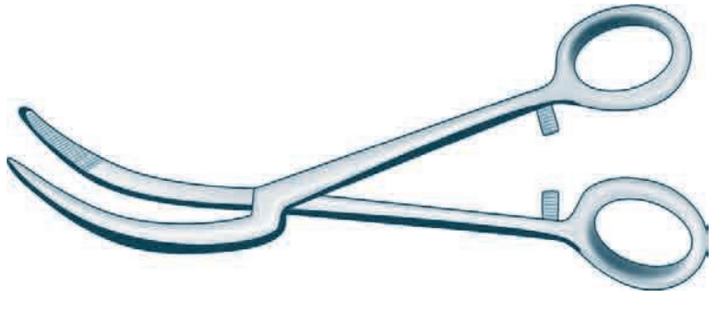


Fig. 5-11: Kelly's artery forceps–commonly used haemostat.

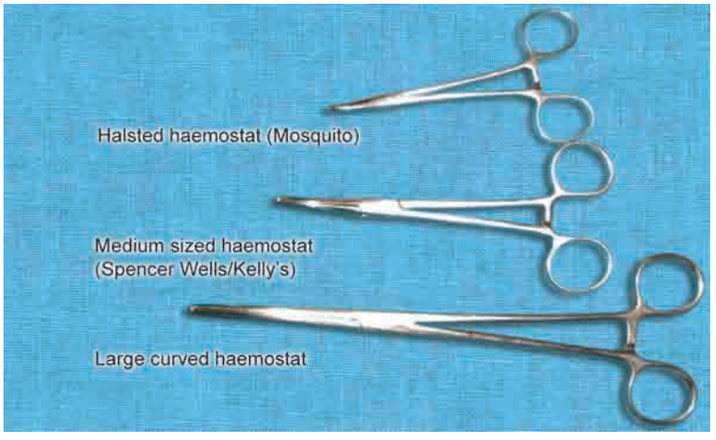


Fig. 5-12: Different sized curved haemostats.

NEGUS ARTERY FORCEPS

It is stout long jawed instrument (forceps) with distal part of the jaws bent like a hook with transverse serrations. It is used to catch bleeding part of the tissues prior to ligation. Initially bleeding area is clamped with haemostat, later Negus artery forceps is clamped underneath and artery is released. It facilitates easier passage of the ligature across the bleeding vessels or tissues **(Fig. 5-13)**.

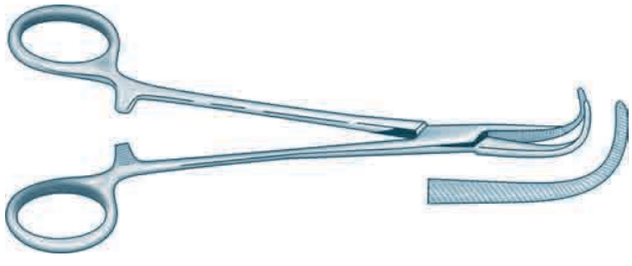


Fig. 5-13: Negus artery forceps.

RIGHT ANGLE FORCEPS–MEIGSTER'S/ LAHEY'S

It has got 90° curves in terminal 1 cm part of the blades. Blades are *longitudinally* serrated. It has got a ratchet. Tip is blunt. It is used to dissect pedicles and to pass ligatures, to dissect the vagus and ligate in vagotomy, to hold bleeding vessels in depth, to dissect major vessels, to dissect and pass ligatures to cystic duct and cystic artery in cholecystectomy and in thyroid, biliary, splenic, gastric, renal and pelvic surgeries **(Figs 5-14A to D)**.

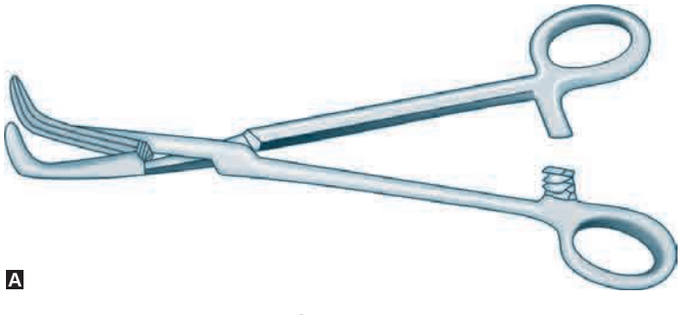
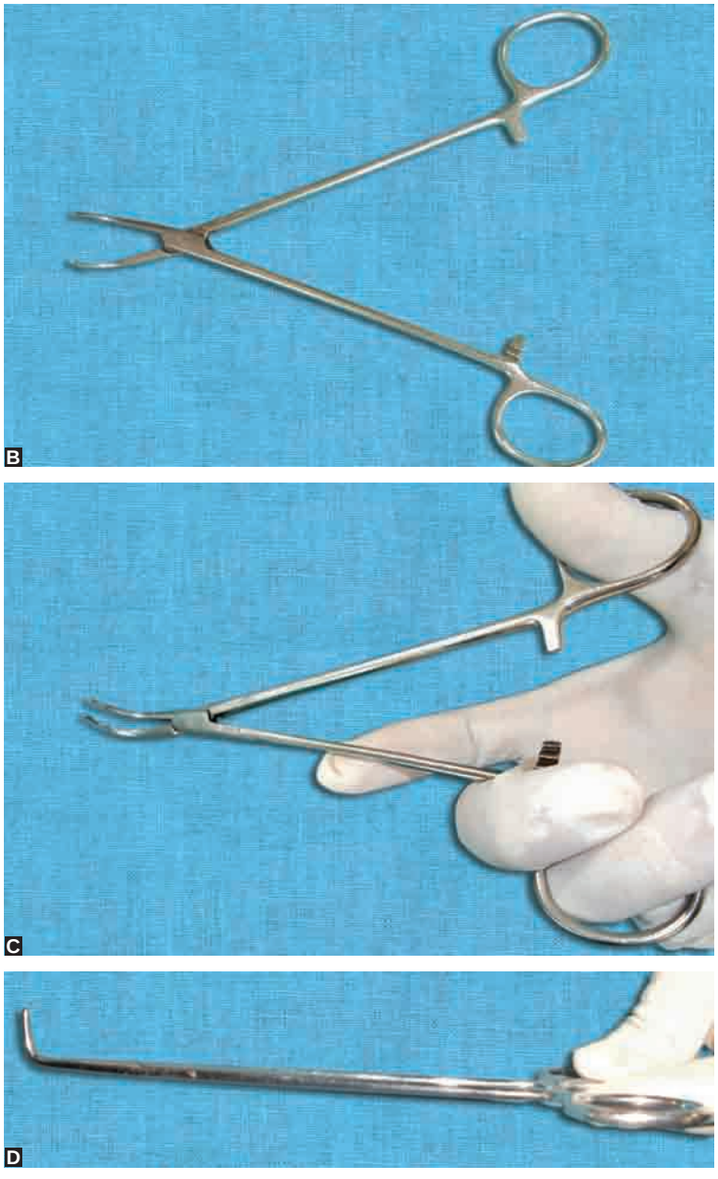


Fig. 5.14A



Figs 5.14B to D

Figs 5-14A to D: Meigster right angle forceps.

WELL'S ARTERIAL CLAMP

It has got doubly right angled distal blades with longitudinal serrations in the jaw. It is used to clamp pedicles like in nephrectomy or splenectomy **(Fig. 5-15)**.

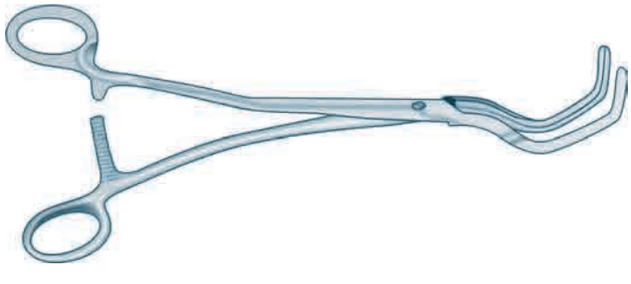


Fig. 5-15: Well's arterial clamp.

BULLDOG CLAMP

Light bulldog clamp has got pinch cock action to open and close. Blades have got fine transverse serrations. Pott's bulldog clamp is paper clip like instrument with strong jaws (with serrations) with spring loaded handle which permits a secure grip of the vessel. Bulldog clamp is used to clamp vessels during vascular anastomosis like for creating AV fistula in patient with renal failure; major vessel surgeries as for aorta, inferior vena cava, portal vein, etc. With a firm grip it blocks the vessel without injuring the vessel wall and without any chance for slippage. Pott's bulldog clamp is used for large vessels like aorta, vena cava **(Figs 5-16 and 5-17)**.

Fig. 5-16: Bulldog clamp.

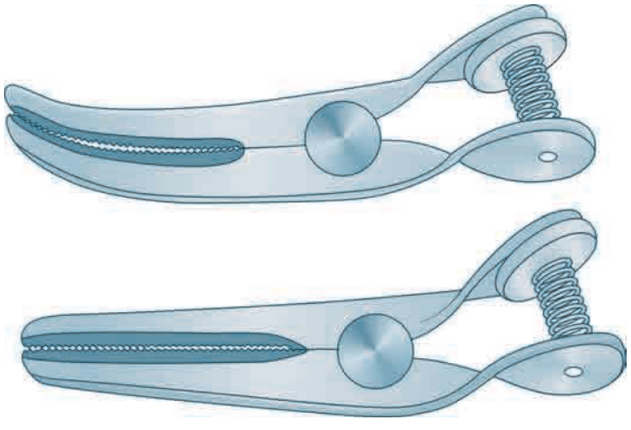


Fig. 5-17: Pott's bulldog clamp.

SATINSKY VASCULAR CLAMP

It is light atraumatic long instrument with C shaped distal blades which has got fine teeth within. It has got a ratchet. It can be applied to part of the circumference of the vessel in portal vein, iliac veins, inferior vena cava while removing tumor thrombus in renal cell carcinoma, in pancreatectomy, major vessel surgeries. Vascular anastomosis can be done using it **(Fig. 5-18)**.

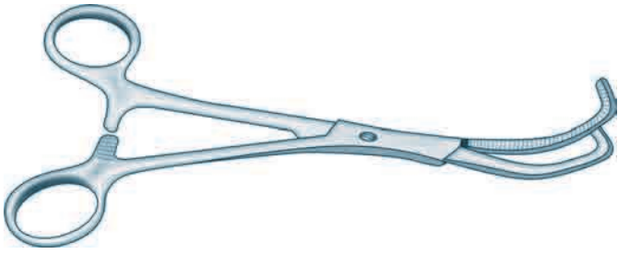


Fig. 5-18: Satinsky vascular clamp.

DE BAKEY'S VASCULAR CLAMP

Its blades are long and well angulated so that it can be used to clamp vessels/bleeders in the depth with good grip without damaging the vessel wall **(Fig. 5-19)**.

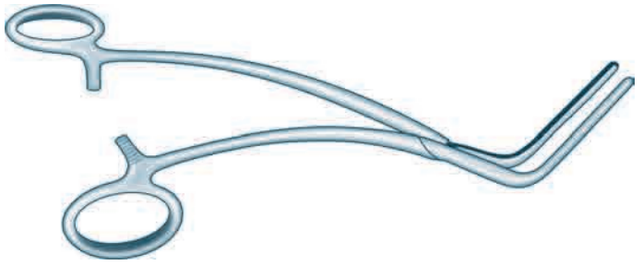


Fig. 5-19: De Bakey's vascular clamp

PEDICLE CLAMPS

A pedicle clamp is a stout haemostat with straight or curved blades with a ratchet. Entire blades are serrated here. It can be with or without teeth.

- *Spencer-Wells pedicle clamp/artery forceps*— has blunt tip without teeth. It can be straight or curved. Its blades are entirely serrated. It can be small/straight/large **(Fig. 5-20)**.

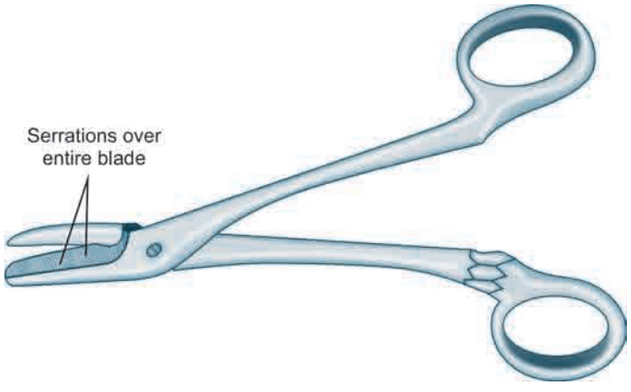


Fig. 5-20: Spencer-Wells's clamp/artery forceps.

- *Robert's pedicle clamp*—It is stout curved instrument with transverse serrations in the distal blades on entire length with a ratchet. Tip is without teeth. It is used to clamp major pedicles during surgeries like nephrectomy/splenectomy **(Fig. 5-21)**.

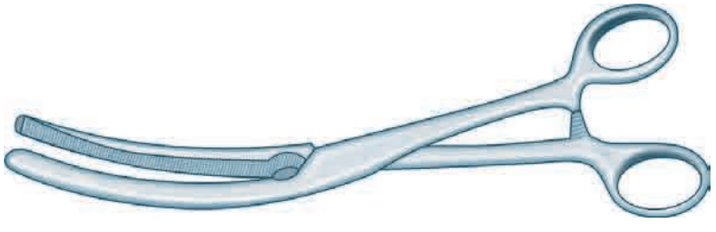


Fig. 5-21: Robert's pedicle clamp.

- *Maingot's pedicle clamp* has got longitudinal ridge on one of the distal blades and a groove to receive in the other blade. Tip has got one–in–two teeth. It has got ratchet. It is a crushing clamp **(Fig. 5-22)**. It is stronger than Kocher's forceps/clamp.
- *Kocher's forceps/clamp*–It has got transverse serrations with one–in–two teeth at the tip. It has got a ratchet. It can be curved/straight.
- *Mayo's pedicle clamp* is stout and large with curved long blades with serrations. It is useful in clamping major pedicles.

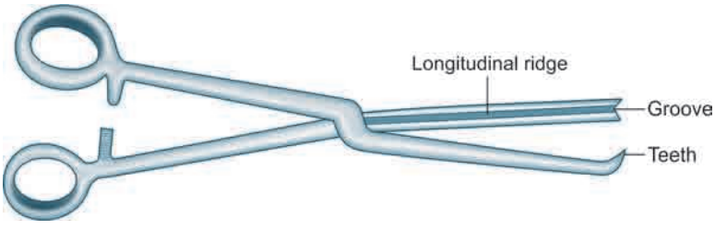
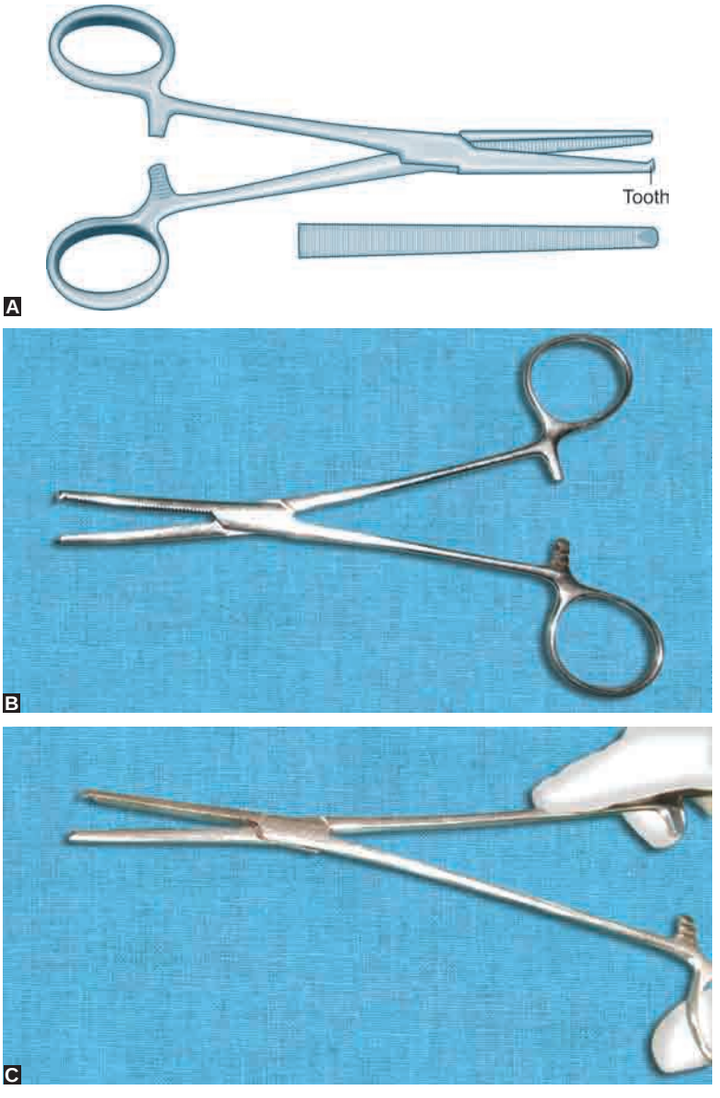


Fig. 5-22: Maingot's pedicle clamp.

KOCHER'S FORCEPS

It has got serrations in the distal blades and apposing tooth in the tip. It holds the tissues/pedicle well and prevents slippage of the tissues and retraction of the vessels/bleeders. It can be straight or curved; small/medium or large type **(Figs 5-23A to C)**.



Figs 5-23A to C: Kocher's forceps (Theodor Kocher from Switzerland got Nobel prize for his extensive work of thyroid surgery–also refer chapter one).

It is used to hold pedicles, tough structures, cut ends of the muscles like—in thyroidectomy/haemorrhoidectomy/mastectomy/polypectomy/hysterectomy.

It is used to hold tough/fibrous structures like in palms/soles/scalp to prevent retraction of vessels during surgery.

It is used to hold peanuts (gauze pellets of 3-4 mm sized used in blunt dissection).

It is used to hold gauze for blunt dissection; to hold resected bowel; to hold ribs during rib resection.

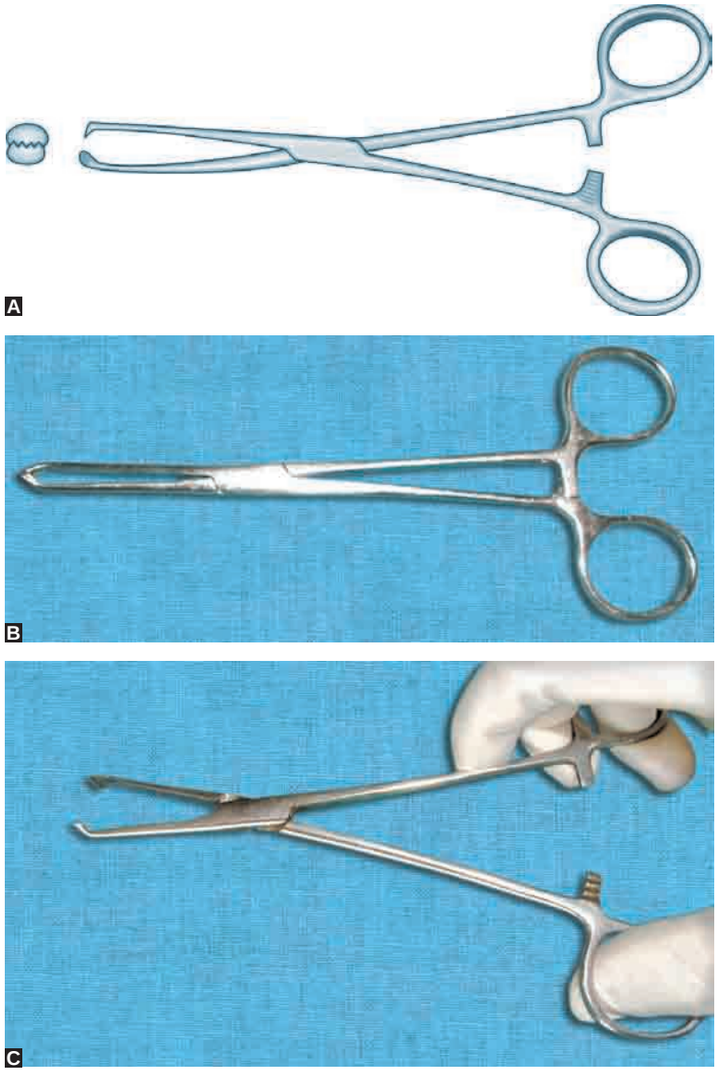
ALLIS' TISSUE HOLDING FORCEPS

Here distal blades are not apposing each other.

Tip has got teeth in each straight blade which are apposing.

It has got *ratchet*.

It is used to hold skin flaps, fascias, fibrous tissue, aponeurosis, galea (in craniotomy) and bladder wall **(Figs 4-24A to C)**. It is essential instrument in any surgery whether major or minor. It can be small/medium/large. Large Allis is used in hysterectomy to hold vaginal wall and tough structures. It is better not to use this instrument to hold delicate structures like bowel/vessel wall.

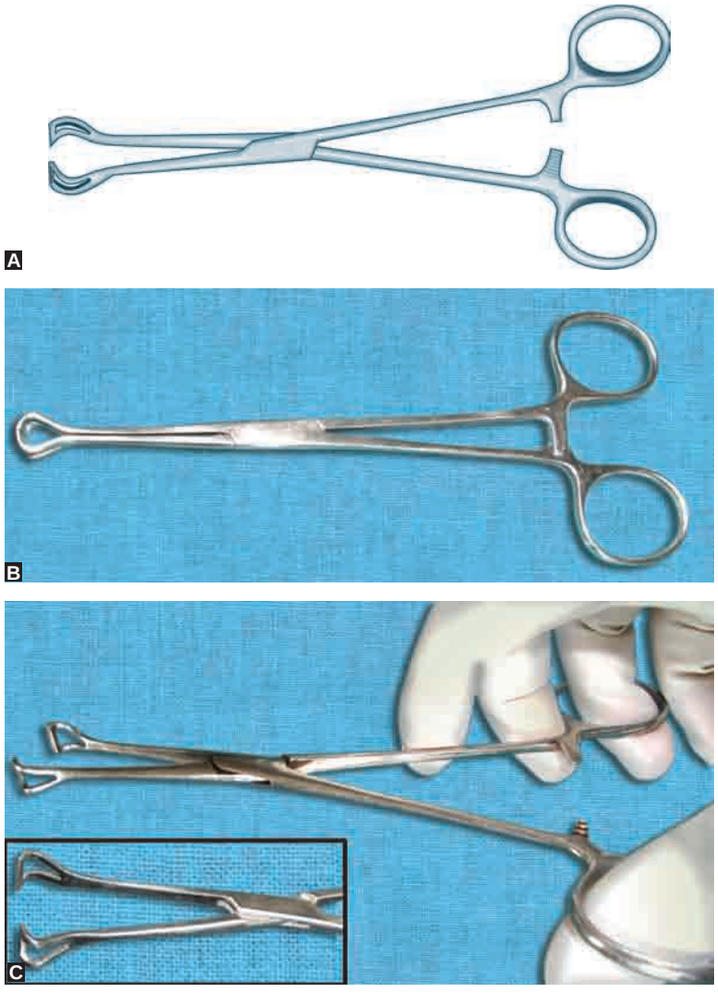


Figs 5-24A to C: Allis' tissue holding forceps.

BABCOCK'S FORCEPS

The distal parts of distal blades are curved with triangular fenestra in it which allows soft tissues to bulge out. Tip is non-traumatic with transverse serrations/ridges on it. It has got a ratchet.

It is used to hold any part of the bowel, fallopian tubes, appendix, urinary bladder, ureter, spermatic cord, lymph node **(Figs 5-25A to C)**.



Figs 5-25A to C: Babcock's forceps.

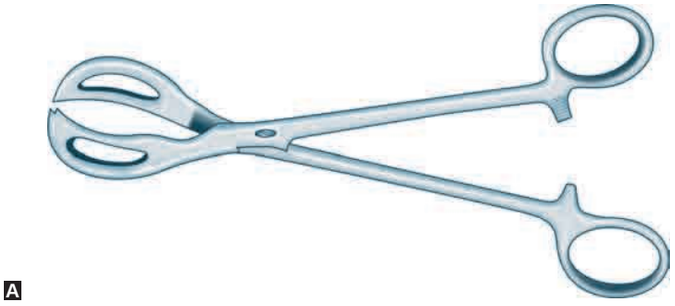
LANE'S TISSUE HOLDING FORCEPS

It has got thick, stout distal blades with oval fenestra in each blade with a broad expanded curvature at the end. It has got apposing tooth (one in two) at the tip and a ratchet **(Figs 5-26A to C)**.

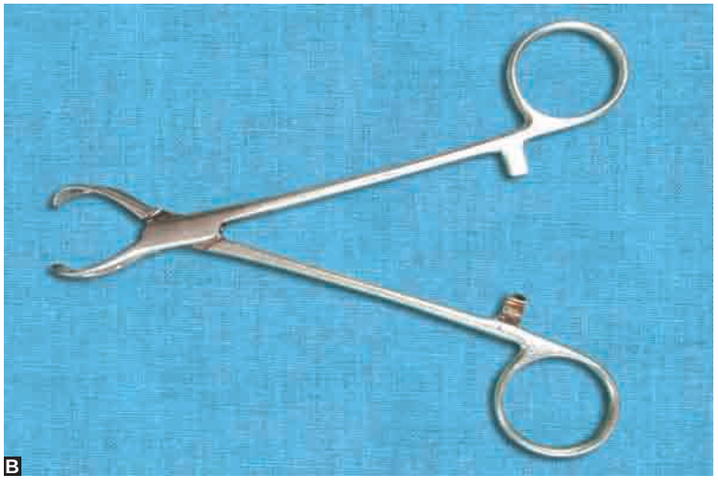
It is used to hold bulky and tough structures (like to hold breast during mastectomy; to hold salivary glands while excising); to hold lymph nodes; to hold tumour tissue. It is also used as towel clip and sponge holding forceps. It is used to hold linea alba and aponeurosis.

MORRANT-BAKER'S APPENDIX HOLDING FORCEPS

It is like Lane's forceps but with apposing serrations proximal to the tooth. These serrations give a good grip on mesoappendix while holding appendix in appendicectomy. Its use is replaced by Babcock's forceps **(Fig. 5-27)**.



A



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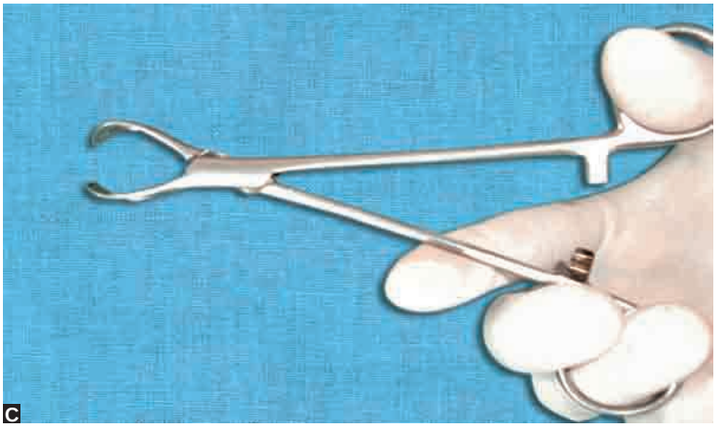


C

Figs 5-26A to C: Lane's tissue holding forceps.

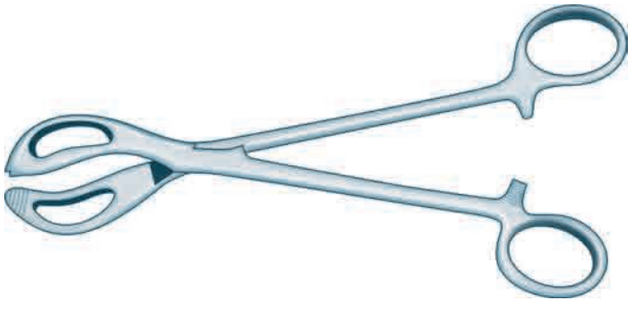


Fig. 5-27: Morrant-Baker's tissue holding forceps.

MOYNIHAN'S TISSUE FORCEPS

It is the tissue holding forceps with thinner and curved blades. Its uses are like Allis' forceps **(Fig. 5-28)**.

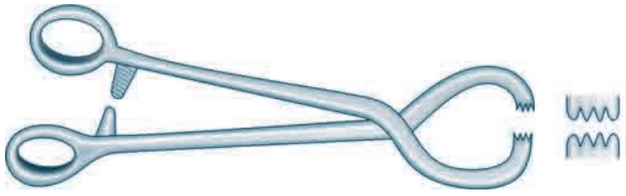


Fig. 5-28: Moynihan's tissue forceps.

KOCHER'S GLAND HOLDING FORCEPS

It has got terminal curved rings on each blade with two spikes on each with inward direction. These spikes create a secure grip of lymph nodes while holding **(Fig. 5-29)**.

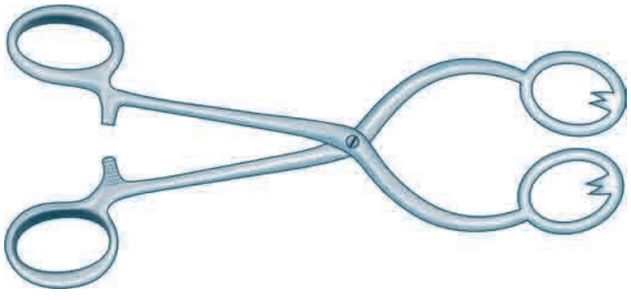


Fig. 5-29: Kocher's gland holding forceps.

YOUNG'S GLAND FORCEPS

It has got long blades with each blade having rounded flat end with a fenestra without any serrations on its inner aspect. It is atraumatic. It has got ratchet. It is used to hold lymph nodes, cyst wall during surgical excision **(Fig. 5-30)**.

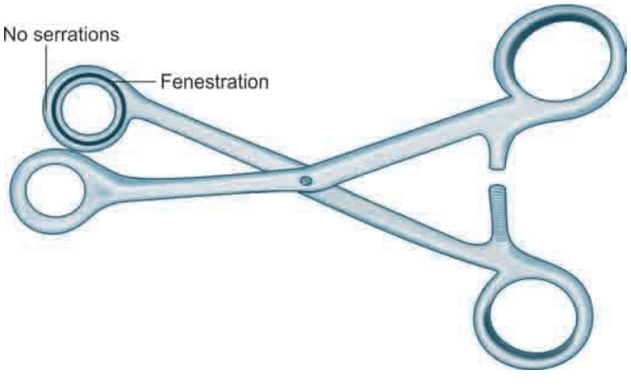
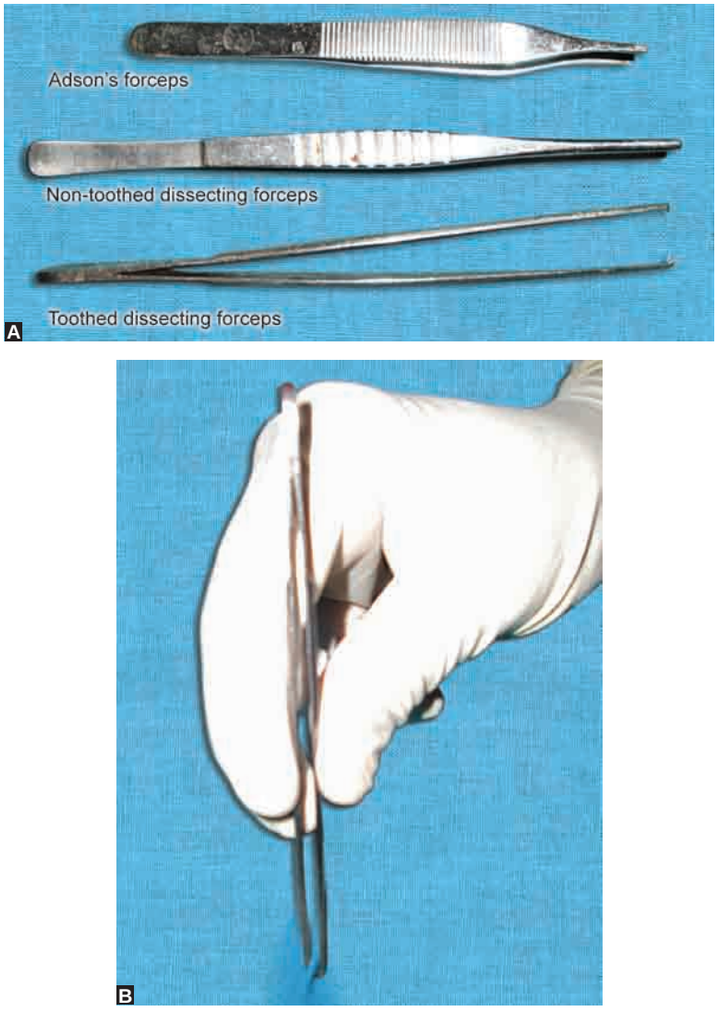


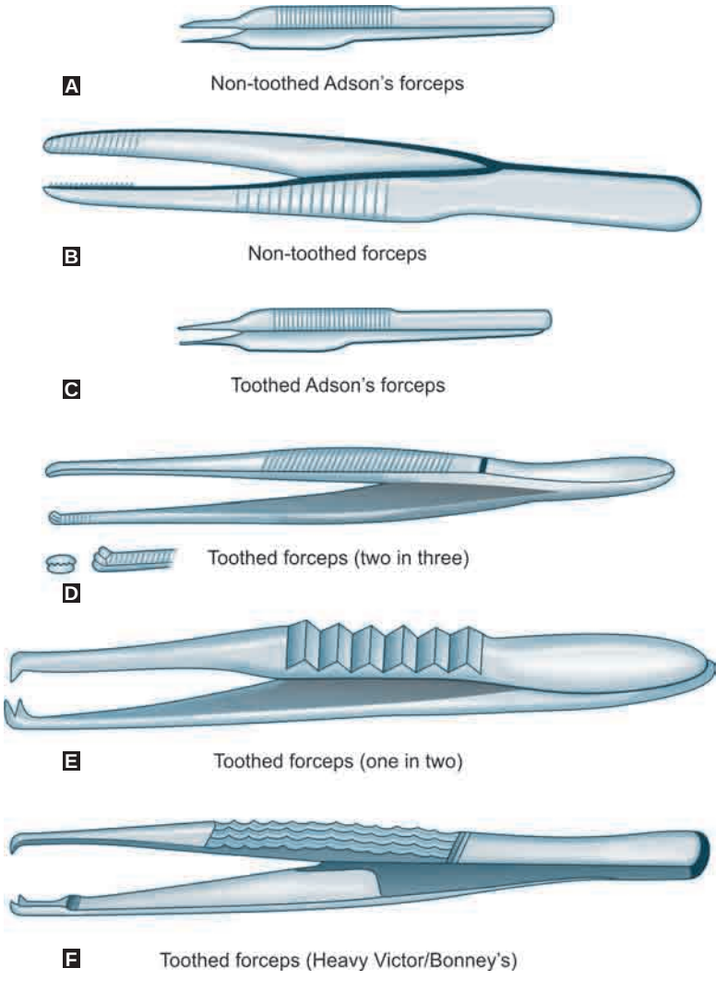
Fig. 5-30: Young's gland holding forceps.

DISSECTING FORCEPS

It is basic essential instrument. It can be toothed or non-toothed. Its outer surface has got serrations/grooves in the middle part. Over this area fingers are placed like a pen to get a good firm grip of the instrument. It is used to hold the tissues and different layers like skin, fascia, aponeurosis, peritoneum, bowel, vessel, nerve, muscle, etc. Toothed dissecting forceps is used to hold skin and other tough structures. It can be one in two/two in three toothed forceps. It is also used for suture removal **(Figs 5-31A and B)**.



Figs 5-31A and B: Different types of dissecting forceps. Photo showing how to hold dissecting forceps.



Figs 5-32A to F: Dissecting forceps (A) Non-toothed Adson's fine forceps, (B) Non-toothed forceps, (C) Toothed Adson's fine forceps, (D) Toothed forceps–two in three type, (E) Toothed forceps-one in two type, (F) Toothed forceps - heavy Victor Bonney's type.

Plain Non-toothed Dissecting Forceps

It is used to hold delicate soft, friable structures like peritoneum, vessels, bowel, nerves, and tendons. It cannot be used to hold skin or tough structures. During surgical dissection it is used to hold/fix/steady/stretch the structures as needed. It is also used to hold and cauterize small bleeding vessels **(Figs 5-32A to F)**.

Toothed-dissecting Forceps

It is used to hold skin and tough structures like fascia, aponeurosis; to remove sutures. It is not used to hold delicate structures like bowel/vessel/nerve. It can have one in two teeth or two in three teeth. Small, fine forceps used for fine works is called as Adson's forceps. *Adson's forceps* can be toothed or non - toothed. *Victor–Bonney's* forceps is heavy toothed dissecting forceps.

KOCHER'S THYROID DISSECTOR

It has got a curved blade with vertical grooves on it. There is an eye on its tip. It is used to dissect the upper pole of thyroid in thyroidectomy and to place as a surface while cutting the superior pedicle. Through eye ligature can be passed **(Fig. 5-33)**.

Fig. 5-33: Kocher's thyroid dissector.

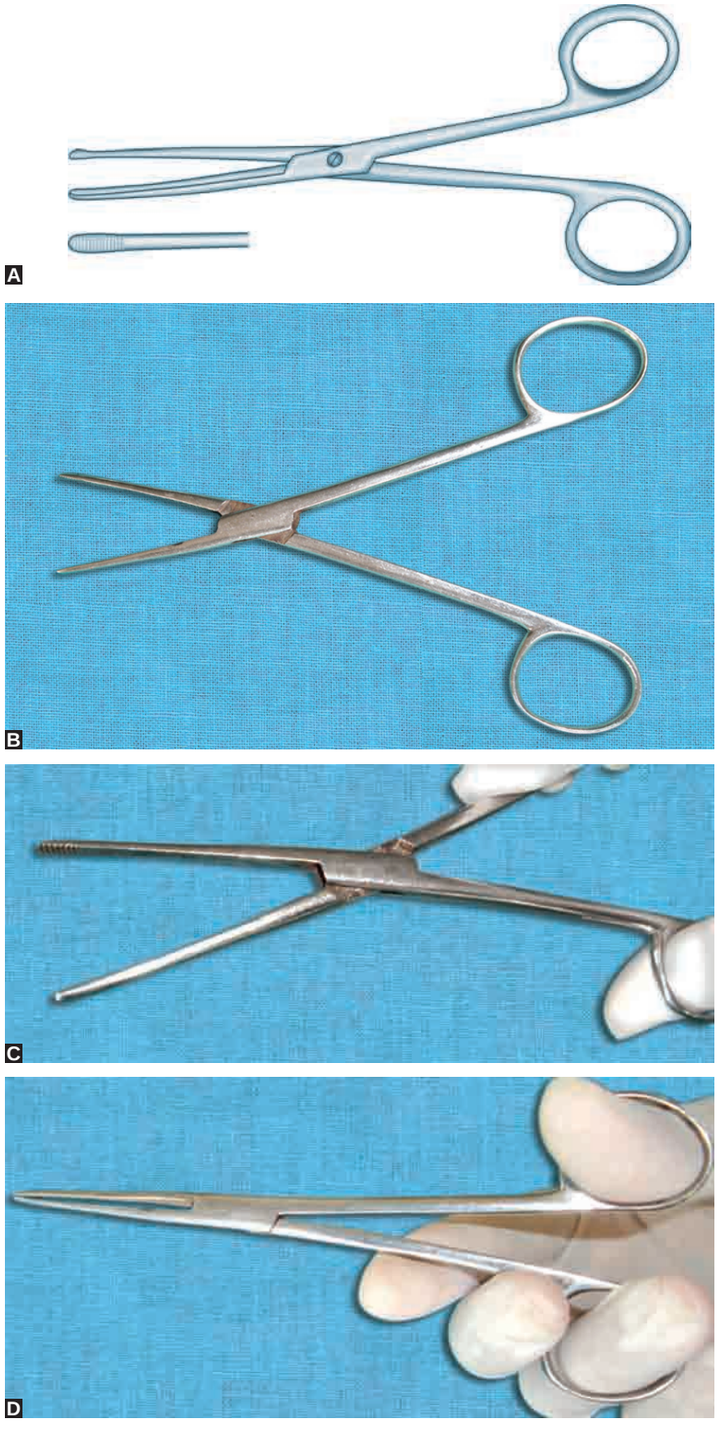
SINUS FORCEPS (LISTER'S)

It has got straight, long blades with serrations in the tip. It does not have ratchet. Serrations allow it hold and break the loculi or wall of the abscess cavity. It is a blunt instrument and so least traumatic and so adjacent neurovascular bundle will not get damaged **(Figs 5-34A to D)**.

It is used to drain pus from abscess cavity (*Hilton's method)*. It is called as sinus forceps because it is initially originated to pack the sinus cavities. It is also used to pack nasal cavity and ear. It is less traumatic.

RUSSIAN FORCEPS

This forceps has got clubbed tip in the blades with serrated inner surface. It is used to hold skin while skin suturing. It gives a very good grip over the skin while suturing without injuring it **(Fig. 5-35)**.



Figs 5-34A to D: Lister's sinus forceps. It does not have lock. It has got serrations on the inner aspect of the distal blades.

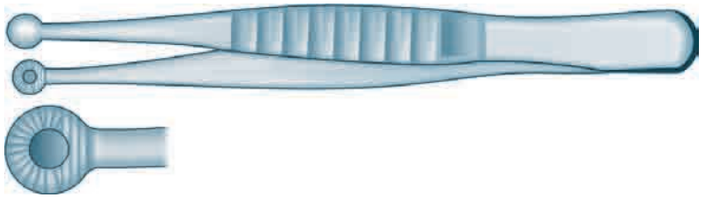


Fig. 5-35: Russian forceps used to hold skin while suturing.

RETRACTORS

A retractor is an instrument used to retract tissues away from the operating field; to expose surgical field properly; to carry out surgery precisely and also to prevent damage to adjacent structures while conducting operation. It also prevents the unnecessary handling of the adjacent tissues **(Fig. 5-36)**.

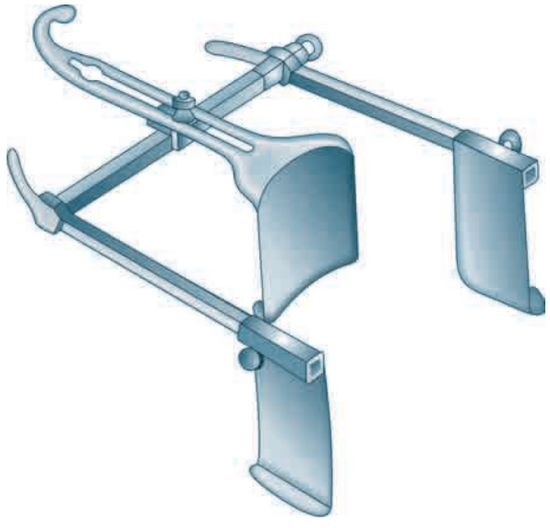


Fig. 5-36: Self-retaining retractor.

Types of retractors –

- *Light retractor* is used to retract vessels, nerves, tendons or any delicate structures.
- *Heavy, stout retractors* are used to retract abdominal wall, ribs, sternum, etc.
- *Broad, flat retractors* are used to retract at curved different angles like for liver, spleen, kidney, bowels, etc.
- *Hook retractors* are used to retract soft tissues.

Retractor may be *plain/non-self-retaining/manual* (which is held by an assistant and its position is adjustable time to time) or *self-retaining* (fixed retraction and continuous non-altered/mechanical). Retractor can also be self-illuminating also with a power lamp at the corner of the blade. Drawback of the manual retraction is that assistant can get fatigue by continuous retraction. Over retraction and injury is possible here.

Self-retaining retractor will not allow regular relaxation of tissues and non-adjustable. It is also bulky. But it maintains fixed position and assistant hands are free for additional work. It may inflict tissue trauma underneath. Placing mops under these instruments will reduce such adverse effect. Fixed deep blades may injure deeper structures like bowel in abdomen. These fixed retractors can be of different types. Chain retractor is cheap good retractor used to retract costal margins in abdomen with blade placing under the costal margin/lower sternum. Its proximal end is connected to an ordinary chain which is fixed to upper end of the table through a stirrup. It is used for surgeries for hiatus hernia, achalasia cardia and lower oesophagus; surgeries of spleen, biliary systems. Upper hand retractors, Omni retractors are different complex retractors used with ends attached to both sides of the operating table. These retractors provide stable exposure of the surgical field to operating surgeon.

Remember–retraction should be gentle and adequate. Over retraction can cause injury to the retracted organ/tissues and often bleeding

Uses of retractors

- Retraction of cut edges of the incision.
- To hold important structures like liver/spleen, etc. away from surgical field.
- To steady the tissues.
- To control bleeding.
- To avoid inadvertent trauma to adjacent structures.

SINGLE HOOK RETRACTOR

It is used to retract the skin. It is used in excision of swellings like cyst, lipoma and neurofibroma. It is used to hold skin flaps while raising the flaps **(Fig. 5-37)**.

Fig. 5-37: Single hook retractor.

VOLKMANN'S RETRACTOR/CAT'S PAW

It is used to retract fascias in soles and palms. There are multiple hooks with pointed edges. Uses are same as single hook retractor. Handle has got serrations. It cannot be used to retract delicate tissues due to presence of sharp teeth at the retracting end **(Fig. 5-38)**.

Fig. 5-38: Volkmann's retractor.

FISCH NERVE HOOK

It is a fine delicate blunt nerve hook used to retract nerves during surgery. Examples: Spinal accessory nerve and hypoglossal nerve retraction in block dissection; ilioinguinal nerve in hernia surgery; lingual and hypoglossal nerves in submandibular surgeries; facial nerve in parotidectomy **(Fig. 5-39)**.

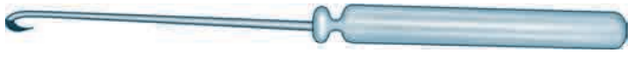


Fig. 5-39: Fisch nerve hook.

SKIN HOOK

It has got sharp curved tip to hold skin with a single puncture. It is used to hold skin flaps during its raise. It is essential instrument in plastic surgery **(Fig. 5-40)**.

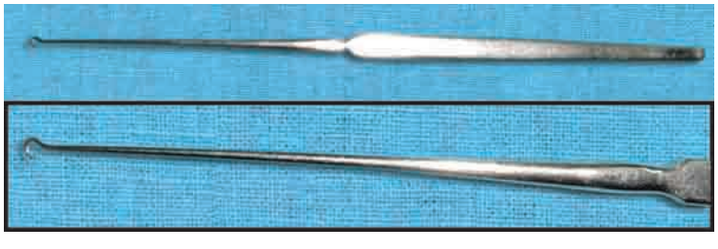
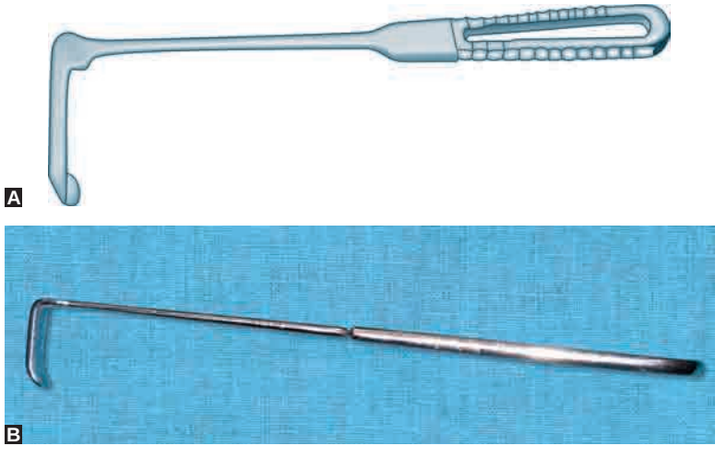


Fig. 5-40: Skin hook.

LANGENBECK'S RETRACTOR

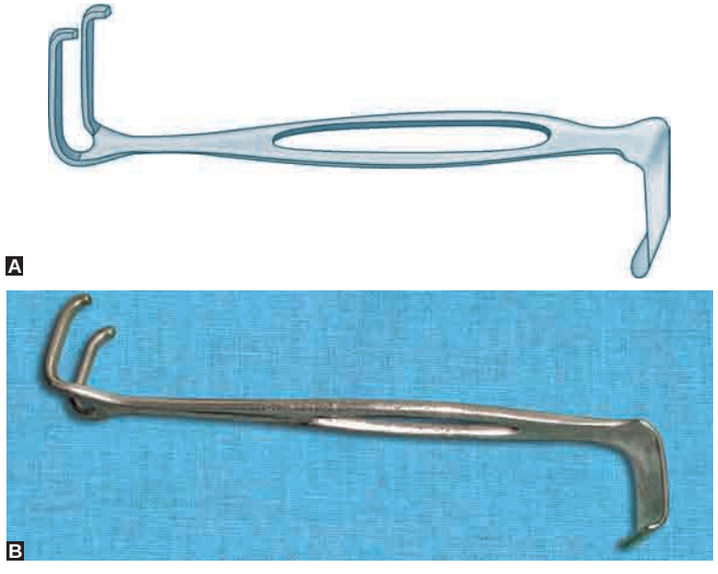
It has got a long handle and a small solid blade. It is used in hernia surgery or any superficial surgeries to retract skin, fascia and aponeurosis, etc. It can be single bladed or double bladed. It is a superficial retractor. It is used to retract structures like skin, fascia or muscle **(Figs 5-41A and B)**.



Figs 5-41A and B: Langenbeck's retractor.

CZERNY'S RETRACTOR (HERNIA RETRACTOR)

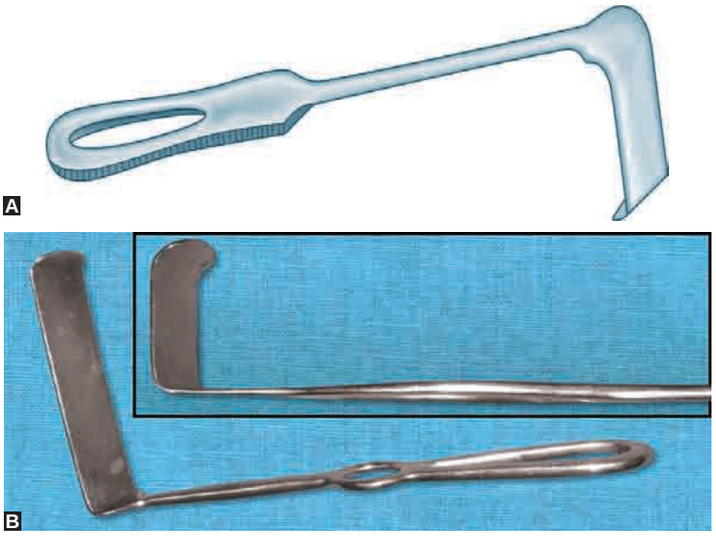
This retractor has got thick and small blade on one side and biflanged hook on the other side in opposite directions. It is used in surgeries like hernia, laparotomy especially during closure. Bleeders in the edge can be identified and cauterized easily. It is a superficial retractor. Biflanged end facilitates placing the terminal stitch on the end of the wound during closure **(Fig. 5-42)**.



Figs 5-42A and B: Czerny's retractor.

RIGHT ANGLE RETRACTOR

Here handle and blade are at right angle to each other **(Figs 5-43A and B)**.

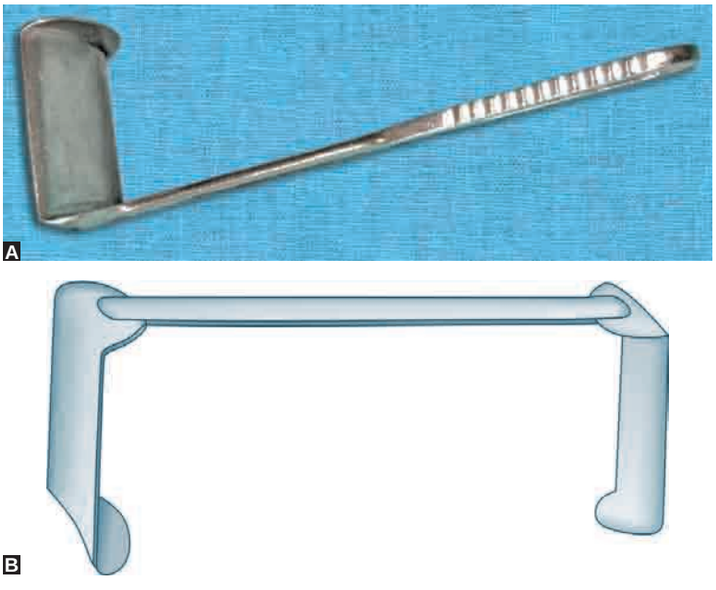


Figs 5-43A and B: Right angle retractor.

MORRIS' RETRACTOR

It may be single blade type or double blade type. It has flat transversely curved blade. There is a blunt projecting ridge with backward projection to have a better hold.

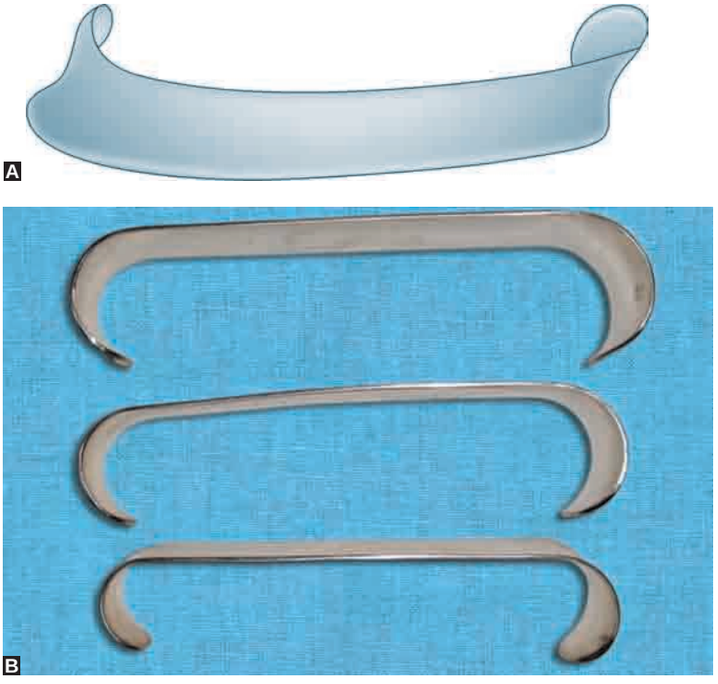
It is used to retract abdominal wall incisions/loin incisions/subcostal wounds/any wounds in depth. Beak end of the retractor end prevents it from slipping from depth of the wound and holds well to wound. It needs an assistant to retract as it is manual retractor. Its use in many places is replaced by self-retaining retractor **(Figs 5-44A and B)**.



Figs 5-44A and B: Morris retractors - single blade (one sided) and double blade (both sided).

'C' SHAPED RETRACTOR—ROUX

It is C shaped with curve at both ends. It is used to retract wounds like in hernia, appendicectomy, wide excisions, oral surgery, etc. C shape gives a proper grip **(Figs 5-45A and B)**.



Figs 5-45A and B: C shaped retractor.

'S' SHAPED RETRACTOR

Here blunt curves on each end are in opposite directions. Uses are like C shaped retractor **(Fig. 5-46)**.

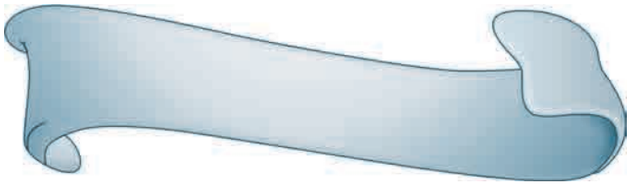


Fig. 5-46: 'S' shaped retractor.

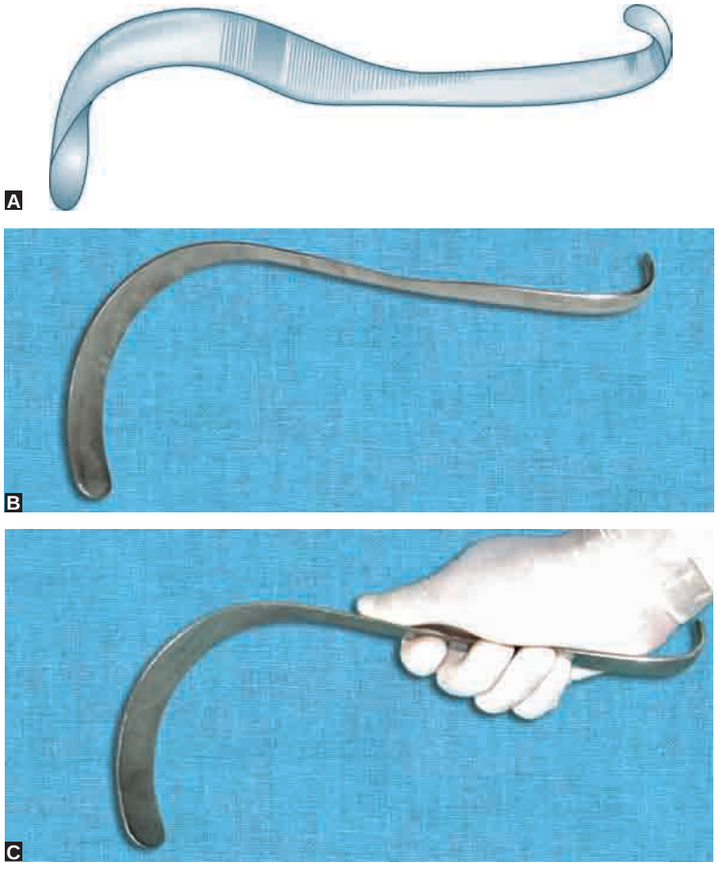
DEAVER'S RETRACTOR

It is an instrument in shape of question mark (?). It is stout but atraumatic. Its action is *levering* of the tissues not by push or pull or traction. Moist mops should be kept underneath prior to placing this retractor. It is a retractor with a broad, gently curved long blade. It has got strong handle **(Figs 5-47A to C)**.

It is used to retract the abdominal wall. It is used to retract liver, spleen and other abdominal viscera. It is atraumatic and gives adequate exposure of the surgical field. All major abdominal surgeries like vagotomy, cholecystectomy, gastrectomy, pancreatic surgeries, colonic surgeries, kidney surgeries, anterior resection/abdominoperineal resection, bladder surgeries, lumbar sympathectomy need this instrument.

KEYLAND'S RETRACTOR

It has got flat wide blade with a right angle handle. It is manual retractor. It is used like Deaver's retractor **(Fig. 5-48)**.



Figs 5-47A to C: Deaver's retractor (manual)/Deaver liver retractor.

Fig. 5-48: Keyland's retractor (manual).

DOYEN'S RETRACTOR

It is used in pelvic surgeries and in laparotomies. It has a curved blade with convex edge with a long handle. It is used to retract urinary bladder **(Figs 5-49A to C)**.

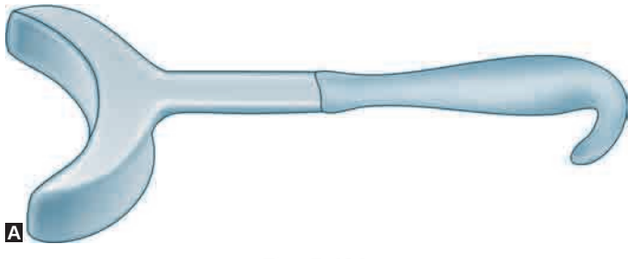
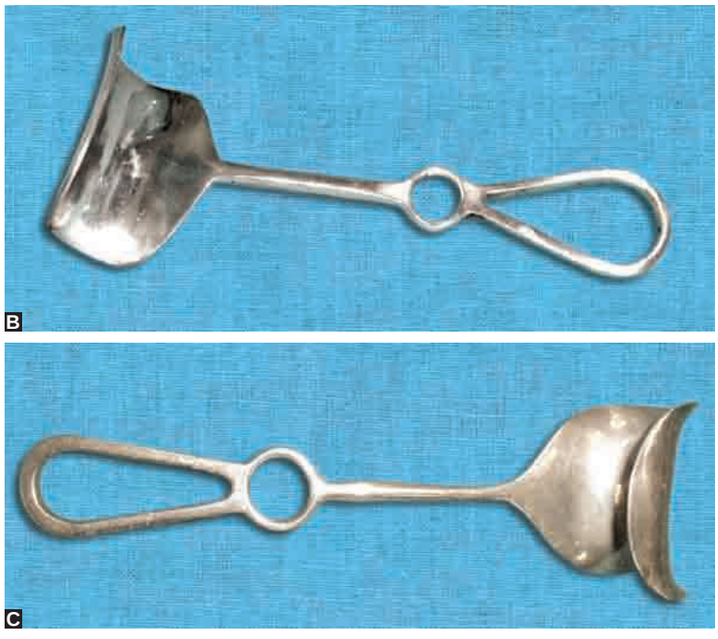


Fig. 5-49A



Figs 5-49B and C

Figs 5-49A to C: Doyen's retractor.

BALFOUR'S SELF-RETAINING RETRACTOR

It has got different adjustable blades so as to retract abdominal wall and tissues during surgery. It has got quadrangular metal frame. Two side heavy blades are hook shaped to fit into the wound sides **(Fig. 5-50)**. There is a detachable third blade to retract the viscera. One of the side blades has got screw to adjust the width of the retraction by side blades. Detachable blade is also fixed through an adjustable screw with a slot. Closed instrument is inserted into the wound and adequately widened as required to have its use. Tissues/bowel/organs should not be trapped while widening and adjusting.

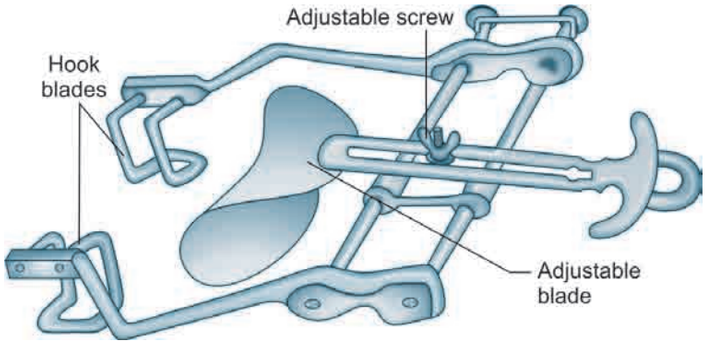


Fig. 5-50: Balfour's self-retaining retractor.

MILLIN'S SELF-RETAINING RETRACTOR

It has got three sided triangular metal frame with two flat side blades and one long S shaped adjustable blade which has got two curves to retract urinary bladder or lower abdominal wall by each as needed. It is used in Millin's open prostatectomy and other pelvic surgeries **(Fig. 5-51)**.

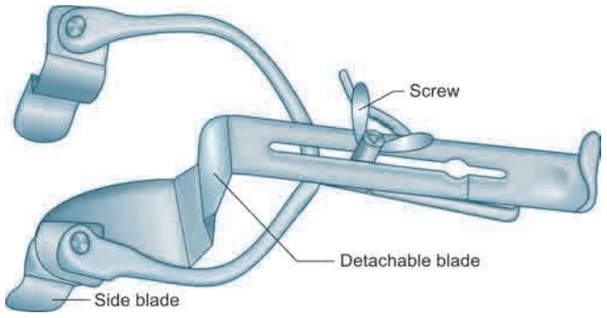


Fig. 5-51: Millin's self-retaining retractor.

JOLL'S THYROID RETRACTOR

It is a self-retaining retractor specifically used for thyroid/parathyroid surgeries. It is a semicircular retractor with two blades attached with a handle. End of the blades are sharp like a towel clip with a catch/ratchet on it. Handle has got a screw by which instrument can be opened or closed. Upper and lower skin flaps can be retracted well in thyroid surgery using this instrument **(Fig. 5-52)**.

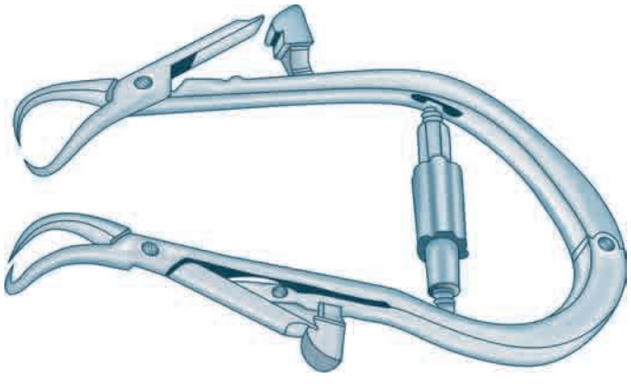


Fig. 5-52: Joll's thyroid retractor.

KOCHER'S THYROID RETRACTOR

This instrument has got two side adjustable multihooked terminals (adjustable with screws) over two side flanges which are connected with a lockable joint. It is used in thyroidectomy **(Fig. 5-53)**.

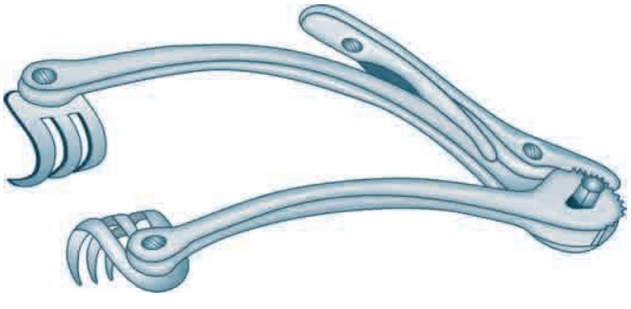
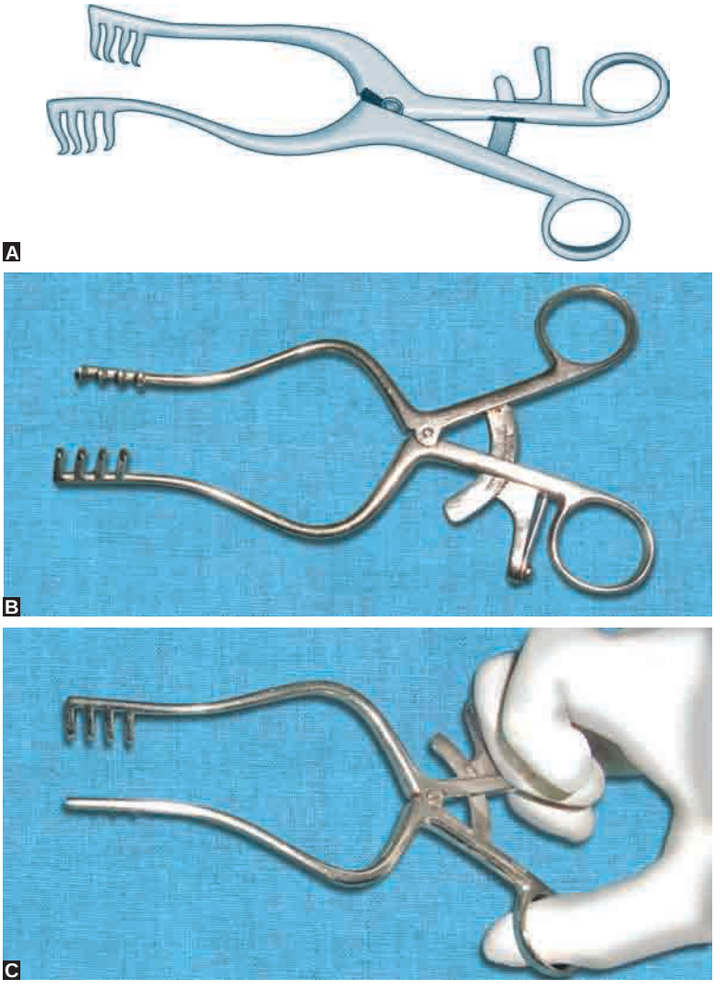


Fig. 5-53: Kocher's thyroid retractor.

MOLLISON'S MASTOID RETRACTOR

It is stout instrument with curved long blades which has got sharp outward curved teeth to retract tissues. Proximal shaft has got ratchet with finger bows. It is self-retaining, haemostatic and gives wide exposure of the field. It is used in mastoid surgery, laminectomy, to retract scalp in neurosurgery, limb surgeries etc. When shafts are approximated blades will open **(Figs 5-54A to C)**.



Figs 5-54A to C: Mastoid retractor.

BLADDER NECK RETRACTOR

It is thin, long instrument with two thin long distal blades. Proximal thin shafts have got a ratchet. When ratchet closes, the blades will open. It is used in retracting bladder neck in bladder surgeries **(Fig. 5-55)**.

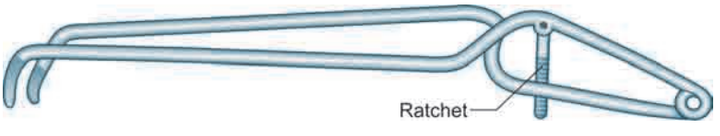


Fig. 5-55: Bladder neck retractor.

CHEEK RETRACTOR

It is single piece instrument with acutely angled blade with inward curled round margin. It is used to retract cheek to inspect the oral cavity as well as to take biopsy of a lesion for diagnosis; dental extractions; interdental wiring; excision of lesions in jaw, gums and oral cavity (epulis, papillomas, mucus cysts, etc.) **(Fig. 5-56)**.

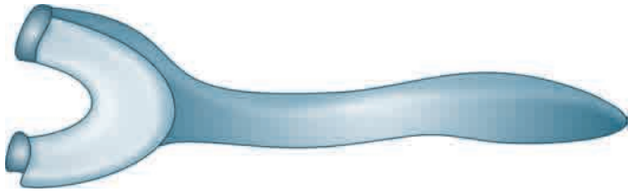


Fig. 5-56: Cheek retractor.

SCAPULA RETRACTOR

It has got a long stout handle with broad right angled blade with serrations. It is used to retract scapula during thoracotomy **(Fig. 5-57)**.

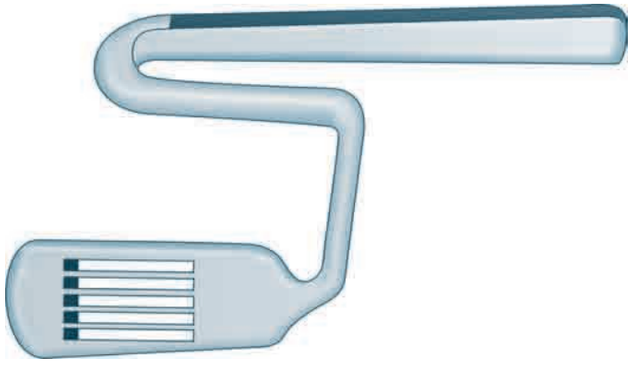


Fig. 5-57: Scapula retractor.

KIDNEY HILUM RETRACTOR

It has got curved C shaped small blade with a long malleable shaft which is slightly curved. It is used in extended pyelolithotomy (Gilvernet's) to retract renal hilar tissues so as to reach the pelvis. Intrarenal pelvis is approached by this manner to remove the stone **(Fig. 5-58)**.

Fig. 5-58: Kidney hilum retractor.

MORRIS KIDNEY RETRACTOR

It has got blade of 6.5 × 5 cm in size with a curve. There is a blunt projecting ridge directed inwards. It is used in renal surgeries like nephrolithotomy, pyelolithotomy, pyeloplasty and nephrectomy **(Fig. 5-59)**.

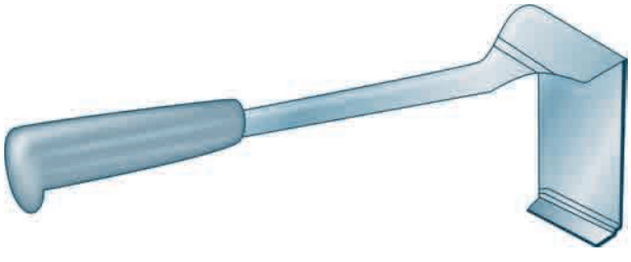


Fig. 5-59: Morris kidney retractor.

ALLISON'S LUNG RETRACTOR

It has got long handle with light blade. Blade is made up of wires. Blade is at right angle to the handle. It is used to retract lungs. Lung can expand between wires of the blade. It is atraumatic. It is used in oesophageal surgery, thoracic sympathectomy, mediastinal surgery **(Fig. 5-60)**.

Fig. 5-60: Allison's lung retractor.

RIB RETRACTOR (TUFFIER'S)

There is a strong short shaft with blades attached to it at right angles. One blade is fixed whereas other one is adjustable which can be fixed with a screw at required width. Blades are deep with outer flanges so as to hold with a proper grip. It is used in thoracotomy in lung/oesophageal and cardiac surgeries (trauma, tumors, mitral valvotomy, mediastinal tumors, diaphragmatic hernia, oesophagectomy, etc.). It is a self retaining retractor **(Fig. 5-61)**. Other rib retractor used is Quervain's rib retractor which is stronger with wing-like blades, fixed with a screw.

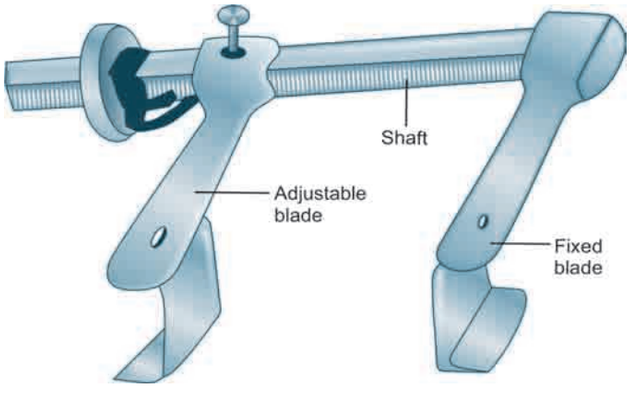


Fig. 5-61: Self-retaining rib retractor.

DOYEN'S RIB RASPATORY

It has got a stout handle with a curved semicircular distal blade to pass under the rib surface for separating the periosteum after incising the periosteum of the rib. Using periosteal elevator periosteum is elevated and raspatory is passed under the periosteum from upper margin of the rib to prevent injury to intercostal vessels. There are separate instruments for right side and left side. Handle is held with blade facing forward and upward to determine the side **(Fig. 5-62)**.

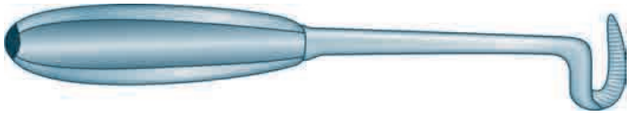


Fig. 5-62: Doyen's rib raspatory.

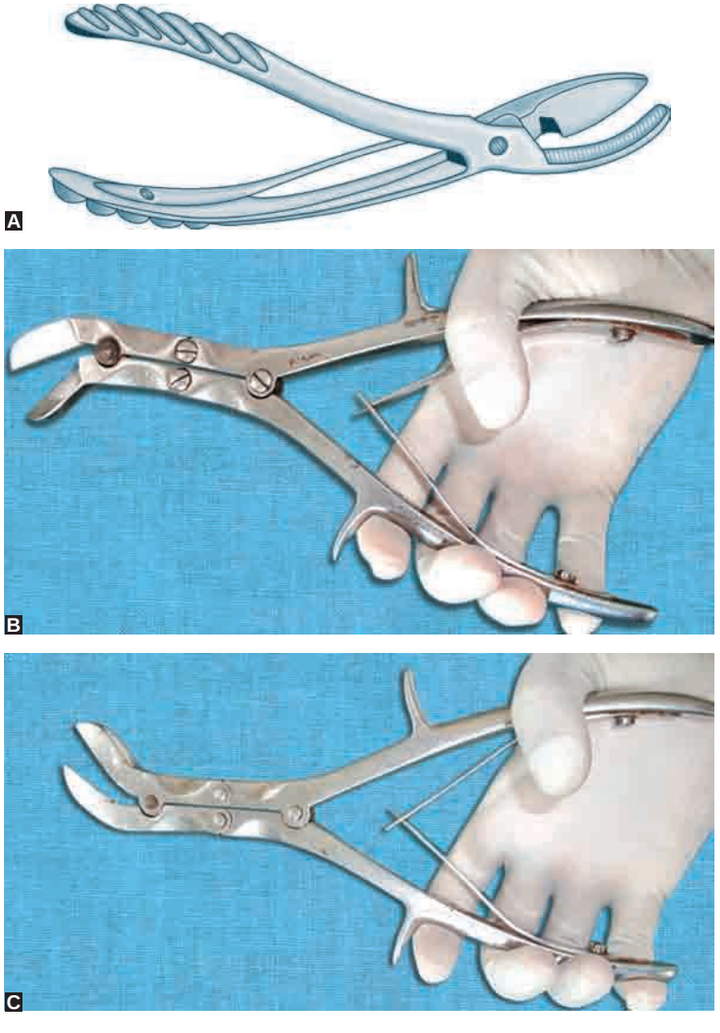
FARABEUF'S RASPATORY

It is a periosteal elevator with a corrugated thumb rest, flat grooved handle and a broad rectangular blade (beveled edge). It is used in elevating the periosteum in cervical rib resection, rib resection for empyema, rib resection in chondromas, in kidney exposure, in osteomyelitis of ribs. Periosteum is retained so that regeneration and remodeling can occur; intercostal vessels and nerves are protected. It is not used to elevate the inner surface of the ribs where Doyen's raspatory is used **(Fig. 5-63)**.

Fig. 5-63: Farabeuf's raspatory with thumb rest.

RIB SHEAR

It has got large rough handles. One blade has got groove with serrations and is blunt. It is passed underneath the rib as a protector to the adjacent tissues. Other blade is cutting one which apposes over the groove of first blade. It cuts the rib from front. Instrument is used for rib resection **(Figs 5-64A to C)**.



Figs 5-64A to C: Rib shear used to cut the ribs.

RIB APPROXIMATOR

It has two strong curved blades with teeth; proximal blade is mobile but can be fixed by a screw whereas distal blade is fixed. It is used to approximate the ribs during closure of thoracotomy. Two blades are placed adjacent to ribs and proximal blade is apposed adequately and fixed with screw. Thoracotomy wound is closed in layers. Screw is loosened to remove the rib approximator **(Fig. 5-65)**.

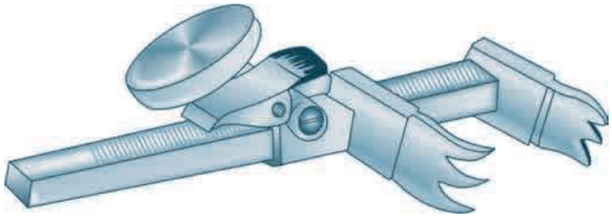


Fig. 5-65: Rib approximator.

DUVAL'S LUNG HOLDING FORCEPS

Its distal blades have triangular aperture with its inner surface being finely serrated to have firm grip on the lungs without any trauma. Blades are gently curved which imparts a smooth action. It is used to hold the lung during lobectomy/pneumonectomy **(Fig. 5-66)**.

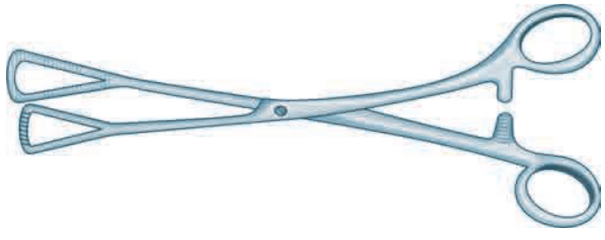


Fig. 5-66: Duval's lung holding forceps.

FRIEDRICH'S LUNG HOLDING FORCEPS

It has got four pronged blades. Each prong is having sigmoid curve with a ball at the tip. It is atraumatic because of smooth ball. It is used to hold wider area of lung tissue **(Fig. 5-67)**.

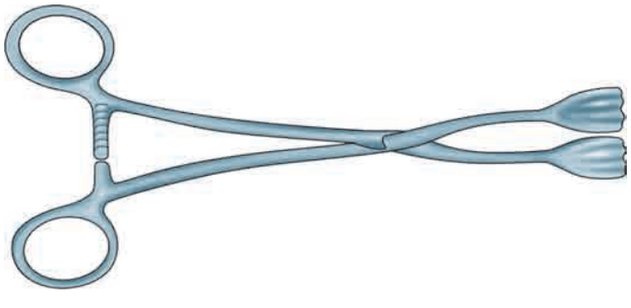


Fig. 5-67: Friedrich's lung holding forceps.

BICKFORD'S BRONCHIAL CLAMP

It has got long distal blade which has got two bends with longitudinal serrations and spikes on the inner surface. It is used to clamp the bronchus as it holds the cartilaginous part firmly **(Fig. 5-68)**.

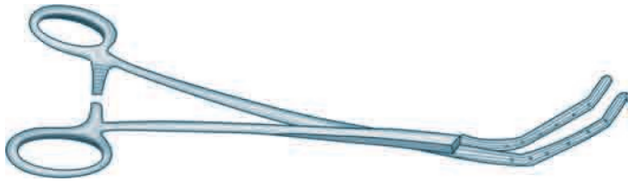


Fig. 5-68: Bickford's bronchial clamp.

SURGICAL NEEDLES

Types (Figs 5-69 to 5-71)

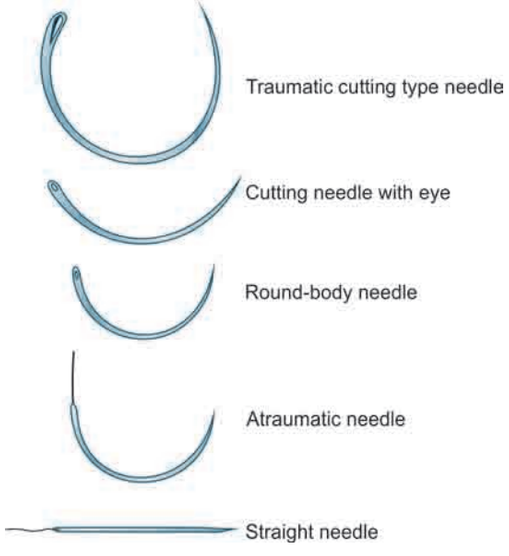


Fig. 5-69: Different types of needles.

Based on the edge

- *Round body needle*—It is round and smooth on cross section. It is used to suture muscles/intestines/soft tissues/vessels/nerves/tendons/peritoneum.
- *Conventional cutting needle*—Here needle is triangular on cross section with apex facing inward. It is used to suture skin/aponeurosis/tough structures.
- *Reverse cutting needle*—Here needle is triangular (reverse) on cross section with apex facing outward. It increases the strength and is less likely to bend while suturing.
- *Taper cut needle*—Here tip of the needle is reverse cut in section but eventually tapers into the body as round in section. It improves the penetration of needle but minimizes the trauma.
- Blunt pointed needles are used to suture friable organs like liver/spleen/kidneys.
- *Spatulated side cutting needle* (saber lock)—is like a spatula with two lateral side cutting edges.
- *Micropoint needles*, either round bodied or reverse cutting or spatulated are used in ophthalmic and microsurgery. It has got an extra honing process.
- *Trocar point needle* is stout strong cutting end with a robust round body. It is used in obstetrics and gynecology.
- *Tru taper needle* is one with tip angle of needle is at 22 degrees (unlike conventional angle is 32 degrees). It is used in vascular surgery.
- *Visiblack needles*—Needles coated with black so that they are visible better in red background. It also prevents the glare from the focus lights by the needles.
- *Dolphin nose needle* is specially designed needle used for surgeries in patients with hepatitis and AIDS which minimizes the risk of puncturing the gloves and fingers of the surgeon.
- *JB needle* (Juergen-Breunner needle)—oval round bodied needle with a steep curve at the distal half to have easy passage of the needle through bowel in gastrointestinal surgeries.
- *Port closure needle* in laparoscopic surgeries.
- *Ski needle* with a ski shaped curvature in the distal part so as to have easy passage through the port for laparoscopic intracorporeal suturing.

Based on curvature:

- Straight needle.
- Curved needle. Half circle; 5/8 circle, etc.

Based on existence of the eye:

- *Atraumatic needle* is eyeless. Here suture material is attached to the needle by *swaging* (Mr Merson of England). Size of the suture material and that of needle is same and so tissue trauma is less. Needle once used is disposed (Not reusable). It is available as sterilized pack. These needles can be round body or cutting.

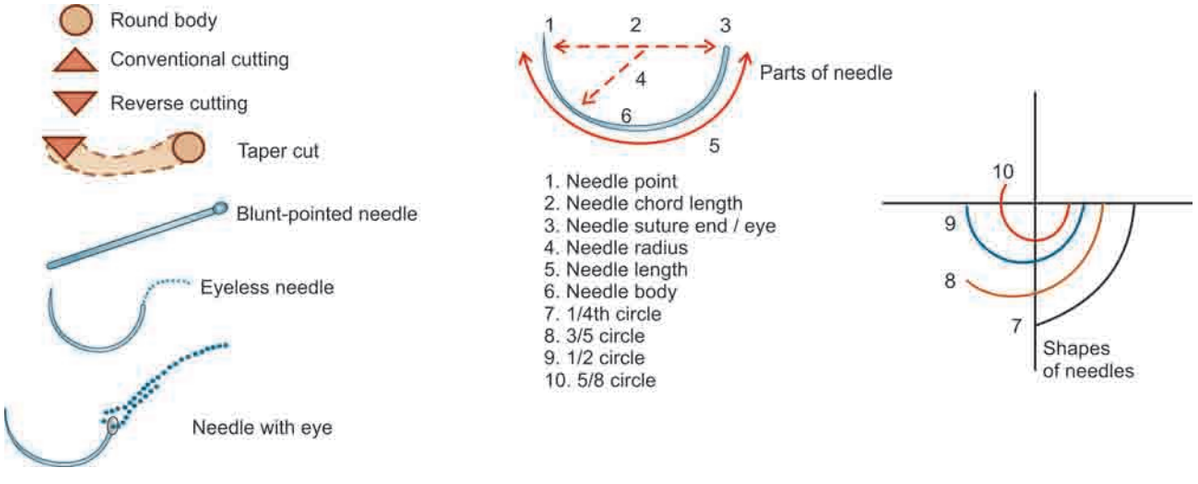


Fig. 5-70: Different types of needles. Diagram also shows the eyeless/eyed needles and gives the meanings of 1/4th, 1/2, 3/8th and 5/8th circle needles.

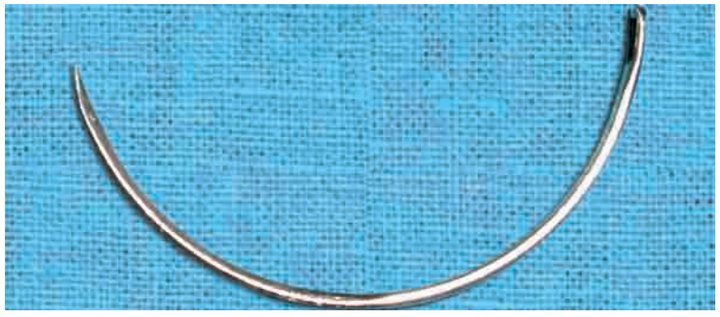


Fig. 5-71: Surgical needle.

- *Traumatic needle:* It is eyed needle. Needle in the eye area is wider than the body of the needle and so tissue trauma is more. These needles are re-usable.

Parts of a surgical needle

- Eye or suture end
- Body–straight/curved
- Needle point is tip
- Circumferential length of the needle
- Needle chord length–distance between the tip and eye

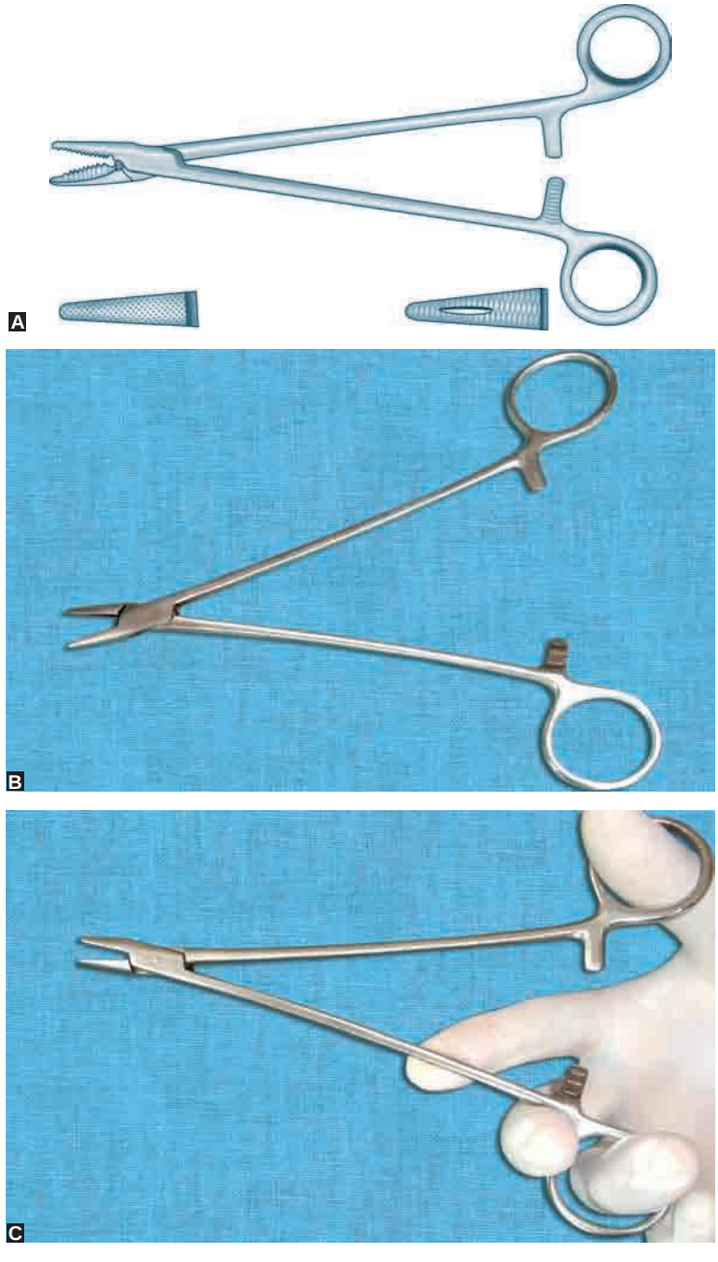
Note:

- Weakest part of the needle is part near the eye.
- Needle is sterilized in cidex/Lysol. It should not be autoclaved as tip gets blunt.
- The needle is held at its center by placing it at the junction of the proximal 2/3rd and distal 1/3rd to have optimal grip, control and precision.
- Needles can be 1/4 circle, 1/2 circle, 3/8 circle or 5/8 circle at their curvatures. (Refer diagram for the same). Needles of different curvature are used at different places depending on the depth of the suturing.
- Needles are made up of stainless steel.
- Atraumatic needles are available as sterilized packs. They are sterilized by ethylene oxide or gamma sterilization along with the sutures which they coexist.
- *Gallie's needle* is large eyed needle which was earlier used in hernias to suture the defect using fascia lata strips.
- *Lane's needle* is half circle cutting needle with a large eye.
- *Mayo needle* is obstetric needle with a large square eye and is strong.
- *Hagedorn reverse flattened point fish hook needle* used for suturing inaccessible sites.
- Symonds round bodied fish hook needles.
- *Bonney Reverdin needle* is a special needle with an eye which is open to one side with small slender shutter which can slid and closed after passing the suture material.
- *Kous Netzoff aluminium needle is* used to suture the liver tear.

NEEDLE HOLDER

Smaller distal blades with criss-cross serrations often with a groove in the middle are the features of a needle holder. Often there is a longitudinal groove in the middle of the distal blade between serrations. Ratio of length of handle to blades is 4:1.

It may be straight or curved. It may be available in different sizes. While holding a needle in a needle holder one should get a good control and good grip. This is achieved by placing the needle at junction of proximal 2/3 and distal 1/3 of the blade. Needle holder should be held between thumb and ring finger. Curved needle holders are available to hold the needles and work at the depth like in pelvis/thoracic cavity for better manoeuvrability and visualisation. Needle holder is sterilised by autoclave **(Figs 5-72A to C)**. *Tungsten–carbide inner surface coated needle holder* is available which has got longer duration of life due to reduced wear and tear of the instrument because of tungsten coating.

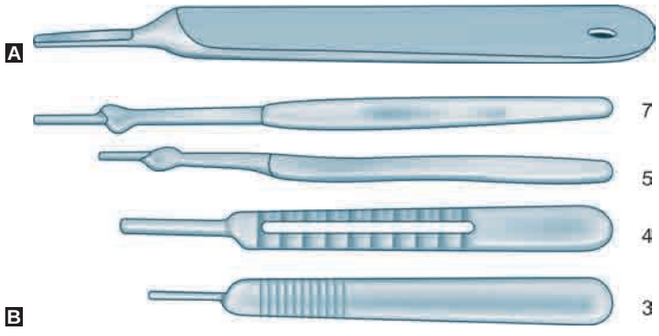


Figs 5-72A to C: Needle holder.

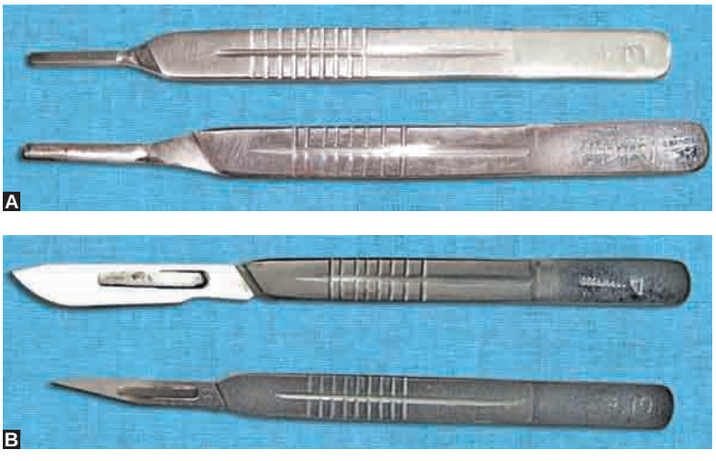
BARD-PARKER'S HANDLE (BP HANDLE)

Bard-Parker's handle is a flat stainless steel instrument with a slot on narrower side on both surfaces to attach scalpel blade. 3, 4, 5 and 7 numbered blades are available. Number 4 handle is wider. Scalpel blades 10, 11, 12, and 15 fit into Bard-Parker handle numbers 3, 5 and 7. Scalpel blades 18, 19, 20, 21, 22, 23 and 24 fit into slot of Bard-Parker's

blade number 4. New blade is used into the slot of the handle for each patient and so sharpness of the blade is maintained. B P handle is sterilised by autoclave **(Figs 5-73 and 5-74)**.



Figs 5-73A and B: Bard-Parker's handles–3, 4, 5 and 7.



Figs 5-74A and B: Bard-Parker handles number 3 and 4. Blades used are no 2 and no 1.

SURGICAL BLADES

They are detachable blades. Number 11 blade is stab knife blade which is used in incision and drainage of an abscess and in making small incision like for drains. Number 12 blade is curved one, used for tonsillectomy. Here cutting edge faces surgeon. Number 15 is used in plastic surgery, head and neck surgery, face surgeries. Numbers 20, 22 and 24 used in skin incisions of major surgeries like laparotomy, thoracotomy, craniotomy, incisions in limb. Blades are sterilised by gamma radiation with aluminum foil packing. Commonly blades are used only once and then disposed. If sterilisation is needed it is done using cetrimide/Lysol immersion (not autoclave or boiling). Scalpel is also used for dissections of fascial planes, raising skin flaps, hernial sac, etc. Fine lateral oblique strokes are used for such dissections. One should have a control over the depth of dissection. When scalpel is used in the abdomen like while cutting the bowel, it should be used in such a way that sharp edge of the blade should face forward so that to avoid inadvertent injury to deeper vital structures. Bowel is cut from mesenteric margin towards anti-mesenteric surface **(Figs 5-75 and 5-76)**.

Different Ways of Placing Incisions

- *Dinner knife position* is used while making lengthy incision.
- *Pen holding/writing position* is used to make incision over the vessels/nerves/tumors.
- *Fiddle–bow position* is used to make incisions with less pressure on delicate tissues.
- *Grasping position* is used to make long sweeping cuts.
- *Stab position* is used to drain an abscess using no 11 blade with no 3 BP handle. It is also used to make an incision to pass a drain corrugated or tube.

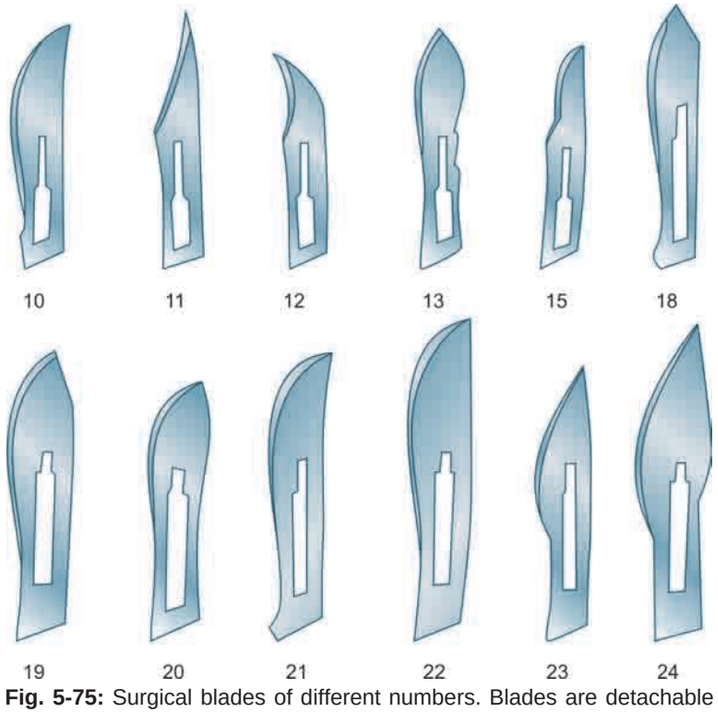


Fig. 5-75: Surgical blades of different numbers. Blades are detachable and used only once.

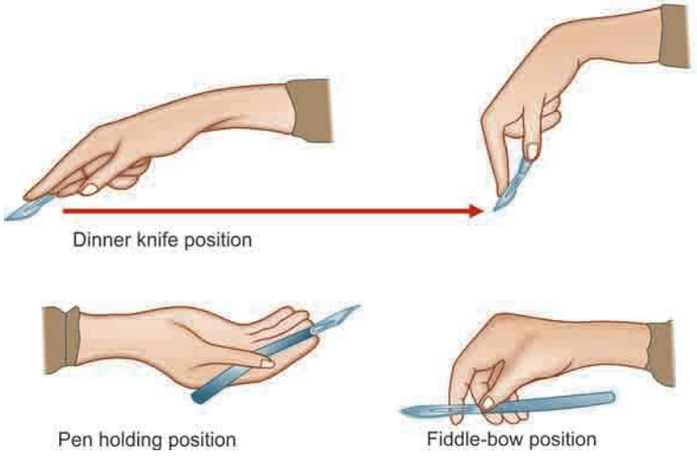


Fig. 5-76: Different positions/methods used to hold knife while making incisions or doing dissections in different surgeries.

Principles in making incision

- Incision should be planned well prior to surgery for adequacy, for possible need for extension during course of the surgery, and indeed be cosmetically acceptable. Ideally incision site should be marked using sterile marker or methylene blue.
- Clean single stroke firm incision should be made with required depth. Repeated strokes and movements should be avoided.
- Knife should be perpendicular to skin to begin with blade pointing perpendicular to skin. But later blade should be parallel with curvature/belly of the blade on the site of the incision.
- While making lengthy incision like in abdomen, incision area should be stretched between thumb and index fingers of other hand of the surgeon.
- Care should be taken to avoid injuries to deeper structures like muscle/nerves/vessels/bowel while making incisions.

TENOTOMY KNIFE

Tenotomy knife straight/curved with a short cutting edge with a fixed handle is used in congenital torticollis to cut sternomastoid muscle, congenital talipes equino varus, adductor tenotomy and lateral sphincterotomy for fissure in ano **(Fig. 5-77)**.

Fig. 5-77: Tenotomy knife.

ANEURYSM NEEDLE

Aneurysm needle is stout instrument with a deep hook in one end with an eye opening in the blunt tip. Eye proceeds as a deep groove in the needle proximally which allows the ligature to stay firmly. This facilitates the passage of the ligatures across the deeper plane around the blood vessels; to ligate the vessel in continuity; in venesection; to pass the ligature around any tubular structures. Earlier it was used to ligate the artery while treating the aneurysm. It is sterilised in glutaraldehyde or lysol but never by boiling or autoclave **(Fig. 5-78)**.

Fig. 5-78: Aneurysm needle.

SCISSORS

Scissors has got various purposes in surgical field like dissection, cutting tissues, cutting suture materials, opening tissue planes, venesection, cutting bandages, corrugated/tube drains and dressing, ophthalmic or microsurgeries, etc. It can be straight, curved, small, medium or long scissors **(Figs 5-79 to 5-83)**.

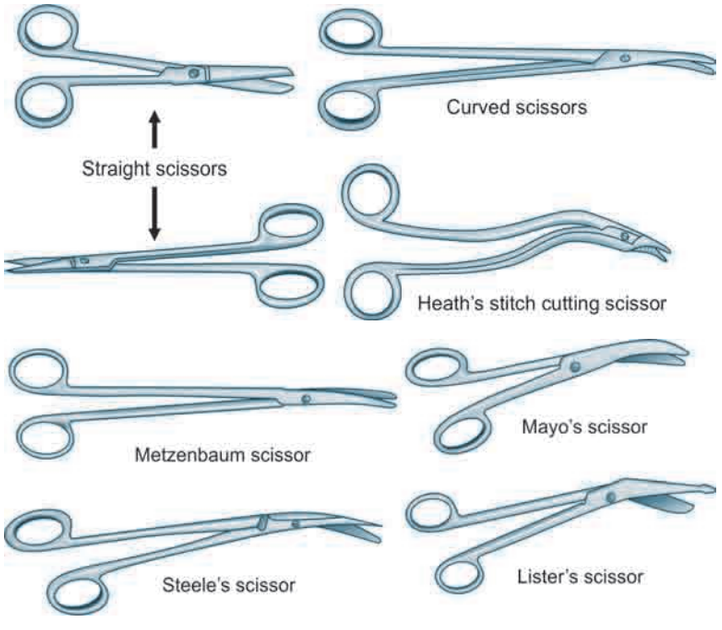


Fig. 5-79: Different scissors used in surgical practice.

Fig. 5-80: Straight scissors used for suture cutting.

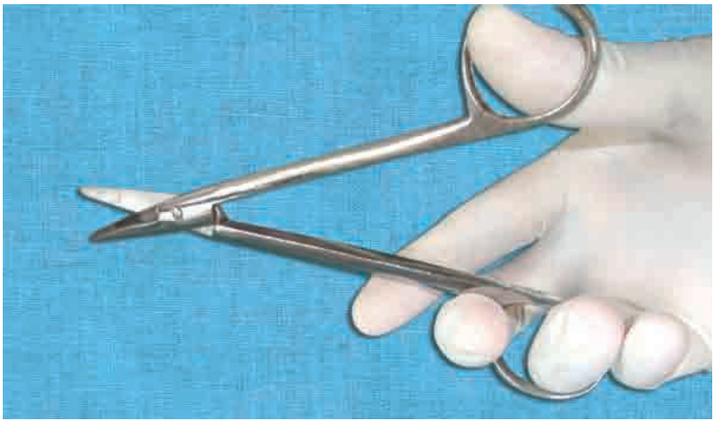


Fig. 5-81: Scissor showing method of holding it.

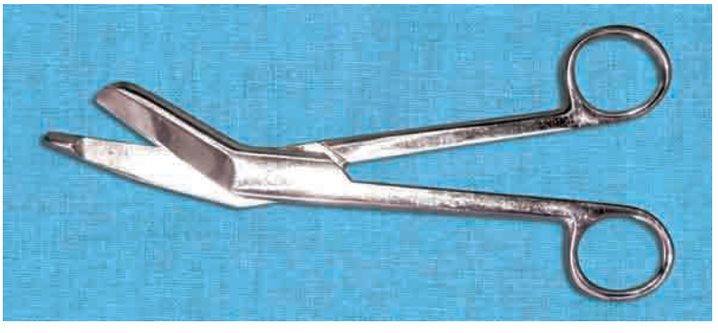


Fig. 5-82: Lister's bandage cutting scissor. Distal blades are bent at angle so that it is passed easily under the bandage. Lower blade has got flat blunt atraumatic tip. This part is passed under the bandage as it is atraumatic. Scissors are sterilised by chemical method using Lysol or glutaraldehyde. Scissors are not autoclaved; not boiled.

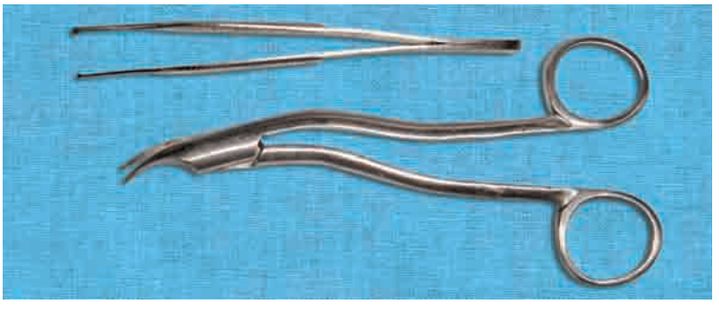


Fig. 5-83: Heath's suture cutting scissor with toothed forceps.

Different scissors are–

Mayo's scissors–are long and stout scissors. It can be blunt tipped/pointed tip/straight or curved.

Mc Indoe scissor–is having fine small blade. It is used mainly for dissection and in cutting delicate structures.

Metzenbaum scissor–has got long blades in comparison to shaft. It is used in depth dissection like vagotomy, cholecystectomy, pelvic surgeries, etc.

Heath suture cutting scissor–has got long shaft, small curves angled blades with tip is having fine serrations which ensures the proper grip of the suture material to be cut. Suture is held with dissecting forceps and is cut using Heath's scissor between knot and skin where suture enters.

Steele's scissor is like Metzenbaum scissor with similar use.

Lister's bandage/dressing cutting scissor has got flat lower blade to avoid damage to skin. Lower blade has got a knob at the terminal.

BOWEL OCCLUSION CLAMPS

Different types of occlusion clamps are discussed as follows **(Figs 5-84 to 5-90):**

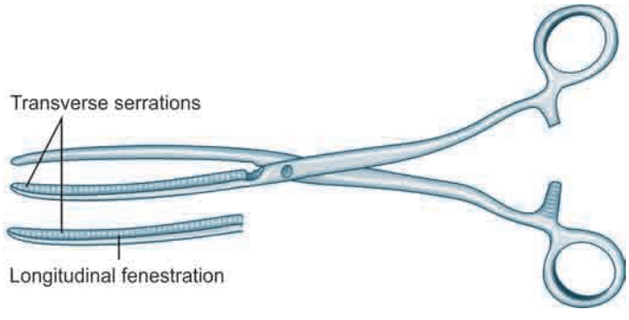


Fig. 5-84: Moynihan's occlusion clamp.

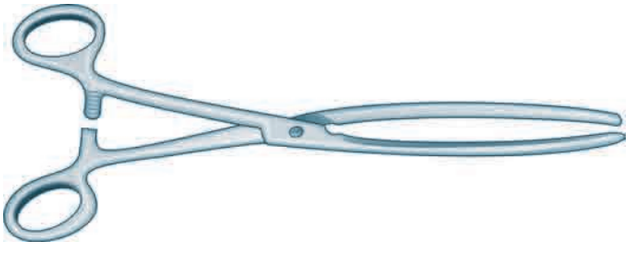


Fig. 5-85: Doyen's occlusion clamp.

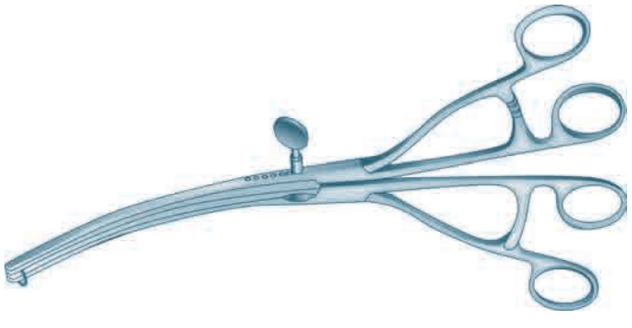


Fig. 5-86: Lane's paired gastrojejunostomy clamps with hook and screws used for gastrojejunostomy.

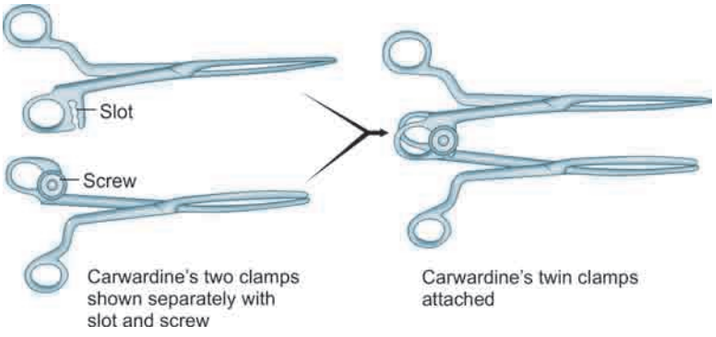


Fig. 5-87: Carwardine's twin intestinal occlusion clamp with screw and slot to fix. It is used to have easier intestinal anastomosis.

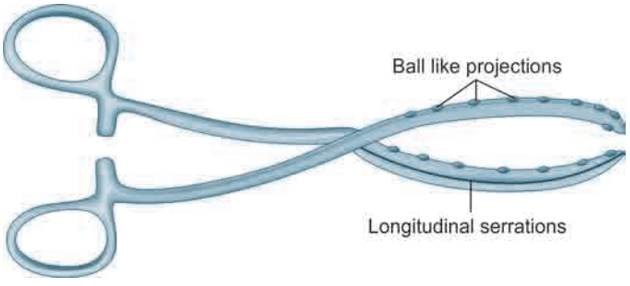


Fig. 5-88: Payr's gastric occlusion clamp.

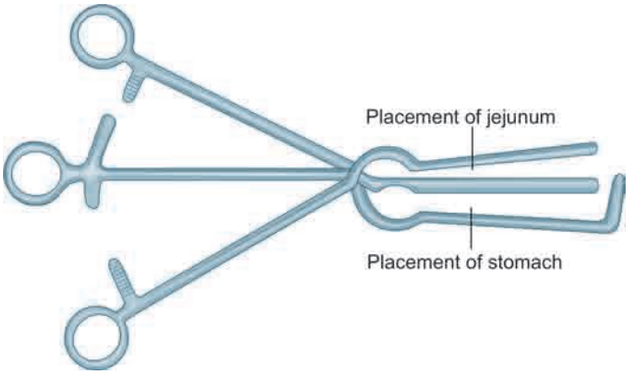
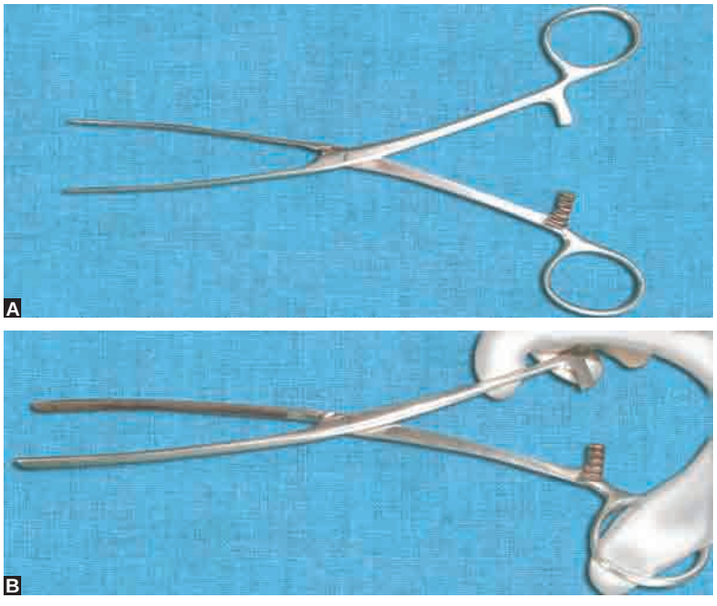


Fig. 5-89: Moynihan's gastrojejunostomy clamp.



Figs 5-90A and B: Occlusion clamps.

Moynihan's occlusion clamp (gastric)

- It has got long distal blades with transverse serrations with a longitudinal fenestration one on each blade.
- It may be straight or curved.
- It is non-traumatic, non-crushing type.
- It occludes lumen of the bowel/stomach and so prevents spillage of the content of the bowel.
- It also occludes the vessels in the wall of the bowel and so prevents bleeding during surgery.
- It is used during anastomosis of the stomach and other parts of the bowel.

Kocher's occlusion clamp (gastric)—Blades have longitudinal serrations without fenestration.

Doyen's intestinal occlusion clamps (straight or curved)—Have longitudinal serrations with apposing blades.

Lane's paired gastrojejunostomy clamps (straight or curved)—It is used in gastrojejunostomy. It steadies the anastomosing parts well. It has got a hook at the tip and a screw on the blade to fix each other.

Carwardine's twin intestinal occlusion clamps— It has got a slot on one part shaft and a corresponding screw on the other part shaft. These slot and screw fits into each other to facilitate proper intestinal anastomosis.

Payr's gastric occlusion clamp–It has got longitudinal serrations on the inner surface of the blades with several ball-like projections along the sides which interlock each other of the opposite blade to have a firm grip on the stomach/bowel while using.

Moynihan's gastrojejunostomy clamp–It has got long fenestrated blades with oblique serrations. Central and one lateral blade are straight where jejunum is placed while doing gastrojejunostomy and third lateral blade is 'L' shaped within which stomach occupies while using. Serrations and L shape prevents slippage of the bowel while anatomizing.

CRUSHING CLAMPS

Payr's crushing clamp–gastric/intestinal/appendix crushing

- It is stout and heavy instrument with double lever in the handle with longitudinal serrations.
- Once applied it crushes the bowel. So before applying it, line of resection of stomach/bowel should be assessed properly. It is applied to the part which has to be removed. Viability of the bowel is lost once it is applied.
- It is used in gastrectomy, resection and anastomosis of the bowel.
- It can be gastric crushing or intestinal crushing or appendix crushing clamp. All are similar; only size of the blades is smaller in intestinal and appendix crushing clamps **(Figs 5-91 and 5-92)**.

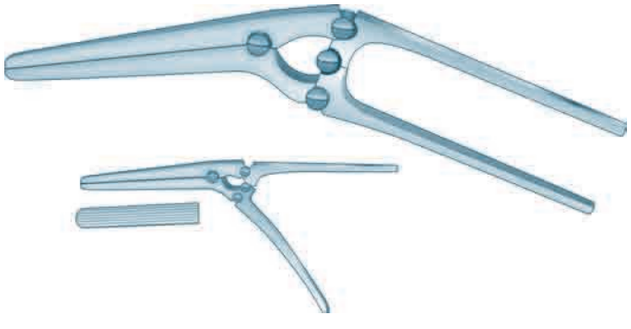


Fig. 5-91: Payr's crushing clamp.

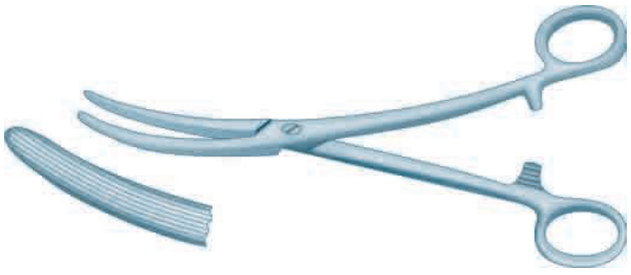


Fig. 5-92: Parker-Kerr crushing clamp.

Parker-Kerr crushing clamp–It is a stout and heavy crushing clamp with longitudinal serrations.

DESJARDIN'S CHOLEDOCHOLITHOTOMY FORCEPS

It has got long distal blades with smooth serrations and fenestra in the tip. It does not have lock and so accidental damage to CBD mucosa or crushing of the CBD stone are avoided.

It is used for choledocholithotomy (removal of CBD stones). Length and curve facilitate the stone extraction better. In laparoscopic cholecystectomy, it can be used to remove stones from gall bladder by passing through the 10 mm port so that makes delivery of the gall bladder easier. Disadvantage is that instrument may dilate the CBD significantly while manipulating **(Figs 5-93 and 5-94)**.

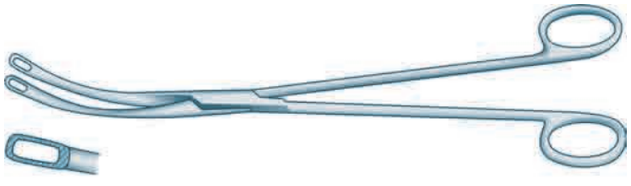
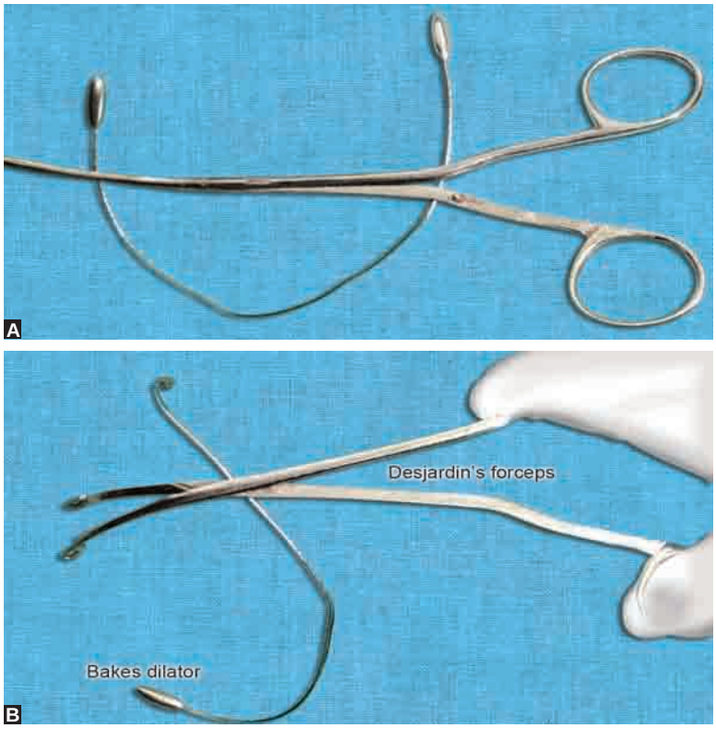


Fig. 5-93: Desjardin's choledocholithotomy forceps.



Figs 5-94A and B: Desjardin's forceps with Bakes dilator.

Lawson-Tait choledocholithotomy forceps/Alligator forceps is used which has got alligator jaws that facilitate passage through a narrow duct with lesser chances of dilating the duct.

BAKES DILATOR

It is long malleable metallic instrument with club at the terminal end. It is available in different sizes.

It is used to assess the CBD, duodenal papilla for patency or block. Dilator is passed through the choledochotomy opening downwards to reach the metal tip (olive blunt tip) to duodenum. It signifies the patency. It is called as *steel sign*. Dilators are passed gradually from lesser diameter to higher diameter size **(Fig. 5-95)**.

Fig. 5-95: Bakes dilator.

CHEATLE'S GALLSTONE SCOOP WITH OR WITHOUT HOOK

It is flexible long instrument with a blunt scoop on one side with a handle. Few instruments often contain a hook on other side. Scoop is to remove the debris from the gall bladder or common bile duct; and also to support or push the stone while removing. Hook is used to dislodge the impacted stone **(Figs 5-96A and B)**.

Figs 5-96A and B: Cheatle's gallstone scoop and also scoop with a hook.

CHOLECYSTECTOMY FORCEPS

These instruments are used to hold the fundus and Hartmann's pouch of the gall bladder during cholecystectomy. It is also used to dissect the cystic duct and artery and to pass ligature around the cystic duct and artery.

Types (Fig. 5-97)

Moynihan's cholecystectomy forceps has long shafts with slight curve at the short distal blades like a parrot beak with oblique serrations inside.

Henry-Gray's cholecystectomy forceps is similar but has right angled blades with transverse serrations.

GALLSTONE PROBE

It is a long malleable instrument with an olive on one or both ends with a handle. Its diameter is 6 mm. It is used to explore the common bile duct to look for patency in hepatic, and presence of stones. Small stones in common bile duct can be pushed into the duodenum. If stone is impacted, its exact location can be found by passing it **(Fig. 5-98)**.

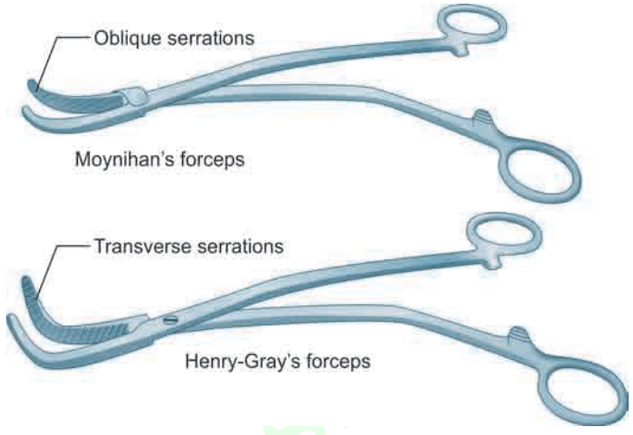


Fig. 5-97: Cholecystectomy forceps–two types–Henry Gray's right angled; Moynihan's parrot beak curved.

Fig. 5-98: Gallstone probe is available as one side or both sides olive tip which is flexible, long and thin.

MAYO-ROBSON'S CHOLECYSTOENTEROSTOMY CLAMP

It has got long curved semicircle-like blades. It is used while bypassing the biliary tree–*cholecysto-enterostomy* done as a palliative procedure in obstructive jaundice (in carcinoma head of the pancreas or periampullary or carcinoma distal common bile duct) **(Fig. 5-99)**. This clamp is used to clamp the gall bladder to keep in position while doing cholecystojejunostomy. But choledochojejunostomy Roux n Y is a better palliative bypass procedure because narrow cystic duct may get blocked later causing re-obstruction of the biliary tree. Cystic duct may end into the common bile duct lower down and its junction may get involved by the tumour invasion causing re-block and so failure of the palliative procedure.

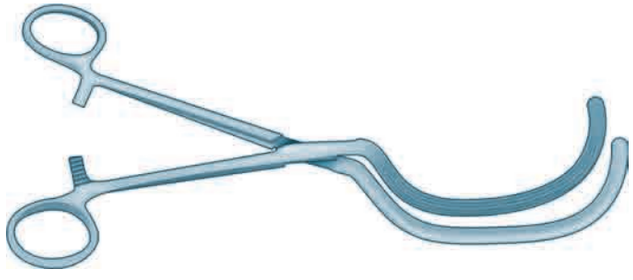
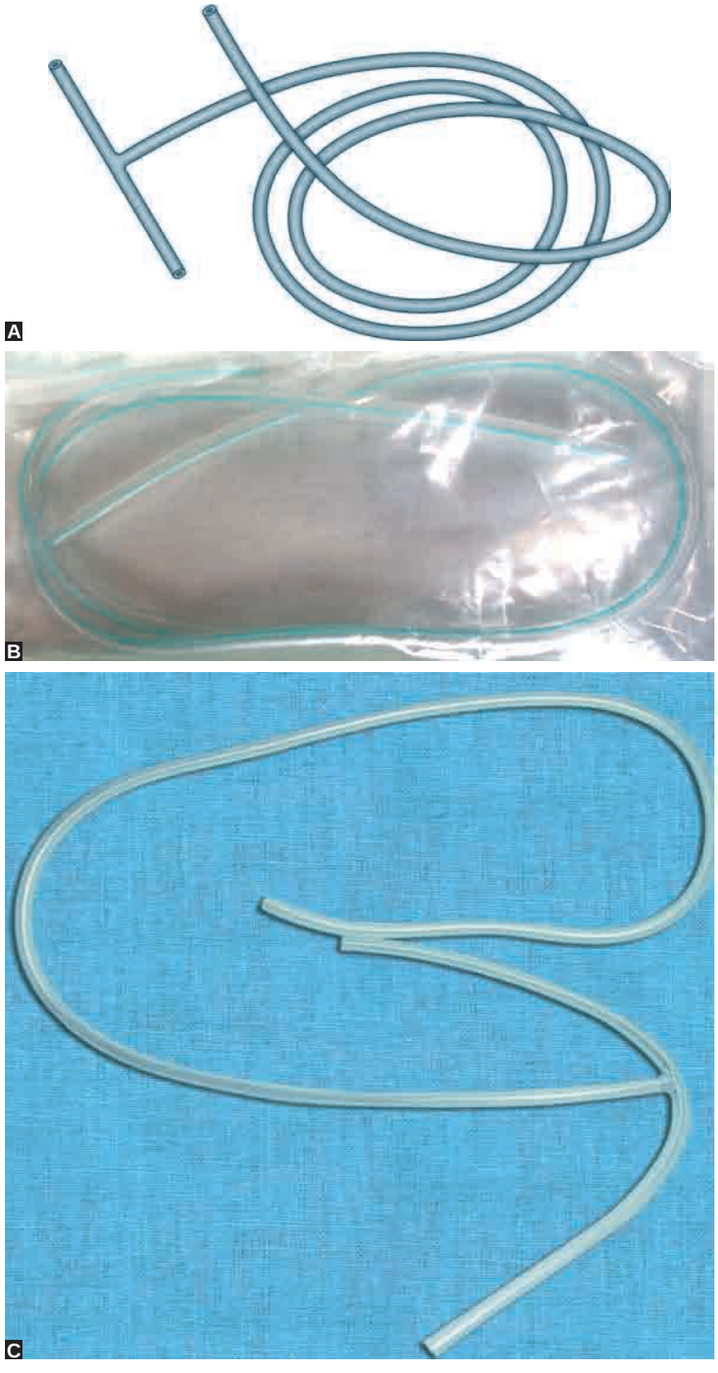


Fig. 5-99: Mayo-Robson's cholecystoenterostomy clamp.

KEHR'S 'T' TUBE

- It is used after opening of CBD (choledochotomy). CBD is closed with 'T' tube in situ.

- It is made up of latex or red rubber. 'T' tube has got horizontal part which is kept in the CBD and vertical part which is allowed to come out to drain bile **(Fig. 5-100)**. Amount of bile draining is measured daily.
  Before removal of 'T' tube, patency of CBD should be confirmed.



Figs 5-100A to C: Kehr's 'T' tubes.

It is done by following methods:

- The vertical limb (done in 10-14 days) is clamped and observed for development of pain, fever and jaundice in 24 hours. If normal then one can presume that there is no obstruction in the CBD.
- Water soluble iodine dye is injected through the tube to visualise biliary tree and free flow of dye into the duodenum. (Postoperative 'T' tube cholangiogram). It is done in 14 days which is the time required to develop fibrous track. Once there is free flow tube is removed and track gets closed on its own.

Complications/problems of T tube

- Kinking/block/break in T tube
- Displacement/slipping of T tube out of common bile duct may cause biliary peritonitis
- Improper pancreatic duct drainage due to tube
- Impaired enterohepatic circulation
- Biliary infection, secondary haemorrhage, bile leak and peritonitis, foreign body reaction
- Difficulty in removal even after adequate pressure is managed by gradual continuous pressure and occasionally exploration may be needed.

SUCTION INSTRUMENTS

These are essential instruments needed in all surgical practice to suck out blood from the surgical field, pus, infected fluid, fluid in peritoneal/thoracic/cranial cavities. It has got a *suction tip* of varying types, *suction tube* which connects tip to the *suction apparatus* and suction creating system, either central suction system *or* power suction system with two suction glass bottles connected to each other *or* manual suction apparatus (now not used). Suction tip has got a long bent tube with openings at one end to suck the fluid, with a stout handle which has got a proximal ridged part at the other end to which suction tube (rubber or plastic) is attached, which is in turn is connected to suction apparatus. Suction tip and suction tubes should be sterile. They are sterilised by autoclave **(Fig. 5-101)**.

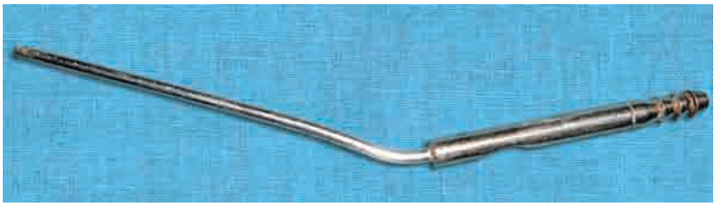


Fig. 5-101: Suction tip.

Types of suction tips–

- *Adson's fine suction tip*–It is angled with a vent/thumb rest to control the suction as needed. It is a fine suction tip which is used in meticulous surgeries like plastic, vascular and reconstructive surgeries. It cannot be used when large quantity of blood/pus/fluid/clot needs to be sucked out **(Fig. 5-102)**.

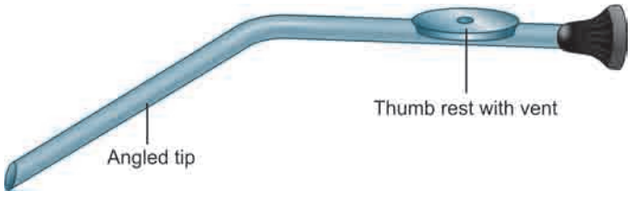


Fig. 5-102: Adson's suction tip.

- *Yankauer suction tip*–It is large suction tip used mainly in peritoneal cavity after lavage; in haemoperitoneum; in peritonitis; in pelvis; in thoracotomy; etc. It has got central hole with outer small multiple holes. It creates strong suction and so

may suck omentum; bowel wall, etc. So with one hand bowel and omentum should be pushed aside while sucking the fluid. Often its tip is supported by a rubber tube. When it is present, care is taken to see that it is not left inside the peritoneal cavity by inadvertent slippage **(Fig. 5-103)**.

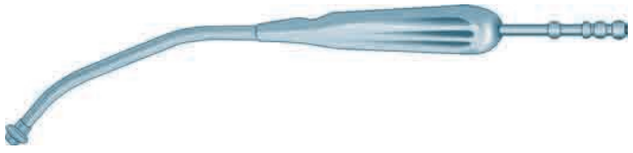


Fig. 5-103: Yankauer suction tip.

- *Poole's multiperforated suction tip*–It has got outer and inner tubes–one inside the other. Outer tube has got multiple holes with blunt closed tip so that bowel/tissues will not be sucked inside. Inner tube has got one terminal and another proximal side holes. Inner tube will be inside the outer tube attached with a screw on proximal aspect. Outer tube has got a thumb rest hole/vent which when closed with thumb, only then the suction tube will function. With thumb placed on the vent suctioning is done in the peritoneum or other cavities, thumb is released while removing the suction tube so that sucking effect on the bowel or omentum or vessels or over the stoma is prevented while withdrawing the suction tip. It acts by sump action principle. It can also be used for decompressing the distended bowel **(Fig. 5-104)**.

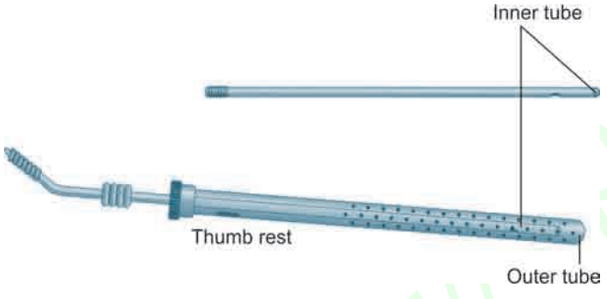


Fig. 5-104: Poole's suction tip.

TRACHEOSTOMY TUBE

Types (Figs 5-105 to 5-108)

1. *Fuller's bivalved tracheostomy tube*: It has got outer tube and inner tube. Outer tube is biflanged and so insertion is easier. Inner tube is longer with an opening on its posterior aspect. Inner tube can be removed and re-inserted easily whenever required. Outer tube flanges are weak and sharp and can break or cause trauma to the tracheal wall. It cannot be used during radiotherapy.
2. *Jackson's tracheostomy tube*: It has got outer tube, inner tube and an obturator. Outer tube has got lock mechanism for inner tube with holes on either side for straps and shield for protection. Inner tube is longer than outer tube. Obturator guides insertion of tube. It is not used in radiotherapy. With tube in place patient cannot speak.
3. *Red-rubber tracheostomy tube.*
4. *PVC tracheostomy tube.*

Modern tracheostomy tubes are made of plastic. They are soft, least irritant and disposable. They have inflatable cuff which makes it easier to give assisted ventilation. Cuff should be deflated at regular intervals to prevent tracheal pressure necrosis of trachea (For assisted ventilation endotracheal tube can be kept for 7 days. Beyond that period patient needs tracheostomy for further ventilation).

Indications for tracheostomy

- In head, neck and facial injuries.
- Tetanus.
- Tracheomalacia after thyroidectomy.
- Laryngeal oedema/spasm.
- Major head and neck surgeries like commando's operation, block dissection, etc.

TRACHEAL DILATOR (TROUSSEAU'S)

Here blades open up while approximating the handle. Blades have got club shaped blunt tip. It is used to dilate the tracheal opening during tracheostomy and to keep it open while introducing the tracheal dilator **(Fig. 5-109)**.

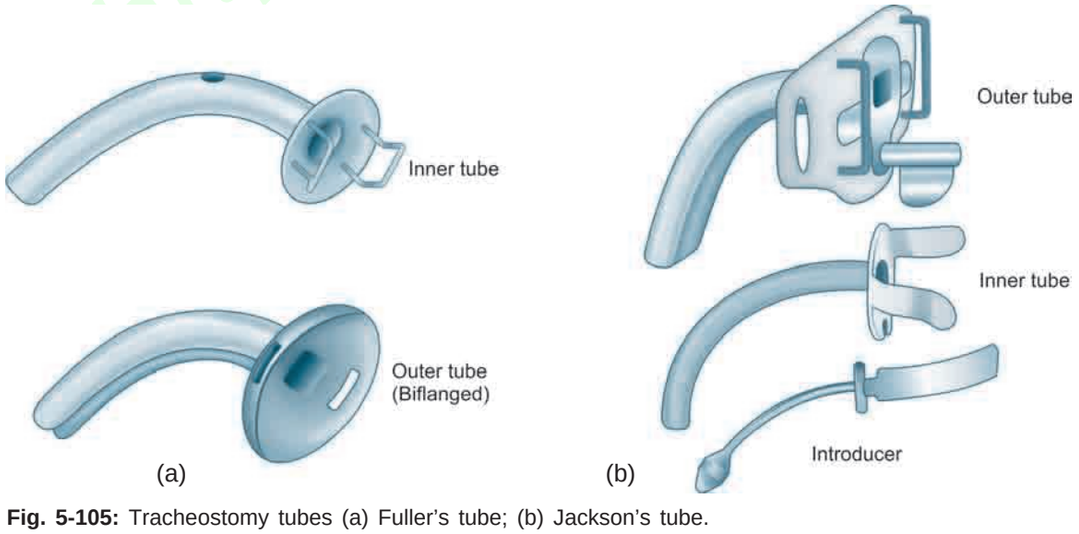


Fig. 5-105: Tracheostomy tubes (a) Fuller's tube; (b) Jackson's tube.

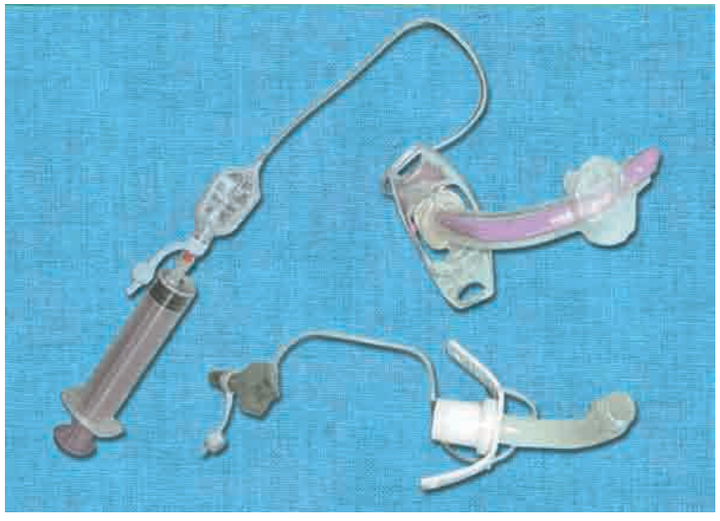


Fig. 5-106: Synthetic disposable tracheostomy tube. Usually number 8.0 or 8.5 is used.

Figs 5-107A and B: Fuller's biflanged tracheostomy tube. It is made up of German silver. Outer biflanged tube is compressible and so acts like a tracheal dilator. Inner tube is longer than outer tube with opening on the convex part which allows phonation and re-education during decannulation. Inner tube cab removed out cleaned properly and can be replaced again with ease. Tracheostomy opening in the neck when blocked with finger, patency of airway and phonation can be checked.

Fig. 5-108: Chevalier Jackson's trachesostomy tube.

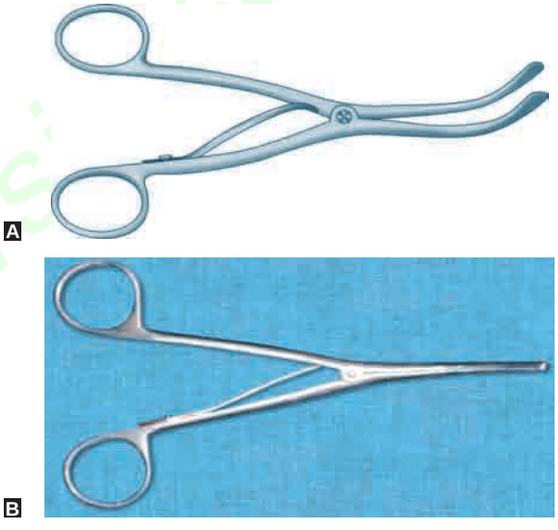


Fig. 5-109: Tracheal dilator.

TRACHEAL HOOK

It is single blunt hook/sharp hook with a handle which is used to stabilise the trachea, retract strap muscles and isthmus during tracheostomy by placing under the cricoid to pull it upwards. Sharp hook is used to stabilize the trachea. Blunt hook is used to retract strap muscles **(Fig. 5-110)**.

Fig. 5-110: Tracheal hook.

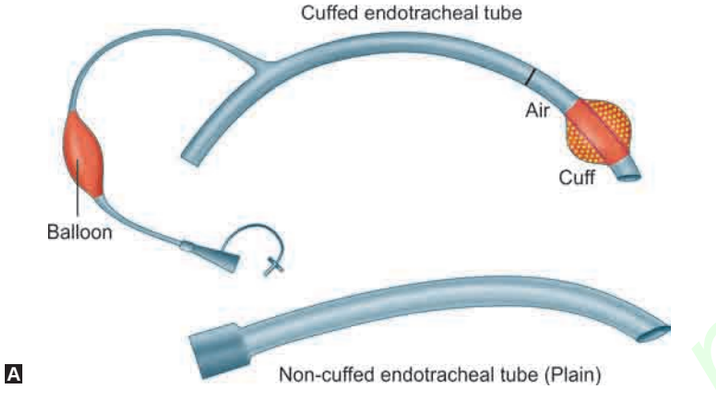
CRICOID HOOK

It has got thin shaft and two curved prongs at the end of the blade with a handle. It is used to retract the isthmus during tracheostomy **(Fig. 5-111)**.

Fig. 5-111: Cricoid hook.

ENDOTRACHEAL TUBE

It is a gently curved tube used to pass into the trachea via the nasal/oral route. It is made up of India rubber or portex. It may be cuffed or non-cuffed (plain). Cuff is present on the distal part of the tube which is inflated using air through a fine tube present on the body of the endotracheal tube. Small pilot balloon on the proximal part is present to check the tension of the cuff. Cuff prevents aspiration and air leak. Capacity of the cuff is 4 ml and often tip is radiopaque. When non-cuffed tube is used, ribbon gauze should be packed around it to protect air way from aspiration. Its distal end is beveled–38 degrees towards left as tube is passed from the right angle of the mouth of the patient. It has got a thick black mark which should pass just beyond the vocal cords. Cuff should be 3 cm beyond vocal cords in adult and 1 cm beyond vocal cords in infants. Different sized tubes are available depending on age of the patient. Number 6.5 to 8.0 in females and 8.0 to 9.5 in males are used. Styllet is often used while passing the endotracheal tube for easy intubation **(Figs 5-112A to C)**.



Figs 5-112A to C: Endotracheal tube.

It is used in general anaesthesia, to maintain airway in emergency in patients with trauma, in patients with respiratory distress, in cardia arrest. It is a life saving tube used during resuscitation. It is usually kept for 7 days. Tracheostomy is done if patient needs further continuation of artificial ventilation.

Types

- *Cole tube*–Here distal part is narrow and is used in paediatric anaesthesia.
- *Lindholm tube*–It has 90 degree curve at oropharynx.
- *Rae preformed tracheal tube*–There is bending in the part of the tube that remains outside. It can be oral or nasal bends.
- *Spiral embedded/armored/reinforced*–Middle segment of the tube is spirally embedded with nylon/metal filaments to make it resistant for kinking and tolerable in high pressure.
- *Endotrol tube* has got cable like mechanism to have a control over the tip.
- *Hi-low jet three*–lumen tracheal tube with main lumen for ventilation, second for jet ventilation, suctioning, oxygenation and bronchoscopy, third one for irrigation and sampling from trachea.
- *Laser shield endotracheal tube* which is made up of silicon with impregnation of metal particles.
- *Oxford endotracheal tube*–Here 2 cm of nasal end of the tube is bent at 90 degrees and is used in cleft lip and cleft palate surgeries.

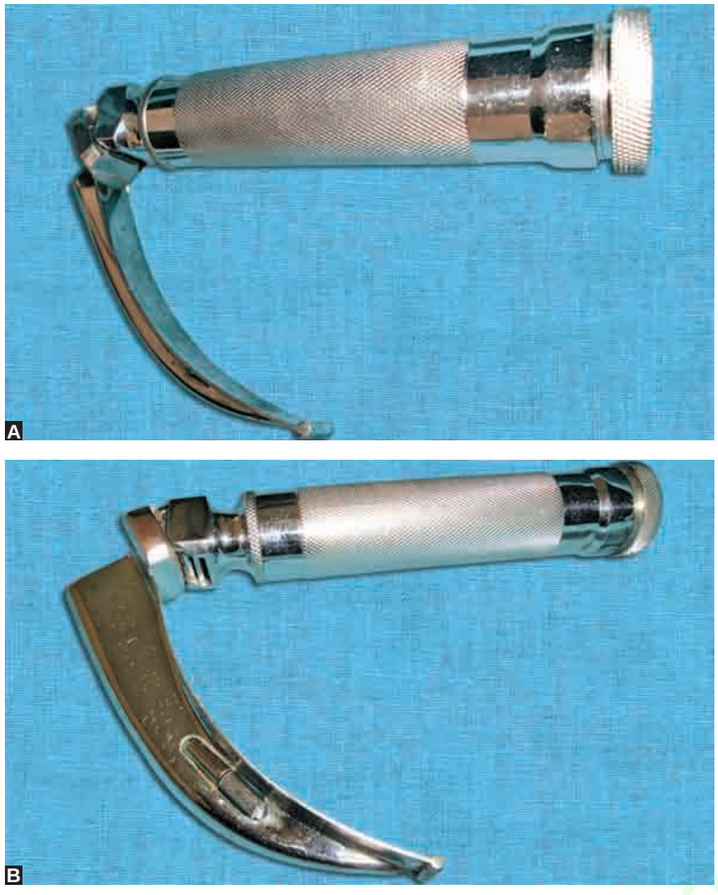
Complications of Endotracheal Tube

- Oesophageal intubation–most dangerous and should be identified by ventilation, auscultation, absence of vapour in the proximal part of the tube. It should be removed and reintroduced immediately.
- Trauma to oral/nasal/pharynx/larynx.
- Right sided intubation as right bronchus is shorter, wider than left and it is in line with tracheal lumen. Left side will not get ventilated in this situation.
- Bronchial obstruction/aspiration.
- Infection–bronchopneumonia, septicaemia.
- Kinking, blocking of the tube.
- Tracheal dilatation/erosion.
- Inadvertent extubation/difficult extubation.
- Laryngeal/pharyngeal oedema, laryngitis.
- Vocal cord dysfunction/laryngeal or tracheal narrowing.

DIRECT LARYNGOSCOPE

It is to visualise larynx; consists of a handle and blade. Handle contains batteries as light source. Blade can be straight or curved and detachable. It contains an illuminating bulb at the tip. Light gets on only when blade is straightened when ready for use when it comes in contact with handle.

MacIntosh blade is commonly used which is curved with a flange to push the tongue to opposite side. Blade is designed for right hander to push the tongue towards left. For left hander separate laryngoscope with blades are used. Bulb at the blade comes in contact with handle once blade is opened right angle to cause illumination. Fiberoptic laryngoscope is brighter with bulb in the handle so that bulb falling into oropharynx or larynx is prevented. Tip of the blade is used to press vallecula so that epiglottis gets lifted to view the glottis. Blades may be small, medium, large or extra large **(Figs 5-113A and B)**.



Figs 5-113A and B: MacIntosh laryngoscope.

Miller blade—Straight blade which is used in children and in difficult cases with tip is passing behind the epiglottis to view glottis. Miller blades are available as 0, 1, 2, 3 and 4.

Problems–Trauma to oropharynx, tachycardia, hypertension, arrhythmias. Inadvertent loosening of the bulb and falling into oropharynx or larynx is real risk.

MAGILL'S FORCEPS

It is long, sidewise angulated with fenestrated blades with rings in the handle without ratchets. Angulation helps while using in proper vision of oropharynx. It is used to assist in endotracheal intubation, nasotracheal intubation, removal of dentures, teeth, foreign body from the oropharynx in anaesthetised patient. It is used to pass nasogastric tube under vision in anaesthetised patient. Oropharyngeal packing is done under vision using Magill's forceps **(Figs 5-114A and B)**.

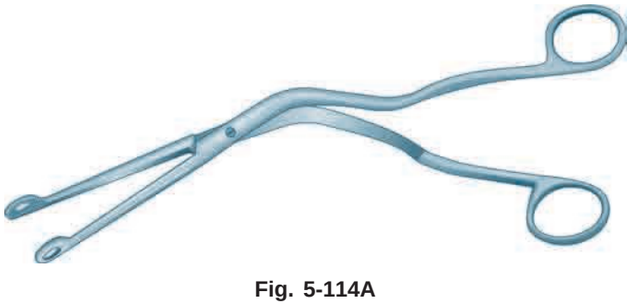


Fig. 5-114A

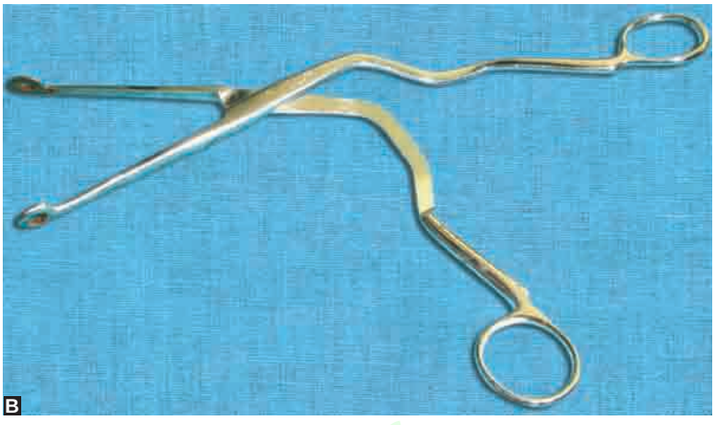


Fig. 5-114B

Figs 5-114A and B: Magill's forceps.

DRAINS

A drain is a created channel which allows any collected fluid to come out after closure of the main wound **(Fig. 5-115)**.

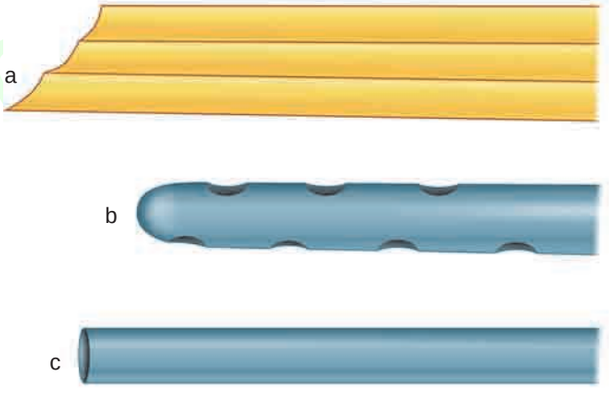


Fig 5-115: Drains: (a) Corrugated rubber drains, (b) Multiple perforated drains, (c) Tube drain.

Types (Figs 5-116 and 5-117)

1. *Corrugated rubber drain:* It drains by capillary action and gravity. It is cheaper and technically easier. But it allows soakage of dressings and causes discomfort to the patient **(Fig. 5-116)**.

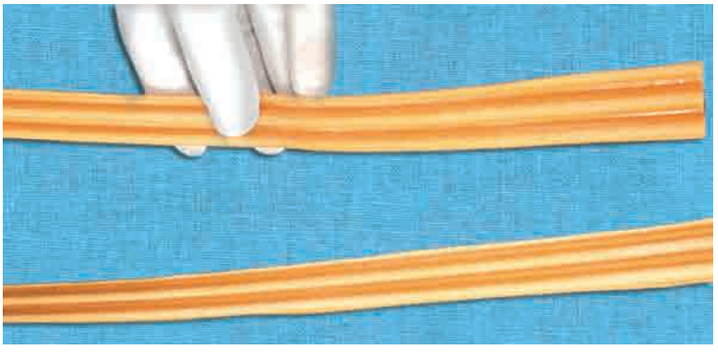


Fig. 5-116: Corrugated drain.

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Figs 5-117A and B: Romovac suction drain. Here suction is created by pressing the suction corrugation. There is a sharp metallic introducer to pass the tube into the required area after puncturing the skin. It is used for thyroidectomy, mastectomy, radical dissection, wide excisions, flap surgeries etc.

2. Tube drains:
   - Malecot catheter can be used as tube drain
   - Penrose soft latex rubber tube
   - Multiple perforated tubes
3. Closed suction tube drain system
4. *Glove drain*
5. *Wick drain* is a gauze drain to drain pus, discharge, etc.

Advantages of Tube Drains

- Quantity of fluid like bile, pus can be measured
- It can be kept for longer time
- Skin excoriation will not occur
- Patient will be more comfortable
- Infection rate is less
- Removal is easier
- Dye can be injected and cavity or communication can be assessed using 'C-ARM'.

Classification of drain system:

1. *Open (static) drains: e*.g. corrugated drain, Penrose drain (soft latex rubber tubing). Infection rate is higher.
2. *Closed siphon drains:* Here drain is connected to a sterile bag with or without one-way valve. It reduces the infection.
3. *Closed suction drain:* Here negative pressure of –100 to –500 mm Hg is used to create vacuum to drain the secretions.
4. *Sump suction drain:* Here negative suction with a parallel air-vent is used to prevent the adjacent soft tissues being sucked into the lumen of the drain.
5. *Under water seal drain* to drain pleural space.

Indications for drains:

- In drainage of an abscess.
- In bleeding surgical conditions like trauma, per-operative bleed.
- In haemo, pyo or pneumothorax.
- In acute abdominal conditions like peritonitis, haemoperitoneum.
- In major abdominal surgeries like of pancreas, biliary tree, stomach, etc.
- In thyroid surgery.
- In hydrocele surgery.

Problems in drains:

- Infection through the drain.
- Displacement.
- It may not drain adequately and can give false information.
- It may interfere with healing process inside.

Presently keeping a drain itself is a questioned debate and controversy all over. Older dictum was 'when in doubt keep a drain and the surgeon can sleep happily'–is questioned at present.

Drains if not used properly may be counterproductive.

Note:

A drain should be placed always in most dependent position and should be brought out through shortest straight route with a separate stab incision. It should be anchored to skin securely. Corrugated drain should be kept with adequate length otherwise it may get into the abdominal cavity during phases of respiration.

INTERCOSTAL DRAINAGE TUBE

It is made up of portex with proximal end having multiple holes which is inserted into the pleural space. Other end is connected to a glass tube the tip of which is dipped inside the under water bottle which allows the expulsion of air outside. This tube end should be dipped in the water column properly. Smaller glass tube often bent in between is not dipped inside the water column which allows the air to go out. It is used in haemothorax/pneumothorax/empyema/after thoracic/oesophageal surgeries. In haemothorax/empyema, chest tube is inserted in the midaxillary line in 6th intercostal space. It is easier to pass the tube in this line as muscles are thin and patient will be comfortable if tube is in this position **(Fig. 5-118)**.

Fig. 5-118: Intercostal drainage tube with underwater seal bottle.

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PAUL'S DRAINAGE TUBE

It is a bent glass tube with two ends. Edge with two collars is passed through the enterotomy into the intestine and fixed with a purse string suture. End with a single collar is attached to a rubber tube to remove the bowel contents from distended bowel. It is not used now **(Fig. 5-119)**.

Fig. 5-119: Paul's drainage tube.

CATHETERS

They are hollow tubes used to relieve urinary retention, obtain urine for analysis, irrigate bladder and to instill drugs into bladder **(Fig. 5-120)**.

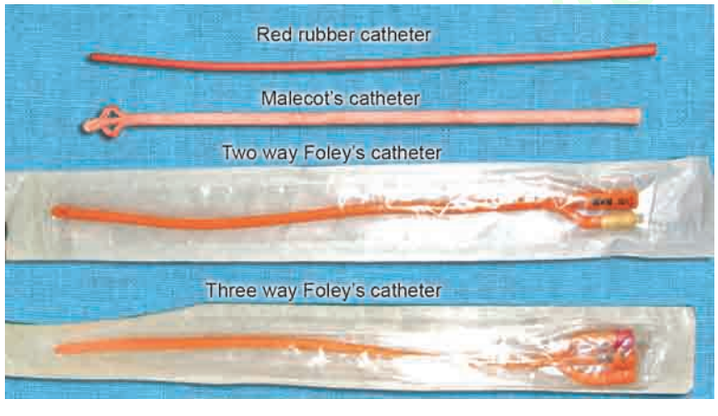


Fig. 5-120: Different urinary catheters—Non-self-retaining red rubber catheter; Self-retaining Malecot's catheter; self-retaining Foley's catheter.

Uses

- To pass per urethrally in retention of urine of any cause [BPH, stricture, trauma)
- To measure the urine output in renal failure, postoperative patients and terminally ill patients, and patients under critical care
- After prostatectomy or TURP–three way catheter is used for irrigation also. Here it is also used as haemostatic by inflating more distilled water into the balloon and giving traction causing tamponade effect
- Paraplegia/neurogenic bladder–initially Foley's catheter is used later condom drainage is better
- To give bladder wash in haematuria, infection, etc.
- Percutaneous suprapubic cystostomy
- Cholecystostomy
- To drain fistulas
- To control bleeding from nostrils/post-haemorrhoidectomy secondary haemorrhage
- In children to give enema or to do barium/contrast enema X-rays
- In obstructed labour, during caesarean section surgery, prior to abdominal hysterectomy (for 1 day), at the end of vaginal hysterectomy (for 5 days), post-partum haemorrhage, during abortion often
- To check cervical incompetence 8 F Foley's catheter is used
- After vesicovaginal fistula repair it is kept for 7-10 days
- After Wertheim's operation it is kept for 14 days
- After bladder injury repair it is kept for 10-14 days.

Types

- *Nonself-retaining catheter*- Simple red rubber catheter.
- *Self-retaining catheter*: Foley's catheter, Malecot's catheter, Gibbon's catheter, De-Pezzer catheter.

Types of Catheterisation

a. *Indwelling catheterisation*: When a catheter is left behind in bladder and remains so it is called an indwelling catheter
It is achieved by:
   - Balloon tip of catheter
   - Foley's catheter
   - Flower tip of catheter
   - Malecot's catheter, De- Pezzers
   - Strapping catheter externally
   - Gibbon's catheter.

b. *Intermittent catheterisation*: A sterile catheter is introduced intermittently by the patient or by others.

FOLEY'S CATHETER (FREDRICK EUGENE BASIL FOLEY-AMERICAN UROLOGIST)

It is a *self retaining* urinary catheter made up of *latex*. It has got a balloon near the tip into which distilled water is infused to make it

India rubber catheter	Latex rubber	Metal catheters	Polyethylene catheters
• Red in color contains high sulfur • Heat resistant • Causes more irritation	• Softer, smooth, less irritant • Can be kept for long time • Sterilized by boiling, autoclave or gamma radiation	• Female and male catheters • are different • Used in difficult catheterization • To empty bladder prior to vaginal hysterectomy	• Transparent and stiffer **Gum elastic catheters** • From gum resins with cotton/silk impregnated • Formalin vapor sterilization • Boiling or autoclave can not be done • Not used now

self retainable. Usually Foley's catheter is kept for 7 days. It is s*terilised* by radiation **(Fig. 5-121).**

Size: Adults 16 F.
Children 8 F or 10 F.

(**F**- *French unit, Charriere unit, where each unit equals 0.33 mm)*. 16 F means circumference of the catheter is 16 mm. Diameter is on-third of circumference).

Fig. 5-121: Foley's catheter.

Types:

1. Two-way Foley's **(Fig. 5-122)**.
2. Three way Foley's—To give bladder irrigation, e.g. Following TURP.
3. Silicon coated Foley's—To reduce reaction and so as to keep for longer period (3 months).

Fig. 5-122: Two way Foley' and Three way Foley's catheters.

Procedure

After cleaning under strict asepsis, lignocaine gel is lubricated into the urethral meatus. Catheter is passed into the urethra. Sometimes *Maryfield introducer* is used to pass Foley's catheter. Once catheter is in the bladder, urine will flow out. It is now connected to an *urosac bag* **(Fig. 5-123)**. Balloon is inflated with 20-30 ml (amount is written on the catheter) of distilled water to make it self-retainable. During removal of the catheter same amount of water should be removed from the balloon before pulling out the catheter. After passing catheter, prepucial skin should be placed backwards otherwise iatrogenic paraphimosis can develop **(Figs 5-123 to 5-125)**.

Fig. 5-123: Urosac bag.

Complications

- Infection
- Encrustation
- Bleeding
- Stone formation
- Blockage, false passage
- Stricture
- Difficulty in removal of the catheter due to blockage of the balloon channel. Here bulb of Foley's can be punctured from above under ultrasound guidance or ether can be injected into the balloon so as to burst it but it may cause chemical cystitis or a stilette (ureteric catheter stillete) can be passed into the channel.

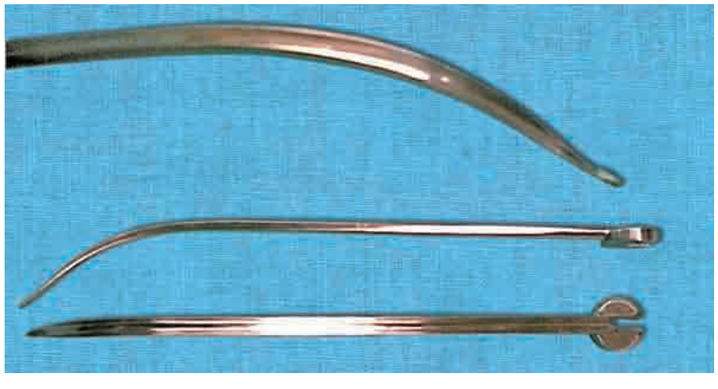


Fig. 5-124: Maryfield Foley's catheter introducer. It has got groove on the convex surface over which catheter is placed. Tip of catheter is hooked on to projection on the tip of the introducer. Once catheter with introducer is inside, introducer is released and removed retaining the catheter which is inflated adequately.

Fig. 5-125: Iatrogenic paraphimosis developed after Foley's catheterisation due to failure to place back the prepucial skin.

MALECOT'S CATHETER

It is self-retaining urinary catheter with an umbrella or flower at the tip. It is made of red rubber, contains sulphur and so it is radiopaque **(Fig. 5-126)**.

It is never introduced per urethrally. It is sterilized by boiling.

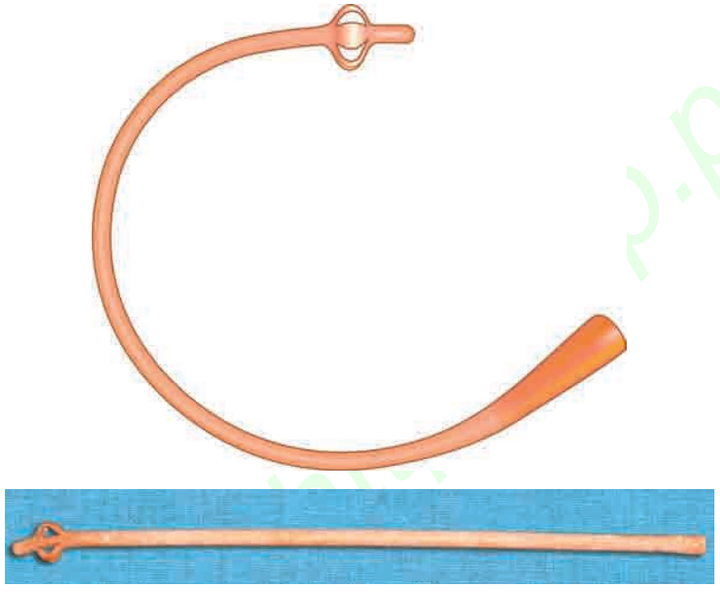


Fig. 5-126: Malecot's catheters.

Uses

- Suprapubic cystostomy (SPC).
  - In case of urinary retention when Foley's catheterisation fails (after two trials)
  - For diversion of urine following bladder, prostate or urethral surgeries
- For continuous drainaige of abscess cavities–
  - Perinephric abscess
  - Pyonephrosis
  - Subphrenic abscess
  - Amoebic liver abscess
- Cabot's nephrostomy
- Cholecystostomy
- Infected pseudocyst of the pancreas
- Gastrostomy, caecostomy (tube type)

Advantages

- Malecot's catheter can be kept for a long period of time (3 months).
- It drains fluid adequately.
- Less infection rate.
- Removal is easier.

Disadvantage

Surgery (Open method) is required to insert the catheter.

Suprapubic Cystostomy (SPC)

It is placing of Malecot catheter into the bladder above the pubis by open method, or percutaneously under guidance using Foley's catheter. It is a temporary opening through the abdomen into the bladder.

Prerequisite: Bladder must be full and is confirmed by dullness below the umbilicus or by ultrasound.

Indication: Retention of urine when urethral catheterisation fails.

Procedure: Under local anaesthesia (Xylocaine 2% above the pubis, in the midline) or G/A, a vertical midline incision of 3 cm in length is placed through linea alba. Skin, fascia, anterior rectus sheath are incised. Recti are retracted. In extraperitoneal space, peritoneum with pad of fat is reflected upward. Bladder is identified by the pattern of detrusor muscle and vesical venous plexus and is confirmed by aspirating urine through a syringe. The bladder is opened near the fundus. Urine is aspirated. Bladder wall is inspected for any pathology. Malecot catheter is straightened using artery forceps and placed in the bladder. Sutures are placed around the Malecot catheter. Wound is closed in layers.

In percutaneous SPC, Foley's catheter is passed into the bladder using trocar and cannula.

Complications

- Injury to bowel, peritoneum.
- Infection.

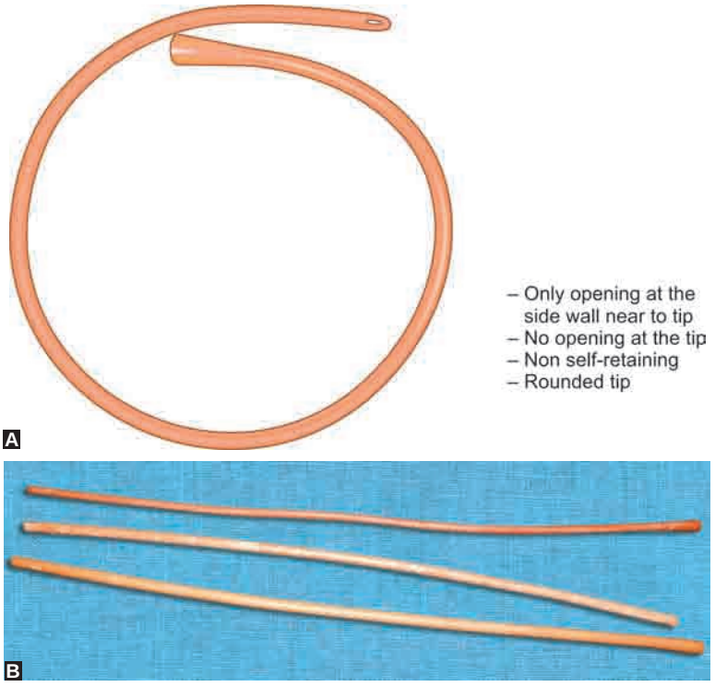
SIMPLE RED RUBBER CATHETER

It is a non self-retaining urinary catheter. It is stiffer than Foley's catheter. Its tip is rounded and blunt. Opening is only on the side wall (In flatus tube opening is present on both sides and also at the tip). Here *English unit* is used to number–diameter is 1 + catheter number/2 **(Fig. 5-127)**.

Uses:

- Used to drain urine from the bladder temporarily in retention of urine.
- To find out residual urine. After passing urine, catheter is introduced into the bladder. The amount of retained urine is measured. If it is more than 30-50 ml it signifies obstruction. It often increases more than 200 ml in conditions like BPH and indicates significant obstruction that needs surgical intervention like TURP.
- While doing cystography to infuse dilute iodine dye into the bladder.
- Single gentle passage of the red rubber catheter is tried as a diagnostic method to identify the urethral/bladder/renal injuries.

Haematuria signifies urinary tract injury. Measured normal saline is infused into the bladder and return volume is collected; if it is less, then it indicates injury to bladder.



Figs 5-127A and B: Simple non self-retaining red rubber catheter.

- For administration of intravesical chemotherapy or therapeutic BCG infusion into the bladder per urethral in bladder carcinoma.
- To collect urine from the bladder for culture and sensitivity.
- To identify the urethra in perineal surgery/urethral surgery/penectomy.
- To dislodge and push back the calculus impacted in the urinary meatus or in the urethra.
- To administer nasal oxygen.
- For suction of throat/endotracheal tube/tracheostomy tube.
- As a tourniquet for venesection and surgeries of fingers and toes.
- Used as a sling in many places like to hold cord, to hold vagus, to hold pedicles, to hold oesophagus/bowel/ureter.
- To irrigate and clear the pus after opening the abscess cavity/or any other cavities in depth.
- To irrigate common bile duct after choledochotomy; to irrigate ureter/renal pelvis after stone removal.
- In pregnancy, labour, puerperium.
- Just prior to vaginal hysterectomy after draping to empty the bladder red rubber or female metal catheter is used.
- Often to diagnose tracheo-oesophageal fistula.

DEPEZZER'S CATHETER

It is a self-retaining catheter with a bulb at the end which makes it self-retaining. Its uses are like Malecot's catheter. It cannot be passed per urethral. Usually 24 French size is used **(Fig. 5-128)**.

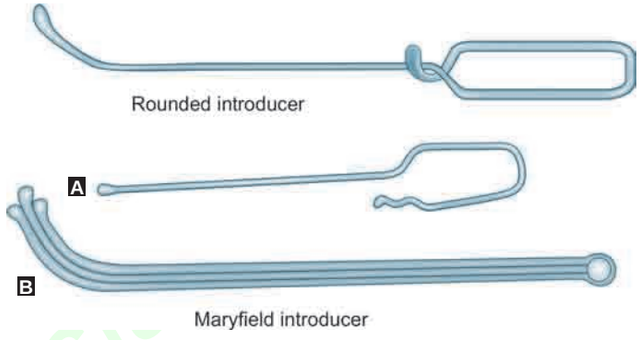
Fig. 5-128: Depezzer's catheter.

CATHETER INTRODUCER

It is used to negotiate the catheter into the urethra or in other places wherever it is used.

Two types:

- Long slender metallic type with rounded tip **(Fig. 5-129)**.
- Maryfield introducer–it is long curved flat metallic introducer with a longitudinal groove over its convex surface over its entire length which ends at the tip as a blunt projection. This projection helps in hooking the catheter tip (Foley's catheter) and the groove accommodates the body of the catheter and prevents it from slipping away **(Fig. 5-129)**.



Figs 5-129: (A) Rounded catheter introducer, (B) Maryfield introducer.

GIBBON'S CATHETER

It is a self retaining catheter made up of plastic with a stillete in it which makes its passage easier through urethra. There are different sizes for males and females because of the difference in length of the urethra in male and female. Catheter has two ribbons attached which can be used to fix to the genitalia by adhesive plaster. Gibbon's catheter is least irritant to urethra **(Fig. 5-130)**.

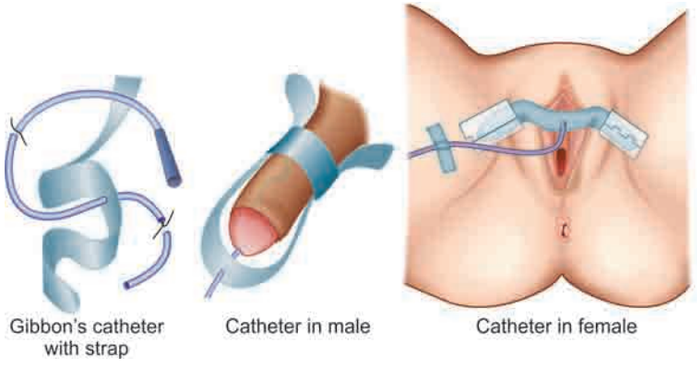


Fig. 5-130: Gibbon's catheter. Note the look and method of fixing in male and female.

TIEMANN CATHETER (FIG. 5.130A)

It is made up of PVC with beaked, stiff tip. Different color codes are used on the beaked tip for different numbers of the catheter. Side holes are located proximal to the color codes.

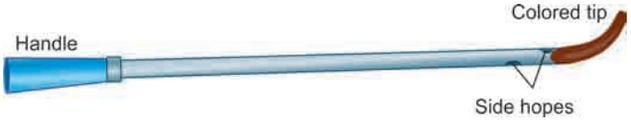


Fig. 5-130A: Tiemann catheter.

No. 12—White
No. 14—Green
No. 16—Vermilon
No. 18—Red
No. 20—Yellow
No. 22—Maroon
No. 24—Blue

METAL CATHETERS

They are metal catheters which are stiff and can be passed into the urethra even if other catheters fail.

Two Types

a. *Male metal catheter*
It is long tube with a curve at the tip. Tip is rounded and blunt with side holes. Two rings near the base help in holding the catheter. It is used to empty the bladder in retention of urine when other types of catheter fail. With prior lubrication of urethra using adequate quantity of lignocaine jelly, it is passed like a dilator with all aseptic precautions. Catheter is passed through the external meatus into the urethra. Once it reaches the bulbar urethra a resistance is felt, then handle is rotated across the inguinal ligament, groin towards the midline over to the abdomen. Sudden release of resistance is felt as catheter enters the bladder. Urine will come out of the catheter easily. Catheter will stay there firmly only if entered properly **(Fig. 5-131)**.

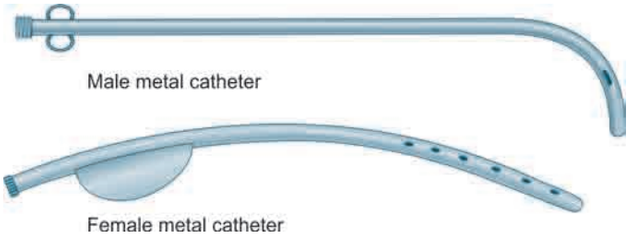


Fig. 5-131: Diagram showing male and female metal catheters.

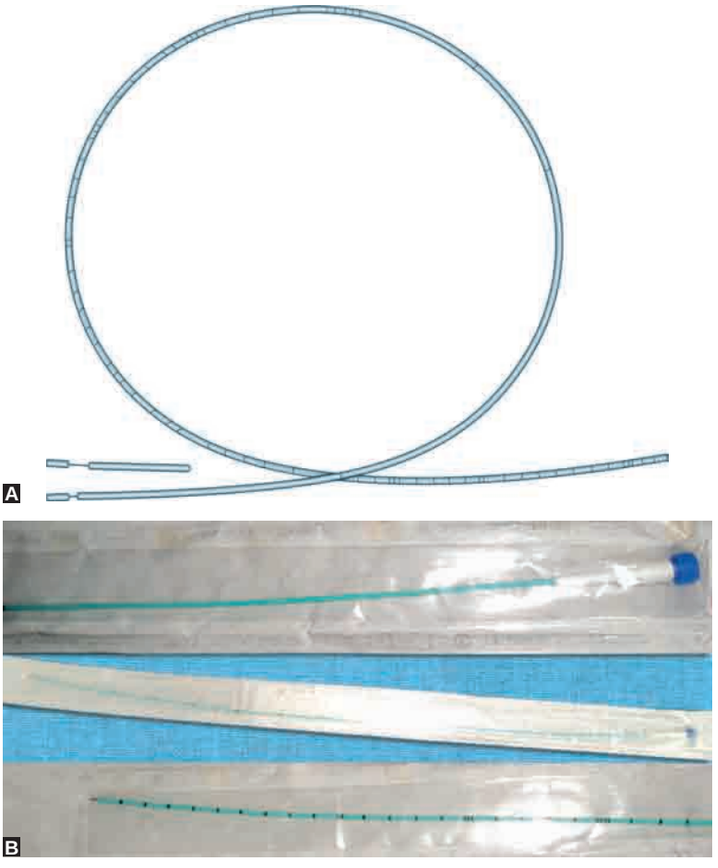
b. *Female metal catheter*
It is short metallic catheter. Tip is rounded with multiple side holes. It has got one flat curved handle. It is used to empty the bladder in pelvic surgeries like vaginal hysterectomy.

URETERIC CATHETER

It is thin slender flexible radiopaque tube of 70 cm length with a black mark at every 5 cm junction. French unit is used. 3-8 French (F) are available. Initially cystoscope is passed and under visualisation ureteric catheter is passed through ureteric orifice with a stillete. Stillete maintains the stiffness and patency of the catheter. It can be olive tipped; whistle; coude'; or open ended. It is used while doing retrograde pyelography (RGP); to do collect selective urine sampling in tuberculosis; to assess and relieve the ureteric obstruction; as an ureteric stent **(Figs 5-132A and B)**.

URETHRAL DILATORS

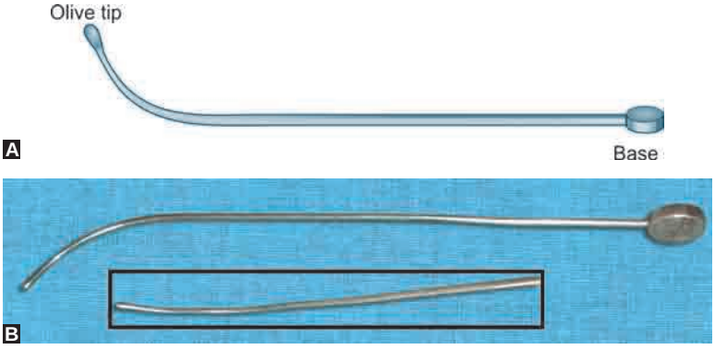
- Lister's dilator
- Clutton's dilator
- Filiform bougies
- Gum elastic bougies
- Olive tip bougies
- Whip bougies



Figs 5-132A and B: Ureteric catheters.

LISTER'S URETHRAL DILATOR

It has got olive tip with a rounded handle. Handle is rounded with numbers marked. Denominator is circumference in mm at the base of the Lister's dilator **(Figs 5-133A and B)**. Numerator signifies circumference just proximal to the olive tip (narrowest point). Difference between denominator and numerator is 3 mm. So each dilator is narrowed for 3 mm from base to proximal end of olive tip. Circumference of olive tip is equal to circumference in the base. Numbering is based on English scale (diameter in mm) = Number/2 + 1. It is used to dilate stricture urethra; to pass catheter by open rail road technique in rupture urethra.



Figs 5-133A and B: Lister's urethral dilator.

With all aseptic precautions urethral dilatation is done (proper cleaning and draping). It is done under local lignocaine jelly application or under general anaesthesia. Dilator is passed up to the bulb when

a resistance is felt. Then handle is gently curved over the inguinal ligament, groin and over the abdomen towards midline. A feel of entry into the bladder is felt while entering the bladder. Once left like that dilator stays there firmly with free side-to-side movement otherwise it will fall back.

Persistent pain; severe resistance and bleeding per urethra are the features to consider failure of the dilator entering into the bladder.

False passage; bleeding; infection and fistula formation are the complications of urethral dilatation.

CLUTTON'S DILATOR

It is a long metallic instrument with a curve and blunt tip at the end. Handle is violin shaped. It is numbered in English units. Denominator of the part signifies the circumference in the base and numerator suggests the circumference in the tip **(Fig. 5-134)**. Difference between denominator and numerator is 4. Numbers are like 6/10; 8/12; 10/14 — so on. Set 12 of dilators are available.

Fig. 5-134: Clutton's dilator.

FILIFORM BOUGIES

It is a small cylindrical hygroscopic instrument used in tight strictures to negotiate one of the bougies. Bougies are passed in bunches into the urethra. One of the bougies will be negotiated across the stricture by trial and error manoeuvre. That particular bougie is left in place which absorbs the urethral fluid and secretions; and gets swollen causing required dilatation. Later metallic dilators like Lister's or Clutton's dilators are passed to achieve adequate dilatation **(Fig. 5-135)**. Many types of filiform bougies are furnished with threaded hollow mounts at the proximal ends. Larger sized screw ended gum elastic bougie can be attached to the filiform follower thread to do the subsequent dilatation.

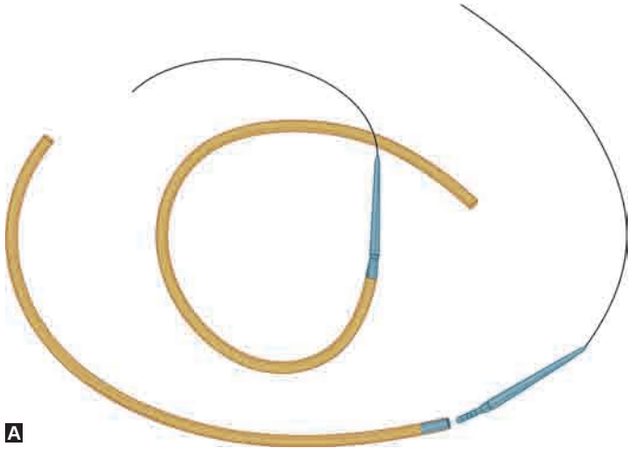


Fig. 5-135A

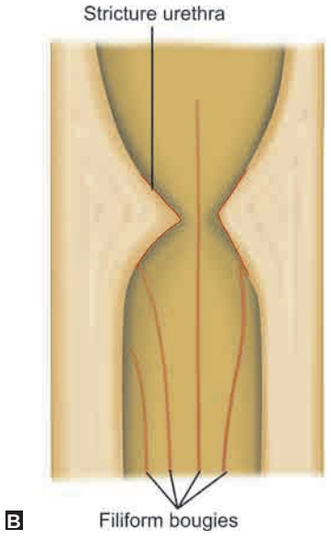


Fig. 5-135B

Figs 5-135A and B: Filiform bougie with followers. One of the bougie can be negotiated through the tight strictures and which helps in further dilatation through metallic dilators.

BLADDER SOUND

It is used to explore the bladder for the presence of stones by sound—hence the name. It is not used now. It can be used as urethral dilator **(Fig. 5-136)**.

Fig. 5-136: Bladder sound.

THOMPSON-WALKER'S SUPRAPUBIC CYSTOLITHOTOMY FORCEPS

It has got a spoon shaped elongated concave blades with spikes on the inner surface which gives secure grip of the stone from the bladder. It has no ratchet. Shaft has got a ring for placement of thumb and another is curved open to place four fingers. It is used to hold and remove stones from the urinary bladder in suprapubic cystolithotomy **(Fig. 5-137)**.

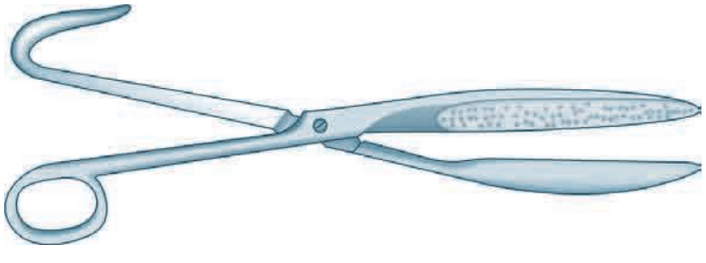


Fig. 5-137: Thompson-Walker suprapubic cystolithotomy forceps.

BOOMERANG NEEDLE

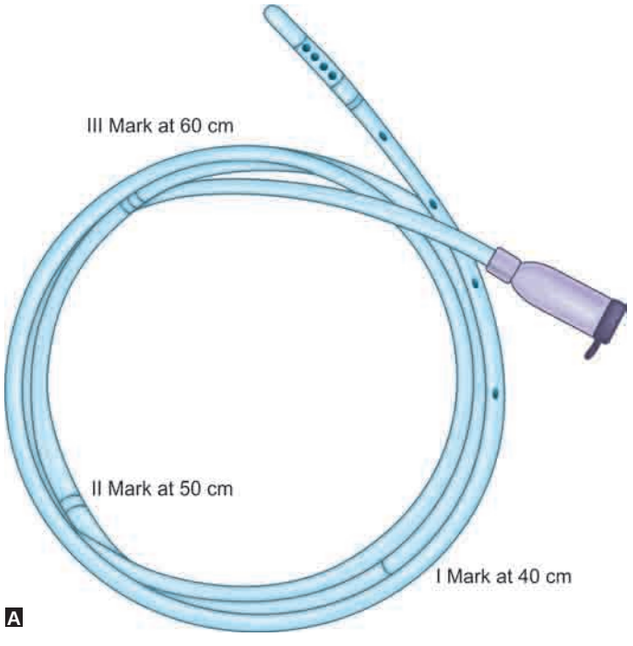
It is sharply curved needle attached to a special holder with a spring within it. Needle has got sharp point and a slot. Suture material is

passed through the slot to pass deep in to the tissues. When handle is compressed through spring, needle rotates inwards passing through the tissues in front. It is used in suturing prostatic capsule in open prostatectomy **(Fig. 5-138)**.

Fig. 5-138: Boomerang needle used to suture prostatic capsule in open prostatectomy.

NASOGASTRIC TUBE/RYLE'S TUBE

It is one meter long which is made up of red rubber or plastic. Original Ryle's tube was made up of moulded red rubber **(Figs 5-139A and B)**. Presently used nasogastric tubes are made up of polyethylene or portex. Tip is blunt without opening. Subterminal multiple openings are present on all the sides. It is sterilised by gamma rays.



Figs 5-139A and B: Ryle's tube.

It has got three lead shots in the tip which makes it radiopaque. It also facilitates easy passage of the tube through the oesophagus. Once tube is inside the stomach, bile/gastric juice will come out of the proximal end, often confirmed by aspiration. Stethoscope is placed over the stomach; syringe with air is pushed into the tube; if tip of the tube is in the stomach air entering into the stomach can be heard through the stethoscope.

It is passed through one of the nostrils using xylocaine 2% jelly. Under anaesthesia it is passed using Magill's forceps. It should be fixed securely to the nostrils otherwise it may get displaced or come out. It should be replaced with new tube in 2 weeks. Intermittent suction or continuous open drainage can be done depending on requirement. In postoperative period it is removed once patient passes flatus; or adequate bowel sounds are heard; and content in the tube is reduced to less than 50 ml.

It has got markings at different levels:

- At 40 cm distance, indicates the level of gastro-oesophageal junction.
- At 50 cm distance, indicates the level of body of the stomach.
- At 60 cm distance, indicates the level of the pylorus.
- At 65 cm distance, indicates the level of the duodenum.

Indications

Diagnostic:

- For gastric function tests. To assess free acid and total acid–in gastric/duodenal ulcers; pyloric obstruction/carcinoma stomach (exfoliative cytology); achylia; Zollinger–Ellison syndrome; pernicious anaemia; saline load test to confirm gastric motility and outlet obstruction; small bowel enema.
- Hollander's test for completion of vagotomy.
- To diagnose tracheo-oesophageal fistula.
- Baid test for pseudocyst of the pancreas.

Therapeutic:

- In acute abdominal conditions like peritonitis/ obstruction, etc.
- In abdominal trauma.
- After abdominal surgeries.
- In pyloric stenosis.
- In upper GIT bleeding.
- In paralytic ileus, gastric dilatation to decompress the bowel
- For feeding purpose in comatose patients, faciomaxillary injuries, major head and neck surgeries, head injuries, pharyngolaryngeal surgeries; surgeries for cleft palate.

Ryle's tube is British type, made up of red rubber, usually 75 cm in length, with lead shot in the tip. It is available as different sizes from 8 French to 18 French units.

Levin's tube is American tube made up of portex, 125 cm in length. *Now it is commonly used tube.*

Complications

- Injury to nostrils and bleeding.
- Pharyngitis/rhinitis.
- Discomfort/unacceptancy.
- Ulceration in the pharynx/oesophagus.
- Aspiration pneumonia as lower sphincter is kept open–dangerous complication—may cause death also.
- Perforation of oesophagus.

Nasogastric tube is contraindicated in corrosive oesophageal burns in initial phases for 2 weeks.

INFANT FEEDING TUBE

It does not have lead shots and no markings. It is used in children and infants similar to Ryle's tube **(Fig. 5-140)**. Length: 52 cm
Sizes: FG 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

Fig. 5-140: Infant feeding tube.

FLATUS TUBE

It is made up of India rubber, 45 cm in length. There is one opening in the tip and another on the side proximal to the tip (Urinary catheter like red rubber catheter has no opening on the tip, only side opening is present) **(Fig. 5-141)**. It is used in sigmoid volvulus to decompress and derotate; in paralytic ileus; in subacute intestinal obstruction. It is passed per anal into the rectosigmoid area. Proximal end is connected to water container to observe the quantity of air bubble which signifies the amount of gas getting deflated.

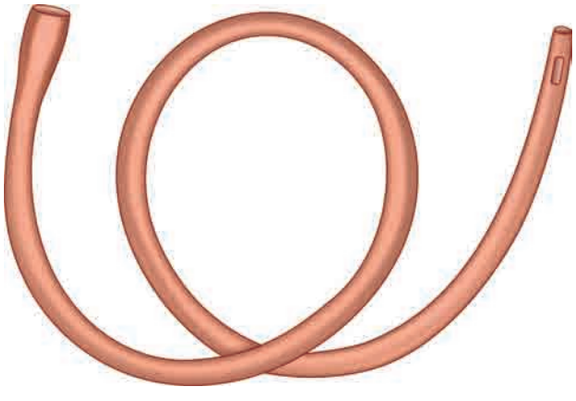


Fig. 5-141: Flatus tube.

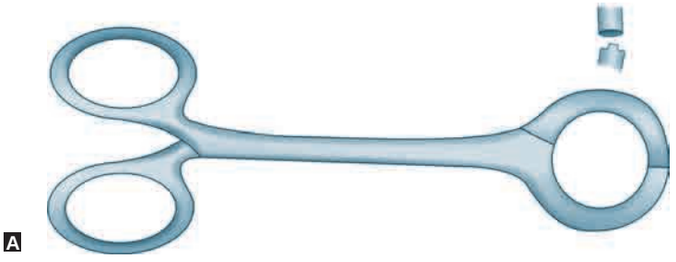
HERNIA BISTOURY

It has got a handle and a flat blade with a small cutting edge on one side near the tip. Tip is blunt. Instrument is used to divide constriction band in strangulated hernia, to cut lacunar ligament in femoral hernia. It helps to protect adjacent structures while cutting the band **(Fig. 5-142)**.

Fig. 5-142: Hernia bistoury.

COLLINGWOOD STEWART'S RING SHAPED BLADE HERNIA FORCEPS

It has got semicircular tips which when approximated forms as ring. It has got a ratchet to have a proper grip. It is used to hold cord structures during inguinal hernia surgery so that hernioplasty/herniorrhaphy can be done effectively **(Figs 5-143A and B)**.



A

B

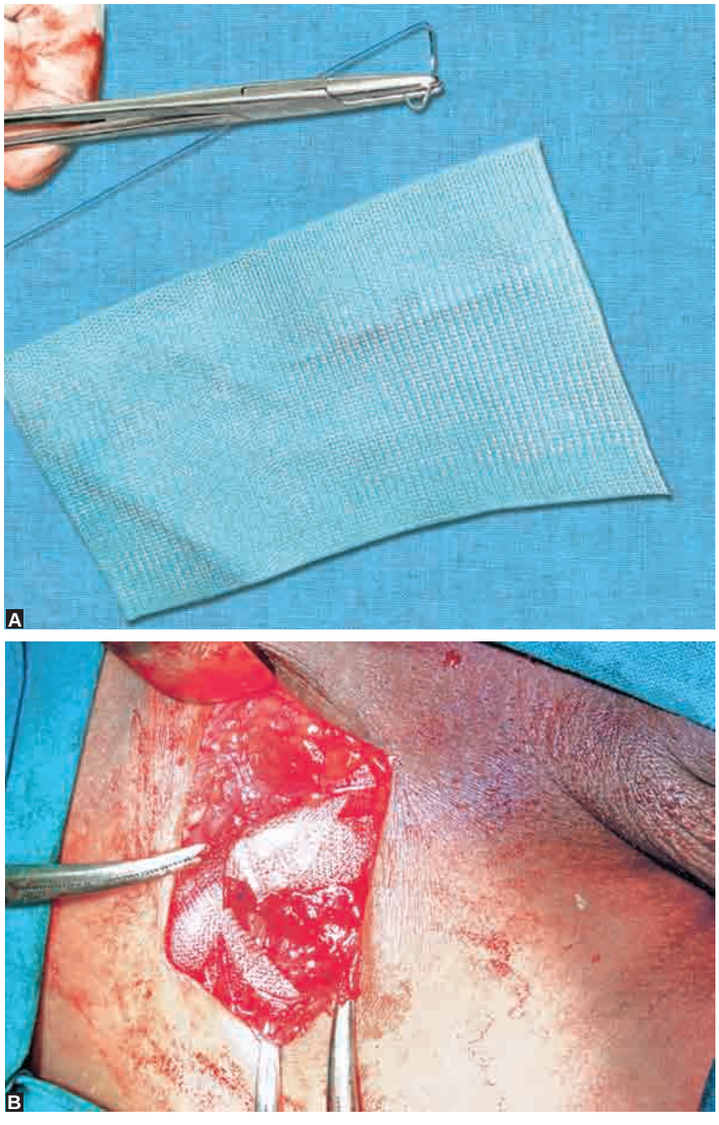
Figs 5-143A and B: Cord holding forceps/ring forceps used to hold cord structures in inguinal hernia surgery.

POLYPROPYLENE MESH

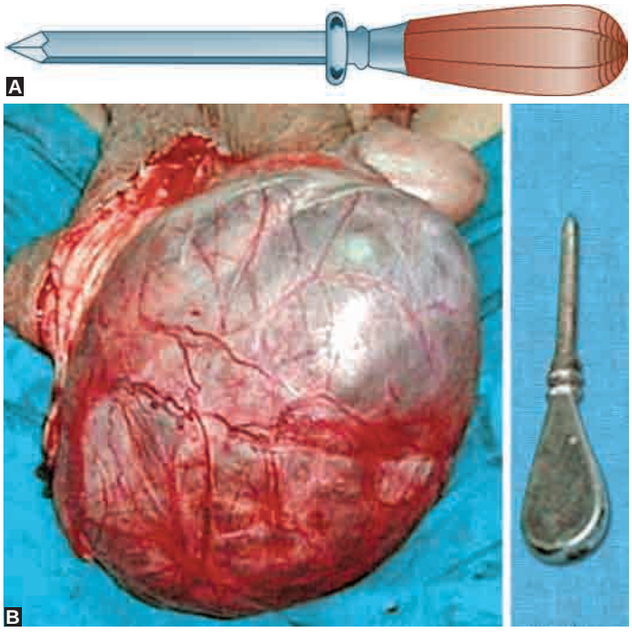
It is polypropylene white coloured monofilament, non absorbable, inert, malleable, strong, synthetic mesh used for herioplasty. Presently prosthetic mesh repair is standard except probably Shouldice repair. Mesh is fixed using polypropylene suture material which is blue in colour **(Figs 5-144A and B)**.

TROCAR AND CANNULA

Trocar has got stout handle with a sharp pointed distal end. Trocar passes through the cannula of different sizes and snugly fits into proximal end of cannula. Trocar with sheath is punctured into the needed place and trocar is removed. Through sheath fluid is evacuated. Through the sheath Foley's catheter can also be passed to keep in place. It is used in per cutaneous cystostomy, draining hydrocele fluid, draining pus from gallbladder, pleural cavity, maxillary antrum, etc. **(Figs 5-145A and B)**.



Figs 5-144A and B: Polypropylene mesh used for hernioplasty.



Figs 5-145A and B: Trocar and cannula.

HERNIA DIRECTOR

Hernia director is used to protect the bowel in strangulated/obstructed hernia while releasing the narrow constricting band. Key's hernia director has got grooved gently curved long blade with ridged stout handle. Childe's hernia director has two wings on sides of the blades as a guard with a handle. Constriction ring is cut using hernia bistoury **(Fig. 5-146)**.

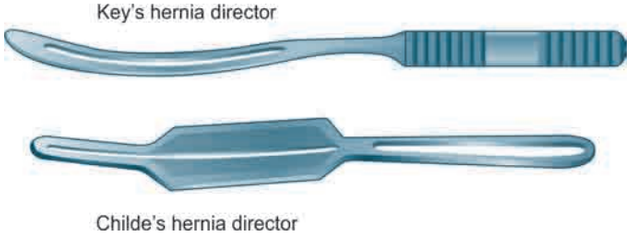


Fig. 5-146: Key's and Childe's hernia directors.

PROCTOSCOPE (KELLY'S)

Indications

- *Diagnostic:* Piles, fissure in ano, polyps, stricture, to see internal opening in fistula, carcinoma or any rectal bleeding
- *Therapeutic:* Injection therapy for partial prolapse or piles, cryotherapy for piles, banding for piles, polypectomy, biopsy for carcinoma rectum or anorectum.

Types

- *Illuminating* with a bulb at the distal part
- *Non-illuminating.*

Parts

Proctoscope is conical shape, with proximal diameter more than the distal, so as to illuminate the light at the required site properly. *Obturator* is the inner part which allows the easy insertion of the proctoscope. Usual medium sized proctoscope is 10 cm in length with proximal diameter of 3.5 cm and distal diameter of 2.5 cm–tapering. This tapering allows light to reflect and pass distally. Proximal funnel shaped flange is 5 cm in diameter **(Figs 5-147A and B)**.

Fig. 5-147A

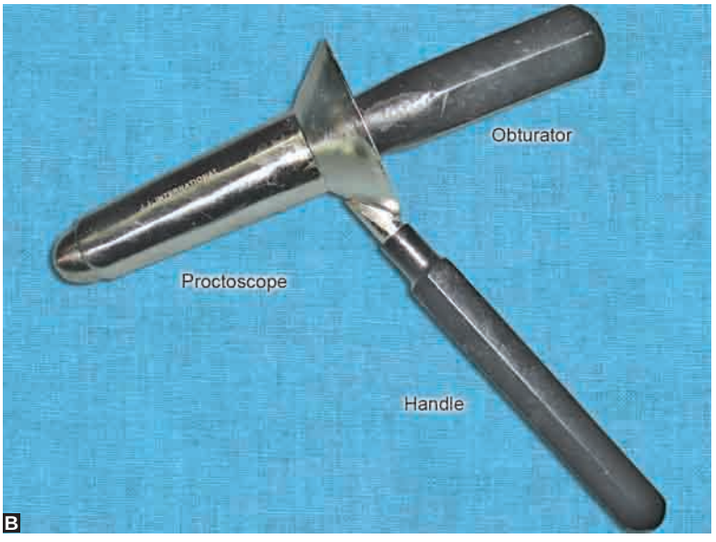


Fig. 5-147B

Figs 5-147A and B: Proctoscope.

Positions for Proctoscopy

- Left lateral position (common),
- Right lateral,
- Lithotomy,
- Knee-elbow position.

Technique of proctoscopy

After doing digital examination, proctoscope with the obturator is introduced inside; through the anal canal in the direction towards the umbilicus. The obturator is removed. Proctoscope is withdrawn and during the course of withdrawal, any pathology has to be looked for.

Acute anal fissure is contraindication for proctoscopy.

SAINT MARK'S ANAL DILATOR

It is hollow conical instrument with both ends closed. Distal end is tapered, smooth and rounded. It is available in three different sizes. It is used for anal dilatation in post-anorectal surgeries and in anal stenosis. Xylocaine jelly is applied to the blunt tip and is gently passed through the anal canal to achieve dilatation **(Fig. 5-148)**.

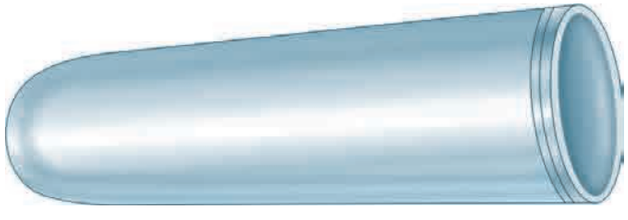


Fig. 5-148: Saint Mark's anal dilator.

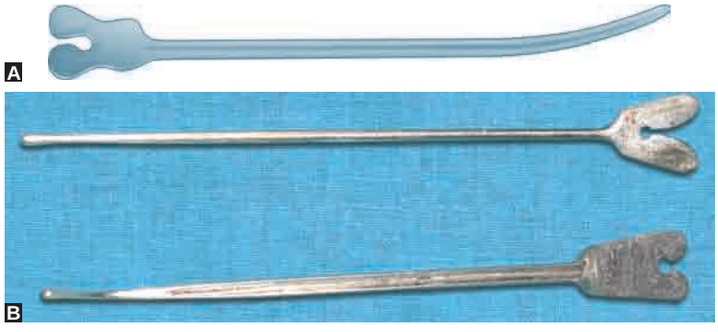
FISTULA BISTOURY

It is a long blade with solid knife with a cutting edge. It is used to lay open the fistula in ano along with Brodie's fistula probe **(Fig. 5-149)**.

Fig. 5-149: Fistula bistoury.

BRODIE'S FISTULA DIRECTOR

It is a long instrument with a winged flat handle. Shaft is curved, gradually tapering to form a pointed tip with a groove along the curvature longitudinally which allows the knife to pass to do fistulotomy. It is used in probing and treating fistula in ano; to release tongue tie as a guide and protector and in external urethrotomy **(Figs 5-150A and B)**.



Figs 5-150A and B: Brodie's fistula director.

PILE HOLDING FORCEPS

It has got long distal blades ending as a ring. Each has got fenestra with a groove on its inner surface. It is used to hold pile mass during haemorrhoidectomy. It differs from sponge holding forceps which has got serrations on the inner aspect of the ring. Tongue holding forceps is also similar but without groove or serrations on the inner aspect of the ring **(Fig. 5-151)**.

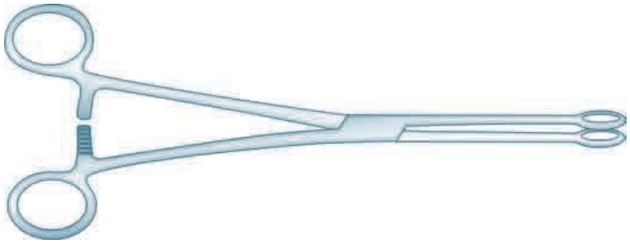


Fig. 5-151: Pile holding forceps has got groove on the inner aspect of the rings in the distal blades.

YEOMAN'S PUNCH BIOPSY FORCEPS

It has got two short stout jaws on the tip. Upper jaw is rectangular, mobile and cutting. Lower jaw is fixed and is having a cup. Through a handle (without ratchet) jaws can be closed and opened. Mobile jaw takes punch biopsy from the rectal lesion whereas fixed jaw accommodates the biopsy tissue in the cup **(Fig. 5-152)**. It is used to take biopsy from rectal lesions like carcinoma, ulcers, polyps, etc.

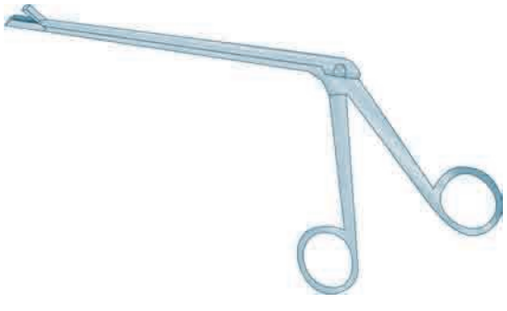


Fig. 5-152: Yeoman's punch biopsy forceps.

MOYNIHAN'S GLASS TUBE

This glass tube of 20 cm in length with a beveled one end and other end connected to a rubber tube with a two circular ridges to facilitate the holding of the purse string suture around the tube. It is used to decompress the proximal bowel in intestinal obstruction without contaminating the peritoneal cavity **(Fig. 5-153)**.

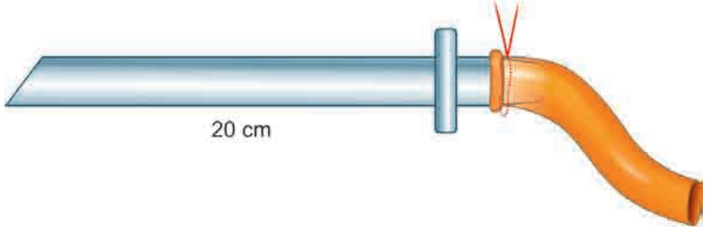


Fig. 5-153: Moynihan's glass tube to decompress bowel in intestinal obstruction.

DUPUYTREN'S ENTEROTOME

It has a stout distal blade with longitudinal serrations. It has got butterfly nut and screw on the proximal end which when tightened causes crushing effect on the structure between the blades. It is specifically used in *colostomy closure extraperitoneally* by placing this instrument over the spur of the colostomy. It is kept in place for 5-7 days and if needed further tightening can be done using screw. Spur gets necrosed and colostomy closes gradually on its own or by placing few sutures in front **(Fig. 5-154)**. Presently colostomy closure is done intraperitoneally by formally suturing bowel wall either single layer or two layers.

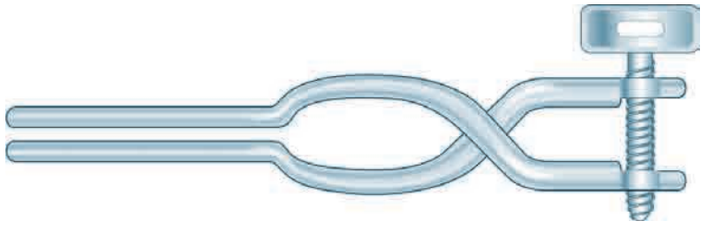


Fig. 5-154: Dupuytren's enterotome used for extra peritoneal closure of the colostomy by crushing the spur.

SPIGOT

It is a glass rod of 10 cm length, with one end narrow and blunt. In colostomy, once a loop of the colon is delivered through the abdominal wound it is used to pass through the mesocolon. It stabilises the loop of colon in position and prevents it from slipping into the peritoneal cavity **(Fig. 5-155)**. It is rarely used now.

Fig. 5-155: Spigot used in as colostomy glass rod to prevent the slipping of the colon into the peritoneal cavity.

HUDSON BRACE WITH PERFORATOR AND BURR

Hudson's brace is used to do burr holes in skull bone. Using brace initially perforator is used to reach and open the inner table. Perforator should be carefully used to avoid injury to deeper structures. Later burr is used to widen the hole made by perforator **(Fig. 5-156)**.

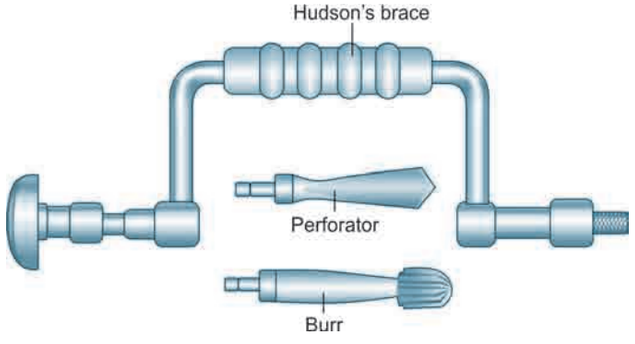


Fig. 5-156: Hudson's brace perforator and burr.

SUTURE MATERIALS

Features of Ideal Suture Material

- Adequate tensile strength.
- Good knot holding property.
- Should be least reactive.
- Easy handling property.
- Should have *less memory*. Recoiling tendency of the suture material after removal from the packet is called as memory of suture material. Suture material should have poor memory. More memory causes recoiling, difficulty in handling and knotting.
- Should be easily available and cost effective.

Classification I

Absorbable

- Catgut—*Natural absorbable monofilament suture material*
  It is 99% collagen derived from the submucosa of jejunum of the sheep or serosa of beef (*Kit* means sheep). After washing, intestine is slit longitudinally into four strands; muscle and fat are removed using water spray–*slimming*. Chemical bath saponification is also used to remove fat. Strands are spun together, dried with tension and electronically polished**.** It is absorbed by inflammatory reaction and phagocytosis.
  Plain catgut is yellowish white in colour. Absorption time is 7 days. It is used for subcutaneous tissue, muscle, circumcision in children.
  Chromic catgut is catgut with chromic acid salt. 20% chromium salt in water with 5 parts of glycerine is used to treat the catgut. It is brown in colour. Its absorption time is 21 days. It is used in suturing muscle, fascia, external oblique aponeurosis, ligating pedicles, etc. Atraumatic sutures are manufactured either by swaging or by entangling the suture material into the grooved proximal part of the needle by mechanical pressure. Wound suture material in a support card is packed in a foil envelope with isopropyl alcohol. It is sterilised by gamma radiation.

- Polyglactic acid/polyglactin 910/vicryl - *Synthetic braided multifilament absorbable*
  It is synthetic absorbable suture material–copolymer of glycolide and lactide. It has got excellent tensile strength, long tensile half life, low reactivity, less memory, easy handling and knotting.
  It gets absorbed in 90 days. Absorption is by hydrolysis. It is violet in color. Coating consists of 50% calcium stearate which acts as a lubricant. It is multifilament and braided. It is very good suture material for bowel anastomosis, suturing muscles, closure of peritoneum. It is sterilised by ethylene oxide.
  Vicryl plus is vicryl coated with antibacterial material (triclosan). Vicryl rapide is low molecular weight vicryl with rapid absorption of suture material. It is used in circumcision and in subcuticular suturing.
- Polyglycolic acid/Dexon/Synthetic polymer of glycolic acid is multifilament absorbable suture material (braided) like vicryl. Usually it is colored green/natural beige. It is sterilised by two stage ethylene oxide process. It is not affected by infection. Its knot security is poor and so at least 5 knots should be placed for security.
- Polyglyconate/Maxon is a monofilament absorbable copolymer of glycolic acid and trimethylene carbonate. It has got good knot holding/security; suppleness and flexibility. It is used in soft tissues and skin. It cannot be used in cardiac/vascular/neural/ophthalmic surgeries. It can be colourless or green coloured.
- Poly Dioxanone suture material/PDS is synthetic monofilament absorbable suture material. It is cream/blue/violet/in colour or colorless with properties like vicryl. It is coustly but better suture material than vicryl. It is relatively inert.
- Polyglecaprone 25/Monocryl is monofilament containing 75% glycolide and 25% caprolactone. It has got smooth surface, excellent handling property, good knot security and adequate tissue compatibility.
- Glycomer/Biosyn monofilament

Uses of absorbable suture materials

- In bowel anastomosis like gastrojejunostomy, resection and anastomosis Vicryl (2 zero) is used
- In cholecystojejunostomy (CCJ), choledochojejunostomy (CDJ), pancreaticojejunostomy - Vicryl is used.
- In suturing muscle, fascia, peritoneum, subcutaneous tissue, mucosa.
- In ligating pedicles, e.g. ligation of pedicles during hysterectomy. 1–zero chromic catgut or vicryl are used.
- In circumcision usually 3-zero plain or chromic catgut or vicryl rapide are used.

Absorbable suture materials should not be used in suturing tendon, nerves, vessels (vascular anastomosis) or in hernia surgery where tissue approximation under stress is needed.

Nonabsorbable suture materials

- Silk is natural multifilament braided nonabsorbable suture material derived from cocoon of silkworm larva. It is black in color, a coating got from a vegetable dye. It is coated suture material to reduce capillary action. Serum proofing of the suture material is also done to reduce the capillary attraction. It has got less memory; good knot holding property; easy handling ability.
- Cotton is twisted multifilament natural nonabsorbable suture material. It is white in colour.
- Linen is derived from bark of cotton tree (natural nonabsorbable twisted multifilament suture material). It is made from flax and cellulose in nature. It has got excellent knotting property and is commonly used as ligatures.
- Polyamide is monofilament synthetic non absorbable polymer. Nylon (New York and LONdon) is a polyamide. Multiple pre-cut nylons are available for skin suturing/ligatures. It has got less tissue reaction, easy handling ability, inertness, adequate elasticity and can be used in presence of infection. Ethilon/surgidek/dermalon/sutupak pre-cut sutures are different polyamides. Memory is high like that of polypropylene and so causes problem. *Polyethylene* (Ethylene) is synthetic monofilament nonabsorbable suture material. It is black in colour.
- Polyester is synthetic multifilament braided polymer–nonabsorbable suture material. Polyester has got high tensile strength and good knot holding property. But it is stiff with difficulty in handling and may cause sawing effect to tissues. Dacron is made up of untreated polymers. It is white in colour. Ethibond is polyester coated with polybutylate–polytetramethylene adipate. It is green in colour. Polydek/tevdek are coated with polytetra flouro ethylene (PTFE). They are green in colour. Black sutulene is impregnated with wax. Silicon treated ticron is white/blue in colour.
- Polypropylene (Prolene) is synthetic monofilament suture material. It is blue in color. It has got high memory. (Prolene mesh used for hernioplasty is white in color). It is inert, flexible, strong and least reactive. It can be re-sterilised by autoclave once or twice.
- Polybutester–Novafil is monofilament, blue colored, synthetic suture material which has got adequate flexibility, suppleness and strength.
- Stainless steel metallic non-toxic suture/wire (steel, tantalum, silver) are useful in approximating bones and tough structures, in orthopedic and thoracic surgeries (sternotomy or thoracotomy), in reconstructive surgeries, surgeries of skull base or head and neck, sinus surgeries, in dental surgeries. Monofilament is called as steel suture/metallic suture. Multifilament is called as metallic/steel wire which can be twisted or braided. Metallic sutures/wires are difficult to handle and to use, may cause injury to surgeons but they are very high tensile strength and low reactivity. Kinking is another problem.

Uses of nonabsorbable suture materials

- In herniorrhaphy for repair.
- For closure of abdomen after laparotomy.
- For vascular anastomosis (6—zero), nerve suturing, tendon suturing.
- For tension suturing in the abdomen.
- For suturing the skin.

Classification II

a. Natural
- Catgut
- Silk
- Cotton
- Linen
- Collagen sutures are derived from collagen fibrils of flexor tendon sheaths/tendo Achilles of beef. It can be plain or chromic.
- Homologous sutures derived from the patient's fascia like strips of fascia lata used for hernioplasty or blepharoplasty.
- Cargile membrane is derived from the submucosa of caecum of ox. It is used to cover peritoneum/pleura and to prevent adhesions. It is not used now.
- Kangaroo tail tendon has got high tensile strength–not used now.

b. Synthetic
- Vicryl, Dexon, PDS, Maxon
- Polypropylene, polyethylene, polyester, polyamide

Classification III

a. Braided: Polyester, Polyamide, Vicryl, Dexon and Silk.
b. Twisted: Cotton, Linen.

Classification IV

a. Monofilament: Polypropylene, Polyethylene, PDS, Catgut and Steel.
b. Multifilament: Polyester, Polyamide, Vicryl, Dexon, Silk and Cotton.

Classification V

a Coated
b. Uncoated.

Numbering of suture material:

2—	Thick. For pedicle ligation.
1—	
1—zero.	
2—zero.	For bowel suturing.
3—zero.	
4—zero.	
5—zero.	For vascular anastomosis.
6—zero.	"
7—zero.	
8—zero.	
9—zero.	For ophthalmic surgery. Requires microscopy

Different types of suture materials are shown in **Figure 5-157**.

Figs 5-157A and B: Photo showing different types of suture materials (with pack).

- Length of the suture material is written on the packs. It can be 45 cm; 76 cm; 90 cm or 152 cm so on
- Company code for a particular suture material is important to identify it in detail
- Lot number, batch number, needle description, needle curvature, needle size are mentioned on the packs.
- Name of manufacturing company, license number, manufacture date and expiry dates are mentioned on the pack.

Types of Suturing (Fig. 5-158)

1. Continuous suturing
2. Interrupted simple suturing
3. Interrupted mattress suturing
4. Subcuticular suturing
5. Horizontal tension suturing
6. Vertical tension suturing

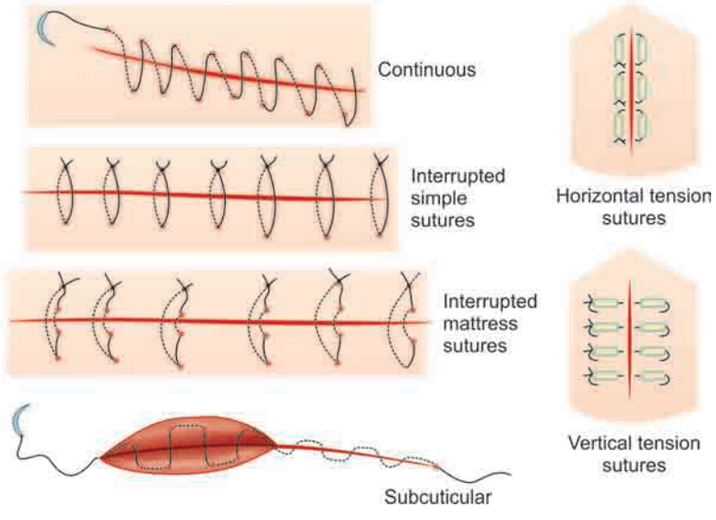


Fig. 5-158: Types of suturing.

Types of Knots (Fig. 5-159)

1. Reef knot.
2. Granny knot.
3. Surgeon's knot.

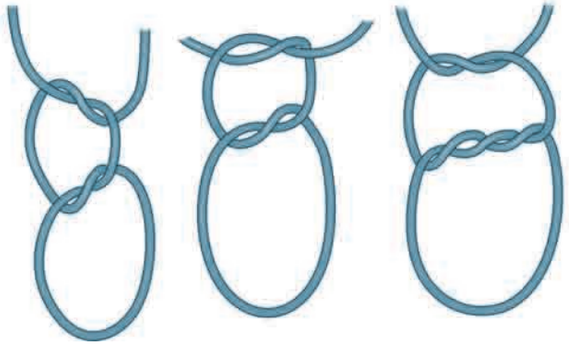


Fig. 5-159: Types of knots

MITCHEL'S CLIP DEVICE

- *Mitchel's metal clip:* It has got two sharp points on their teeth to grip the edges of the skin wound when applied.
- *Mitchel's clip applicator:* It has got a groove on the inner surface of each blade with a tooth on the ends of the blades to apply the clips to the edges of skin wound.
- *Mitchel's clip extractor:* It has got short distal blades, one blade has a hood which comes in front of the clip while another blade is flat which comes under the clip, with pressure on the finger rings clip is extracted. It does not have ratchet.
- *Mitchel's clip magazine:* Here clips are arranged in a row and other end with teeth is used to hold the skin margins together like a toothed forceps **(Fig. 5-160)**.

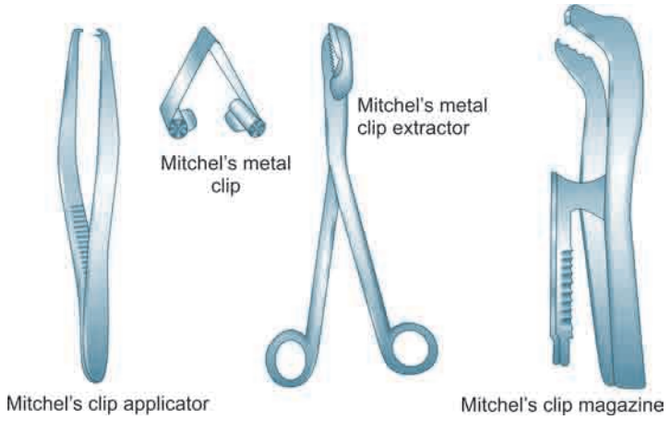


Fig. 5-160: Mitchel's clip devices with clip, applicator, extractor and clip magazine.

SYRINGES

It is basic instrument in medical practice used to give injections through any route, aspirate fluids, to give wash over surface or deeper places.

Types

Bectin Dickenson syringe (BD syringe): It is a glass syringe with a glass piston and barrel having a nozzle at the end to fit into the BD needle. Proximal end of the barrel has got a rim with one side being flat that prevents from rolling and breakage. It is sterilised by boiling. Disposable plastic BD syringes are commonly used now which is sterilised by gamma radiation. BD injection syringes are available as 2 ml, 3 ml, 5 ml, 10 ml, 20 ml, 50 ml and 100 ml capacity. 1 ml tuberculin/insulin syringes, Luer–lock BD syringes (needle can be locked near the nozzle to prevent slipping of the needle) are other modifications **(Fig. 5-161)**.

Record syringes: It is like BD syringe with a metallic screw at the proximal end of the barrel which can fix the barrel of the syringe so that piston will not come out.

Indications for sclerotherapy in piles	Contraindications for sclerotherapy
• 1st and early 2nd degree piles	• Infection at the site
• Piles in pregnancy and old individuals	• Secondary piles
	• Association of fissure in ano or fistula in ano

Fig. 5-161A: Bectin Dickenson syringe (BD syringe).

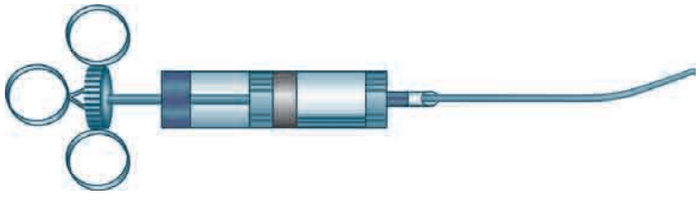


Fig. 5-161B: Gabriel syringe.

Gabriel syringe: It is used for injection sclerotherapy for internal piles using 5% phenol in almond/olive oil (almond/vegetable oil acts as a vehicle which holds phenol for long period of action). It is a stainless steel syringe with two metallic finger brims near the proximal end. One more metallic finger brim is present on the proximal end of the piston to place thumb while injecting. Special needle which may be straight or curved and sharply pointed is used for injection of haemorrhoids. Patient is placed in left lateral position. Using proctoscope pedicle/upper part of the piles is identified. Sclerosant is injected into the submucosal plane only which is confirmed by pale bleb with thin vessels over it. If it turns as white patch it means it is more superficial and needle is withdrawn and replaced in submucosal plane. 4 ml at each site with two piles in one sitting is done and further injections are given if needed with a 3 weeks gap until complete sclerosis and obliteration of piles occurs.

Asepto Syringe/Dakin's Syringe

It is made up of glass with broad flanged proximal end to which a rubber bulb can be fitted into it. It has got a tapered tip through which tubes/catheters can be fit to give wash, to suck the contents. It is used to give bladder wash in infection, in post-prostatectomy period, to give wash in different cavities and in depth, to instill methylene blue into the bladder to find out any fistula, to remove clots from prostate or other cavities during surgery **(Fig. 5-162)**.

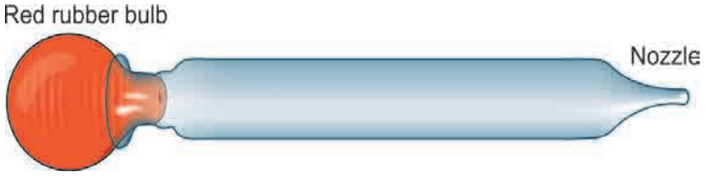


Fig. 5-162: Asepto syringe used for bladder wash.

Toomy Syringe

It is used to give bladder wash through cystoscope while doing transurethral resection of prostate (TURP). It has got a metallic nozzle which fits well into the cystoscopic sheath. It creates a strong suction force to suck the irrigated fluid **(Fig. 5-163)**.

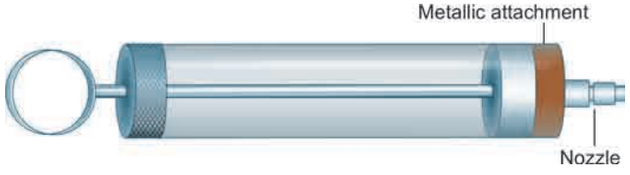
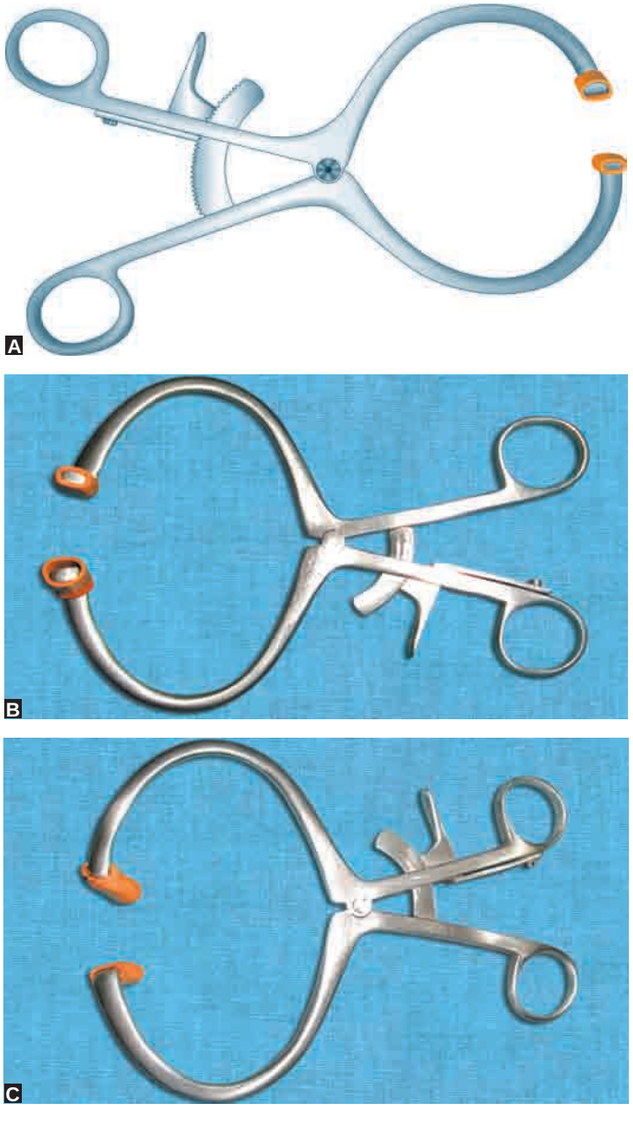


Fig. 5-163: Toomy syringe.

DOYEN'S MOUTH GAG

It has got flat, broad, strong, curved distal blades which has got serrations on the outer aspect so as to have proper grip over teeth. Blades are covered with rubber tubes to prevent injury to enamel. It is used for biopsies in oral cavity, dental extraction, tonsillectomy, excisions of small oral cavity lesions **(Figs 5-164A to C)**.



Figs 5-164A to C: Doyen's mouth gag.

JENING'S MOUTH GAG

It is a self-retaining mouth gag with a thin rim and ratchet. Blades fit into the alveolar margins not on the teeth. So it is useful in edentulous patients. It has got a gap to pass endotracheal tube **(Fig. 5-165)**.

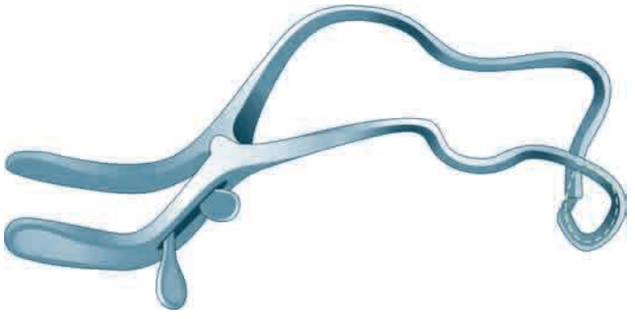


Fig. 5-165: Jening's mouth gag.

TONGUE DEPRESSOR

It is a flat steel atraumatic plate with a 90 degree angle at the centre. Ends are rounded with smooth edge. It is used to inspect posterior third of tongue, oral cavity, tonsils, to take biopsy, etc. Anterior-two-third of the tongue is depressed gently with tongue depressor **(Fig. 5-166)**.

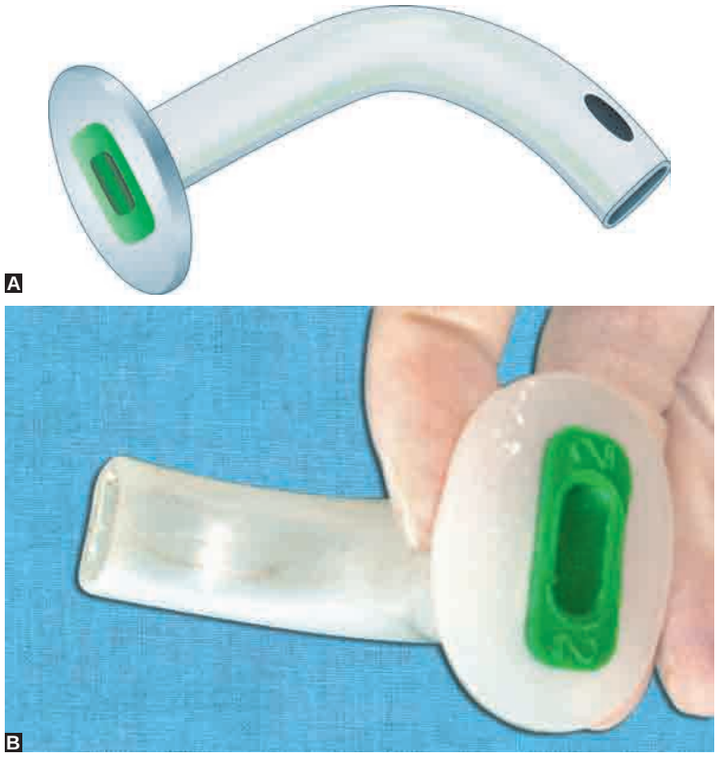
Fig. 5-166: Tongue depressor.

AIRWAY

It is curved metal/plastic hollow instrument with broad proximal end and curved tapered distal end. It helps breathing to patient during postoperative period, and when patient is in intensive care. It also promotes the suction of secretions through the hollow. It prevents fall back of tongue in unconscious patient, in patient with head injury and during induction of general anesthesia. In a patient with epilepsy it is used to prevent fall back of tongue during convulsion period **(Figs 5-167A and B)**.

It is oropharyngeal airway. It has got a flange (prevents swallowing of airway and keeps it in place), bite block (prevents biting and kinking) and curved body. *Guidel disposable airway* is available in different sizes. *Ovassapian airway* is modified with round channel to facilitate easy passage of fiberoptic bronchoscope. Airway which

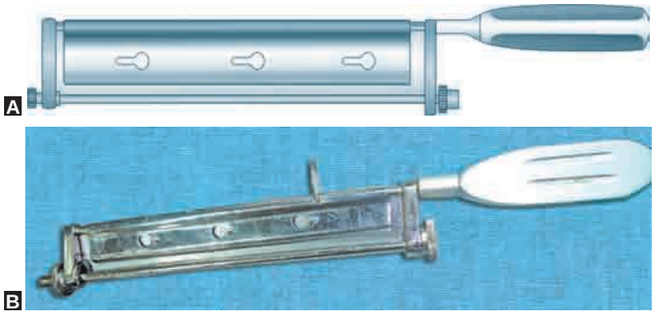
is cuffed is another modification of airway which can be connected to breathing circuits.



Figs 5-167A and B: Airway.

HUMBY'S KNIFE

It is used to take split skin graft from donor site. Usually it is taken from thigh. Often it can also be taken from arm, leg, and forearm. Humby's knife has got stout handle, two flat leaves in blade, one of which is fixed and other can be rotated **(Figs 5-168A and B)**. Disposable skin grafting blade is passed between the rods into the flat leave which has got three knobs which fits exactly into the openings of the blade. Front leaf has got slots which when pushed gets fixed over the blade. Using firm constant pressure with sawing action split skin is harvested from the thigh. Punctuate bleeding over the donor area confirms the proper skin harvesting. Donor graft is placed over the sterile wooden board. Multiple small window cuts are made to prevent formation of seroma. Skin is placed over the recipient bed and fixed using polypropylene sutures or skin staples. Dressing is placed and part is immobilised. Graft is inspected on 5th day for take up. Donor area is inspected after 10 days and kept open without dressing. Stages of graft intake are–stage of plasmatic imbibition, stage of revascularisation and stage of circulation.



Figs 5-168A and B: Humby's knife to harvest skin graft.

Other knives used for harvesting skin graft are:

- Braithwaite's skin grafting knife–disposable blade
- Watson's skin grafting knife–disposable blade
- Thiersch's skin grafting knife–It has got knife with permanent blade.
- Electrical dermatome .

MYER'S VEIN STRIPPER

It is used strip off varicose vein usually long saphenous vein. It is passed from above just below the saphenofemoral junction. Usually stripping is done up to the middle of the leg. Saphenous neuralgia is a rare complication **(Fig. 5-169)**.

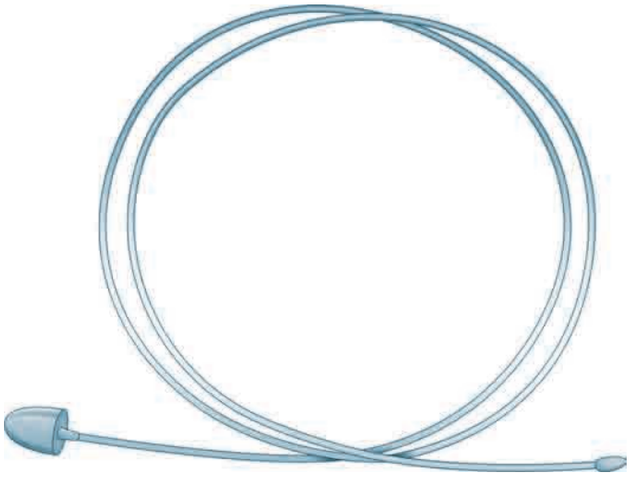


Fig. 5-169: Myer's vein stripper.

BONE CUTTING FORCEPS

It has got short blades with sharp firm cutting edges to cut bones; with a stout handle with ridges. It gives optimum mechanical force to cut bones/bone spurs. Some instruments are supported with leverage system **(Fig. 5-170)**.

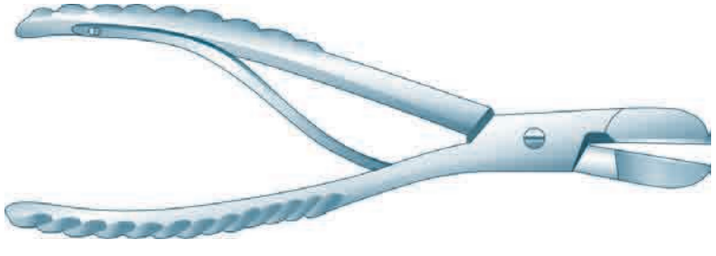


Fig. 5-170: Bone cutting forceps.

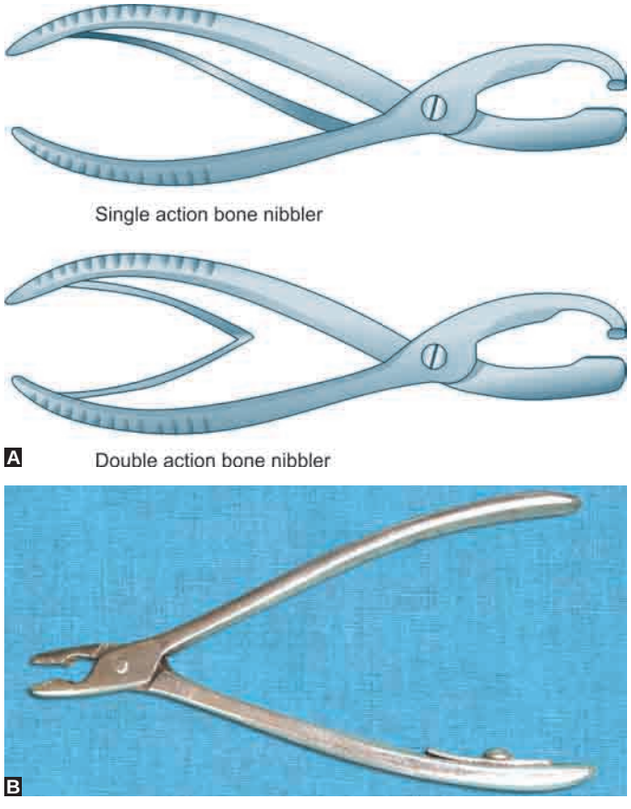
BONE ELEVATOR/BONE LEVER

It has got curved blade with blunt edge and serrations on concave surface. Proximal long shaft has got ring for grip. Some bone lever has got proximal knife-like handle instead of ring. It is used in manipulating the fracture segments in open reduction and so to isolate fracture ends from surrounding soft tissues. It is also used to elevate the fracture segments/bone from the depth for placement of nails/fixation **(Fig. 5-171)**.

Fig. 5-171: Bone elevator/bone lever.

BONE NIBBLER

It has got sharp edges in the tip with blades being concave. It may be having single action/double action joint. It is used to nibble the bone in pieces like in craniectomy, rib resection, amputations of small bones, etc. **(Figs 5-172A and B)**.



Figs 5-172A and B: Bone nibbling forceps/bone nibbler.

SEQUESTRECTOMY FORCEPS/ SEQUESTRUM HOLDING FORCEPS

It has a stout blade with thick transverse serrations with a groove in the middle without a ratchet. It is used to remove sequestrum in osteomyelitis. Sequestrum should be formed before removal X-ray should show clear radiolucency around dense dead bone–a sign of complete separation of the sequestrum **(Fig. 5-173)**.

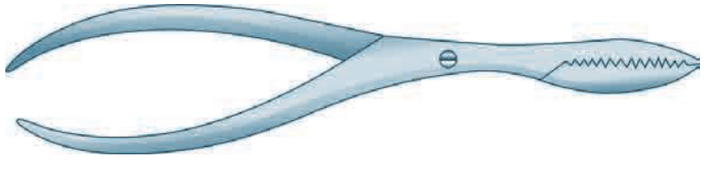


Fig. 5-173: Sequestrectomy forceps/sequestrum holding forceps.

FERGUSSON'S BONE HOLDING FORCEPS/ LION FORCEPS

It has got curved blade with stout blunt teeth, looks like jaw of a lion. Bone is held in the gap between the jaws. It is used to hold bones in open reduction of fractures, maxilla in maxillectomy, and mandible in mandibular fixation **(Fig. 5-174)**.

Fig. 5-174: Fergusson's bone holding forceps/lion forceps.

CHISEL

Chisel has got proximal rounded flat head which receives the blows of a mallet. Handle is stout, 10 cm in length. Shaft is of equal size of handle which ends as one side beveled only (abrupt beveling). It is used to chip the bone using mallet blow. It is also used in bone grafting, sequestrectomy, etc. (**Figs 5-175A and B**).

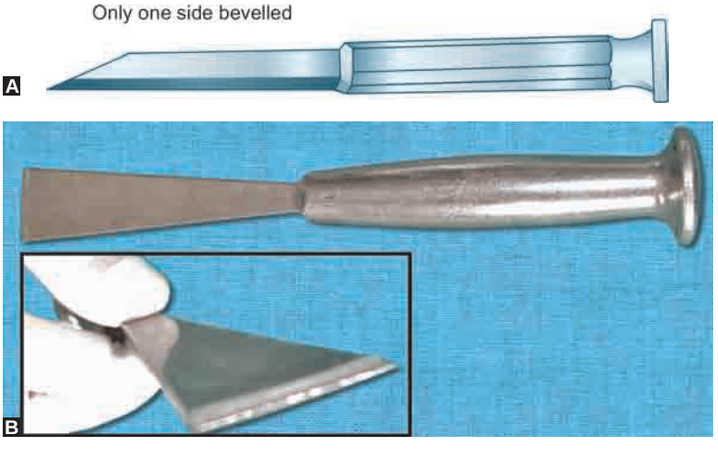


Fig. 5-175A and B: Chisel.

OSTEOTOME

It is similar to chisel but both sides is bevelled and beveling is gradual. Shaft has got the marks to find out the length of the osteotome inside the wound. It is used for all osteotomies in different congenital and acquired conditions **(Figs 5-176A and B)**.

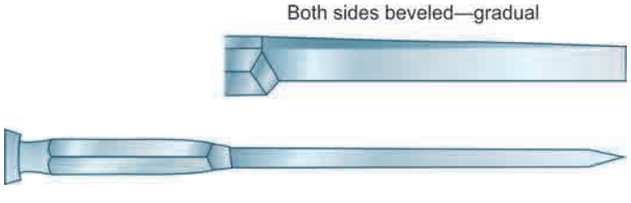


Fig. 5-176A

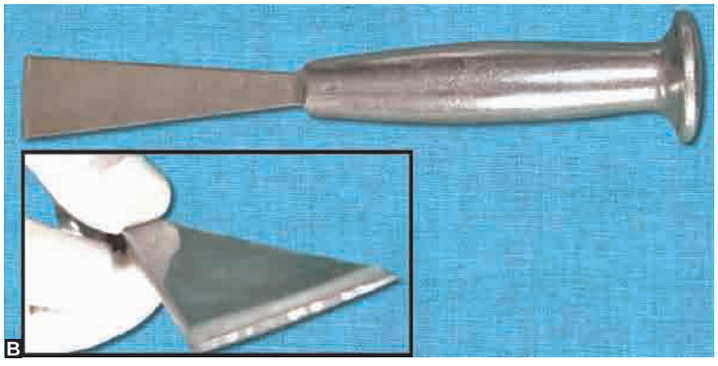


Fig. 5-176B

Figs 5-176A and B: Osteotome.

MALLET

Mallet is a hammer made up of stainless steel or lead. It is lighter than conventional hammer. It is used to give repeated blows on the flat surface over the head of chisel or osteotome. Blow should be flat without rebound **(Fig. 5-177)**.

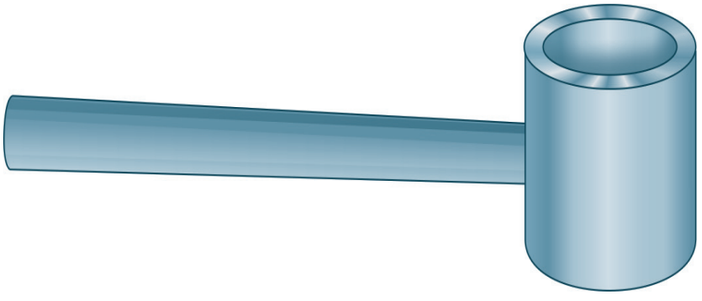


Fig. 5-177: Mallet.

GIGLI'S SAW

It is 14 inches long with four flexible metal wires braided together with rough sharp surface. It has got loops on either ends to hook the handles on it which is essential while cutting the bone. It is used to cut the bones like mandible, maxilla, amputation of femur/tibia, skull bones between the trephine holes. It is originally used to cut the pubic bone in narrow pelvis **(Fig. 5-178)**.

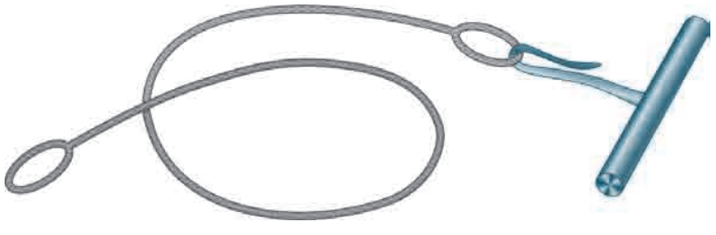


Fig. 5-178: Gigli's saw/Gigli's wire saw.

KIDNEY TRAY

It is the tray which is kidney shaped. It is used to collect material like fluid, clots, pus, foreign body, gauze, to keep BP handle with blade, to collect daughter cysts in hydatid cyst surgery, in necrosectomy of pancreas etc. It is sterilised and kept in instrument trolley **(Fig. 5-179)**.

Fig. 5-179: Kidney tray.

GALLIE CUP

It is used as a sterilised cup in the instrument trolley to provide antiseptic cleaning solution like povidone iodine, surgical spirit; to keep needles, gauze in the trolley, to collect material, to keep saline needed during surgery. It is essential instrument in all surgery **(Fig. 5-180)**.

Fig. 5-180: Gallie cup.

MAYO'S TABLE

It is the table which is fixed to the side of the operating table and it crosses across the OT table so that draping is done over it to keep instruments over it. Instruments will not fall down if surgeon uses it. It is used when position of the patient is in such a way that it is difficult to place instruments over direct draping. Examples are surgeries in kidney position, lateral position, head and neck surgeries **(Fig. 5-181)**.

Fig. 5-181: Mayo's table.

VOLKMANN'S SCOOP

It is spoon shaped strong stout instrument with serrations in the middle part. Ends are spoon shaped with cups. Spoons on the ends are of different sizes. It is used to scoop granulation tissue, ulcer bed, before skin grafting, to collect tissues, scoop sinus cavities, clearing necrotic materials from abscess cavities, curette cavities and sinus track in chronic osteomyelitis **(Figs 5-182A and B)**.

Figs 5-182A and B: Volkmann's scoop.

FINE LENGTHY STRAIGHT AND BAYONET FORCEPS

Toothed and no toothed lengthy straight or *bayonet* (French–dagger/long blade of rifle) forceps are used in fine dissection and holding tissues and cauterising tissues. Many cautery instruments are fine and often with bayonet. Bayonet shape gives proper vision in depth to proceed with procedure or cautery **(Fig. 5-183)**.

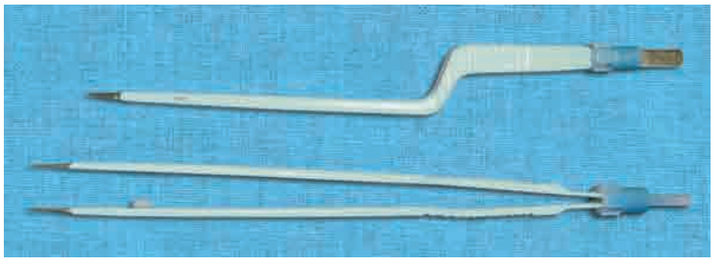


Fig. 5-183: Straight lengthy and bayonet forceps.

CYSTOSCOPE

It is the instrument used by urologists, to visualise urinary bladder, for removal of urinary bladder stones, for TURP, for stricturotomy in urethral stricture, for taking biopsy **(Fig. 5-184)**.

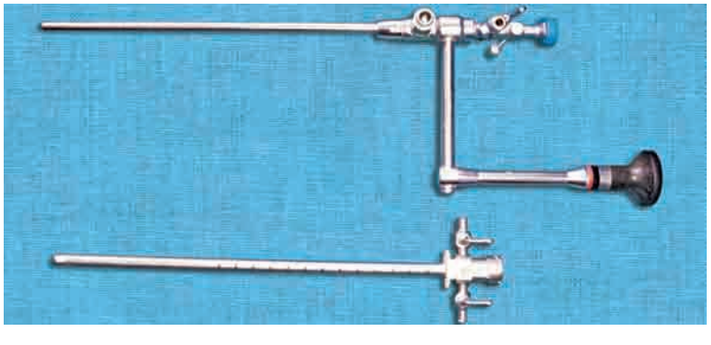


Fig. 5-184: Cystoscope.

AMBU BAG

It is a manual resuscitator with self-inflating bag, bag inlet and non-rebreathing valve. Self-inflating bag returns back into its original shape after compression. During compression air/oxygen enters the patient through non-breathing valve. When compression is released air enters through unidirectional valve to return the bag to its original shape. Exhaled air of the patient returns to atmosphere through non-breathing valve. It is *assisted manual breathing unit*. It can be connected to oxygen reservoir or to atmosphere air. It is used in cardiopulmonary resuscitation, during transporting critically ill patients **(Fig. 5-185)**.

Fig. 5-185: Ambu bag.

LAPAROSCOPIC INSTRUMENTS

There is separate set of laparoscopic instruments with 3 chip camera, telescope light source, CO_2 insufflator, various instruments, harmonic scalpel etc. Details about that are discussed in appropriate places **(Figs 5-186 to 5-199).**

Fig. 5-186A

Fig. 5-186B

Figs 5-186A and B: Laparoscopic instrument trolley and set.

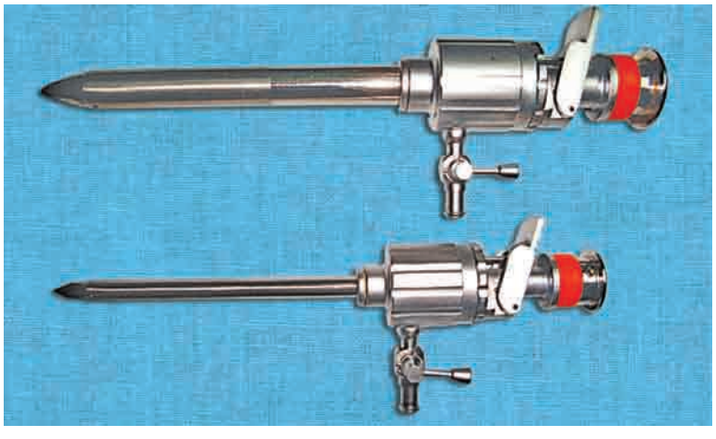


Fig. 5-187: Laparoscopic trocars–10 mm and 5 mm.

Fig. 5-188A

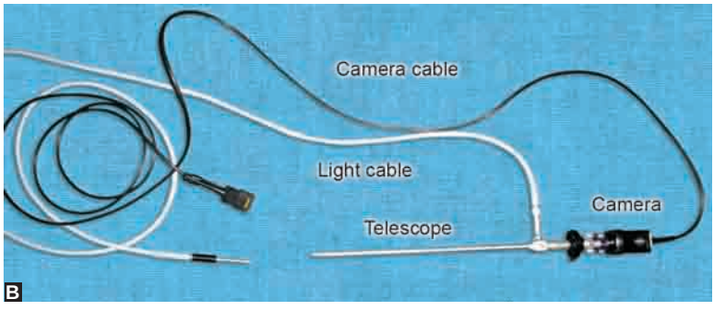


Fig. 5-188B

Figs 5-188A and B: Laparoscopic camera, light cable, camera cable and telescope.

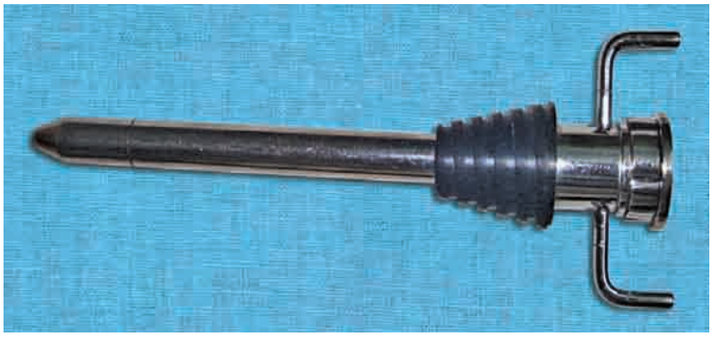


Fig. 5-189: Laparoscopic Hassans cannula.

Fig. 5-190: Laparoscopic port closure needle. First one is curved needle; second one is standard laparoscopic closure needle.

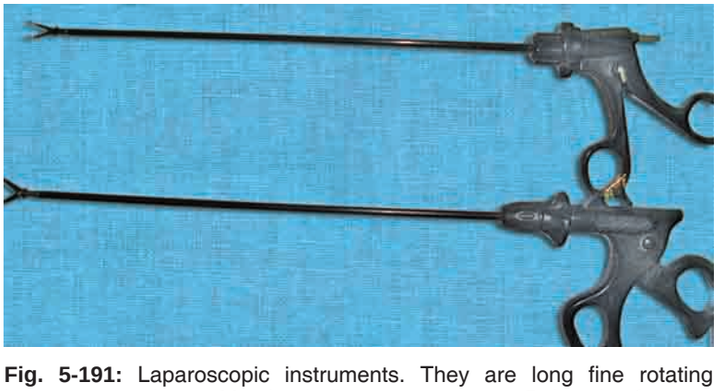


Fig. 5-191: Laparoscopic instruments. They are long fine rotating instruments–scissor, Maryland dissector, grasper, Babcocks forceps, toothed grasper, right angled dissector, etc.

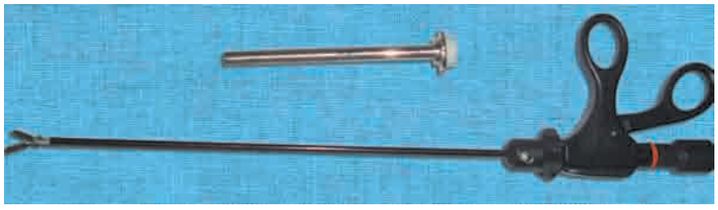


Fig. 5-192: Laparoscopic reducer (10 mm to 5 mm), and bipolar instrument.

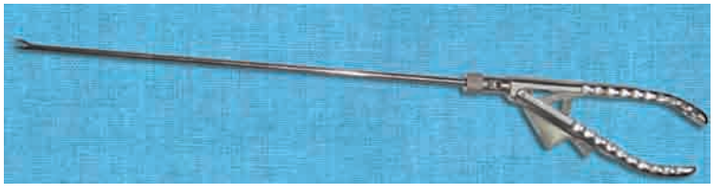


Fig. 5-193: Laparoscopic needle holder.

Fig. 5-194: Laparoscopic suction device.

Fig. 5-195: Veress needle.

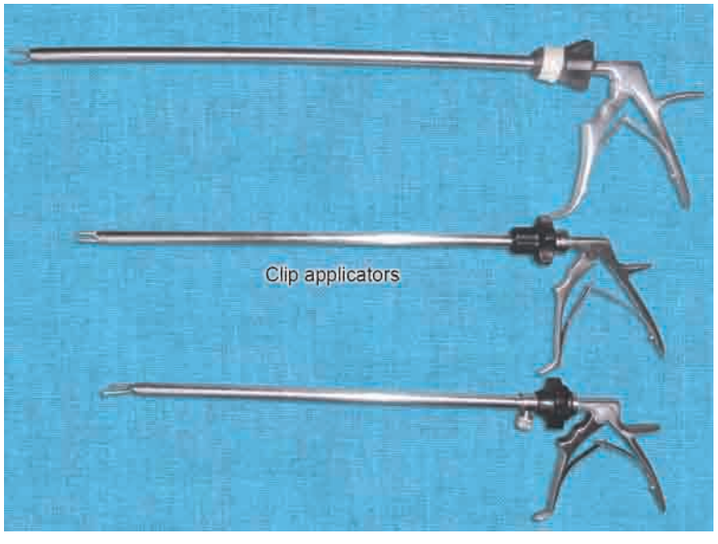


Fig. 5-196: Clip applicators

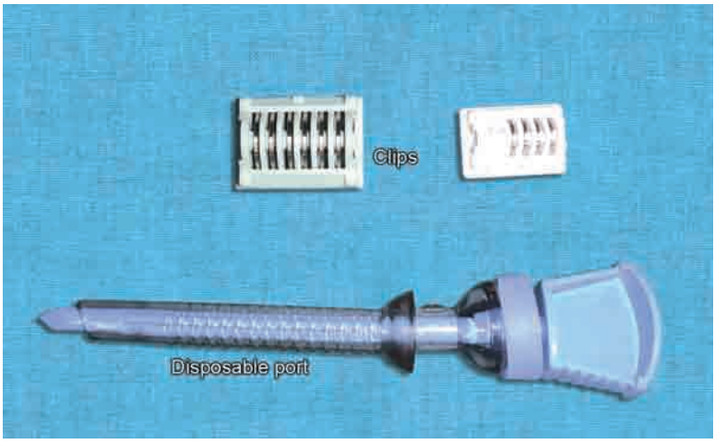


Fig. 5-197: Disposable port

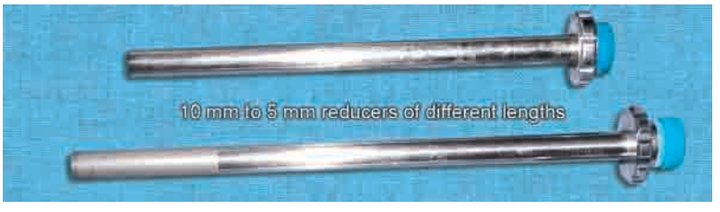
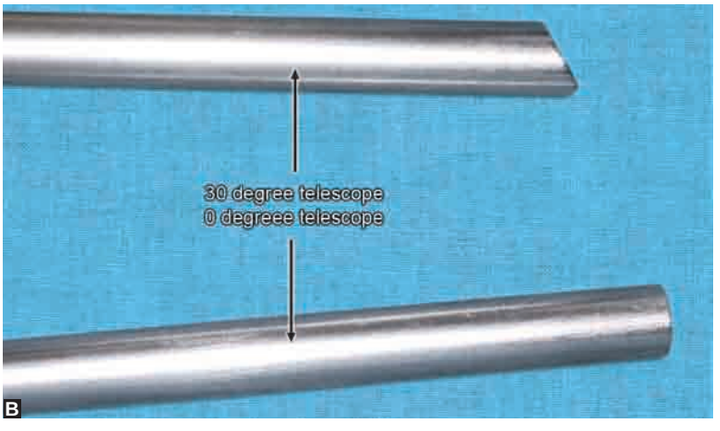


Fig. 5-198: Reducer



Figs 5-199A and B: Telescope

Chapter

7

Basic Surgical Procedures

URINARY CATHETERISATION

Catheters used—Simple non self-retaining red rubber catheter, Foley's self-retaining catheter, Gibbon's catheter, metal catheter.

Indications—Retention of urine due to BPH, stricture urethra, trauma (with all care and precaution gently one trial is done); in major surgery post-operative period; in patients with acute conditions and shock patients to measure the hourly urine output.

Causes of retention of urine

Bladder outlet obstruction

- BPH, Carcinoma prostate.
- Prostatitis, prostatic abscess.
- Bladder carcinoma close to bladder neck.
- Bladder stone obstructing bladder neck.
- Hypertrophy of bladder neck muscle.
- Stricture at bladder neck.

Causes at urethral level

- Urethral stricture- may be due to trauma or inflammatory (gonococcal/nonspecific) or neoplastic or after catheterisation/cystoscopy or after surgery (TURP/urethral surgery/perineal urethrostomy).
- Urethral stone.
- Tumors.
- Posterior urethral valve.
- Urethral trauma.
- Meatal stenosis.
- Pinhole meatus/phimosis.

Other causes

- Post-operative period.
- Post-surgery—After haemorrhoidectomy/fissurectomy/fistulectomy.
- Spinal injury/spinal surgery/spinal anaesthesia.
- Drugs like anticholinergics, antidepressants or antihypertensives.

Foley's catheter is commonly used. Urosac bag, gloves, sterile towel, 2% xylocaine gelly and distilled water are needed.

Procedure

The patient is explained about the procedure. Sterile gloves are worn after hand wash. Patient will be in supine position with legs apart. Genitalia are cleaned with povidone iodine solution. Draping is done using sterile towel. Prepuce is retracted and glans is cleaned again. 20 ml of 2% xylocaine is taken in a syringe and pushed into the urethra through the external meatus. After 5 minutes, penis is held vertically (so that urethra gets straightened to make easier passage of the catheter) and Foley's catheter tip is lubricated with jelly and is gently passed into the urinary bladder. Urine flow through the catheter confirms that it is inside the bladder. It is advanced further more and balloon near the tip is inflated *using distilled water*. Air is not used for this purpose. Normal saline may get crystallised and so ideal is distilled water. (Note: in endotracheal tube only air is used to inflate the balloon. Water should never be used because if balloon bursts aspiration can occur). Quantity inflated should be noted in the case sheet. Usually 20 ml is used. It is actually written in the Foley's catheter. After inflation catheter is pulled out to confirm that balloon is inflated properly. Catheter is connected to urosac bag. Prepuce is placed in normal position otherwise paraphimosis can develop.

In adult 16 F catheter is used. F-French unit- 16 mm circumference (Charriere unit). Often Foley's catheter is kept for 7-10 days. If there is a need to keep catheter for more than 10 days then silicon coated Foley's catheter is used as it is least reactive. Foley's catheter is made up of latex. In children 10 F or 8 F is used.

Three-way Foley's catheter is used to irrigate the bladder with normal saline/glycine solution continuously in post TURP (Transurethral Resection of Prostate) or after bladder surgery or after bladder trauma.

Foley's catheter often is reinforced with tension wires to prevent block and is called as haematuric Foley's catheter.

Maryfield introducer is used often to pass the Foley's catheter into the bladder. It has got a curve with a groove over the convex part to accommodate the catheter.

Balloon should be *deflated completely* before removal of the catheter otherwise urethral injury and haematuria can occur.

In females labia majora are retracted apart to identify the urethral orifice to pass the catheter.

Complications of Catheterisation

Infection, false passage, bleeding, inability to deflate the balloon while removing the catheter. In such occasions, following methods are used—Inflating the balloon further with ether/air/water to cause bursting of the balloon; passing guidewire of the ureteric catheter via the inflating channel; Traction is to catheter so as to make balloon nonmobile and fixed. Long, fine needle is passed per-abdomen in suprapubic place so as to puncture the balloon.

Causes for Inability to Pass the Catheter

Urethral stricture, BPH, non-cooperation by the patient and meatal stenosis

INSERTION OF A NASOGASTRIC TUBE

Indications

For decompressing stomach in intestinal obstruction, after abdominal surgery. It prevents aspiration and distension of intestines.

For Gastric Function Tests

In gastric outlet obstruction to decompress the stomach and also to give stomach wash. Stomach tube is better (Ewald's tube) for this.

For Feeding Purpose

Baid test: Passed Ryle's tube will be palpable per abdomen in pseudocyst of pancreas as stomach is stretched forward.

Ryle's tube will not enter the stomach in Boerhaave's syndrome.

Procedure

Procedure is explained to the patient. Usually no. 16 tube is used in adult. It is one meter long usually of plastic (earlier red rubber) with three lead shots in the tip. Lead shots in the tip make it easier to pass (Infant feeding tube does not have lead shots). It has got different marking ring/rings (2, 3 and 4). First ring signifies O-G junction (40 cm). Two rings for body of stomach (50 cm), three for the pylorus (60 cm) and four for duodenum (70 cm).

Xylocaine jelly 2% is applied to the tube. It is passed through one of the nostrils (wider one) horizontally until it reaches the posterior pharyngeal wall. Patient is asked to swallow if needed with the help of cup of water. Tube passes through the relaxed cricopharyngeus and then into oesophagus. Afterwards it is easier to pass down the oesophagus. Once it is adequately in the oesophagus tube is fixed to nostril.

Confirmation of the tube in the stomach is done by aspirating the bile and also by injecting 30 ml of air through the tube which can be heard in the epigastrium with a stethoscope as a gurgling sound **(Fig. 7-1)**.

Tube can be used for continuous drainage or drainage hourly or at regular intervals.

Problems with Ryle's Tube

Discomfort to the patient; blockage; coiling in the mouth; displacement.

Fig. 7-1: After passing the Ryle's tube I to the stomach, air from the syringe should be infused through the tube and when auscultated gush of air into the stomach can be heard which confirms that tube tip is in the stomach.

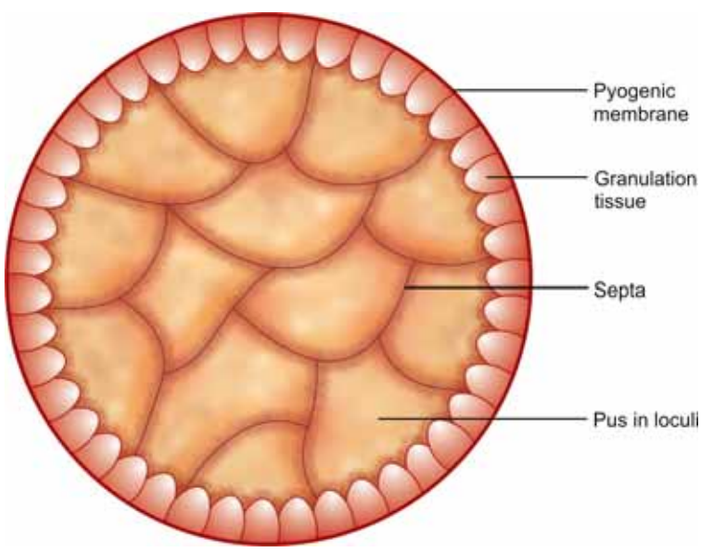


Fig. 7-2: Pyogenic abscess—Parts.

ABSCESS DRAINAGE

Abscess is a localised collection of pus lined by granulation tissue covered by pyogenic membrane. It contains pus in loculi **(Fig. 7-2)**.

Bacteria causing abscess—Staphylococcus aureus, *Streptococcus pyogenes*, Gram-negative bacteria (*E. coli*, *Pseudomonas*, *Klebsiella*), and anaerobes.

Factors precipitating abscess formation—General condition of the patient: Nutrition, anaemia, age of the patient. Associated diseases: Diabetes, HIV, immunosuppression. Type and virulence of the organisms. Trauma, haematoma, and road traffic accidents.

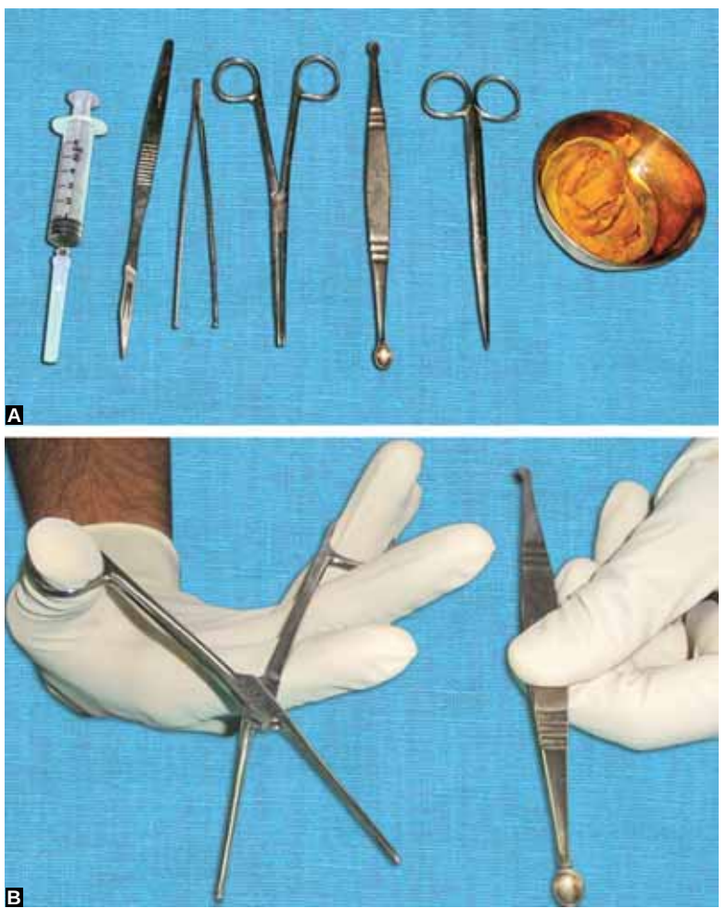
Abscess should be drained once it is formed only under the cover of antibiotics.

Features of formed abscess

- Pointing tenderness
- Visible pus
- Excruciating pain
- Localised swelling
- Induration (browny induration).

Abscess is Drained by Hilton's Method

Under general or regional anaesthesia, after cleaning and draping, using needle with syringe pus is aspirated and confirmed. Adequate incision is made over the skin longitudinal to neurovascular bundle. Pyogenic membrane is opened using sinus forceps. Pus is collected for culture and sensitivity. All loculi should be broken. Wound is washed with saline or povidone iodine. Gauze drain or corrugated drain is placed in the wound. Antibiotics are continued. Wound is allowed to granulate and heal **(Figs 7-3 to 7-5)**.



Figs 7-3A and B: instruments used for drainage of a pyogenic abscess—Syringe with needle for aspiration; 11 number blade; toothed dissecting forceps; Lister's sinus forceps; scoop; scissor; roller pack soaked in povidone iodine.

Local anaesthesia may not act as pus is acidic in nature and xylocaine will not be effective in this acidic media.

***Complications*—**Improper drainage and residual abscess; septicaemia; sinus formation; if abscess is located near major vessels, sloughing of the wall of the vessel and torrential haemorrhage can occur occasionally.

Sarcoma and aneurysms may mimic pyogenic abscess especially when it is deep seated and so necessary investigations like CT scan and aspiration of the content should be done before incision and drainage **(Figs 7-6 and 7-7)**.

Abscess in special locations may not show features of formed abscess. In those locations abscess should be drained without waiting for features of formed abscess- pointing, fluctuation. They are—Parotid abscess; breast abscess; Ludwig's angina—it is actually a cellulitis not an abscess but needs exploration and decompression; thigh abscess; ischiorectal abscess.

Parotid Abscess

Parotid abscess presents as severe pain and tender swelling in the parotid region in front of the tragus. Often patient will be toxic, dehydrated with trismus. Parotid abscess is drained under general anaesthesia with endotracheal tube in place. *Blair's* vertical incision is placed in front of the tragus. Abscess cavity is opened using sinus forceps with multiple horizontal incisions in deeper plane. Care should be taken not to traumatise the facial nerve. After draining pus and proper saline wash drain is placed into the wound. Loose sutures in the skin may be placed. Facial nerve injury, septicaemia, laryngeal oedema and local spread of sepsis are the complications. Infection when spreads to pharynx/larynx/parapharyngeal space needs tracheostomy **(Fig. 7-8)**.

Breast Abscess

Breast abscess is commonly due to *Staphylococcus aureus*. It is common in lactating women. It should always be drained under general anaesthesia. There will not be any localisation. Diffuse swelling and tenderness all over the breast is common. Occasionally tender axillary lymph nodes may be palpable. After cleaning and draping, pus is aspirated and confirmed initially. Either circumareolar or submammary incision is made. After draining pus and breaking loculi, a counter-incision is made on the upper part. After proper saline wash of the wound, drain is placed across the *incision and counter-incision*. If patient is lactating, suppression of lactation is done using Bromocryptine 2.5 mg. Regular expression of milk either manually or using breast pump should be done. Otherwise recurrent infection or fistula can occur.

Acute breast abscess may mimic mastitis carcinomatosis/inflammatory carcinoma of breast.

Breast abscess which is not drained but treated with antibiotics may form organised, hard, non-tender swelling in the breast called as Antibioma which will mimic carcinoma breast. Antibioma contains thick walled fibrous tissue with sterile pus as flaques inside. It needs excision **(Figs 7-9 to 7-12)**.

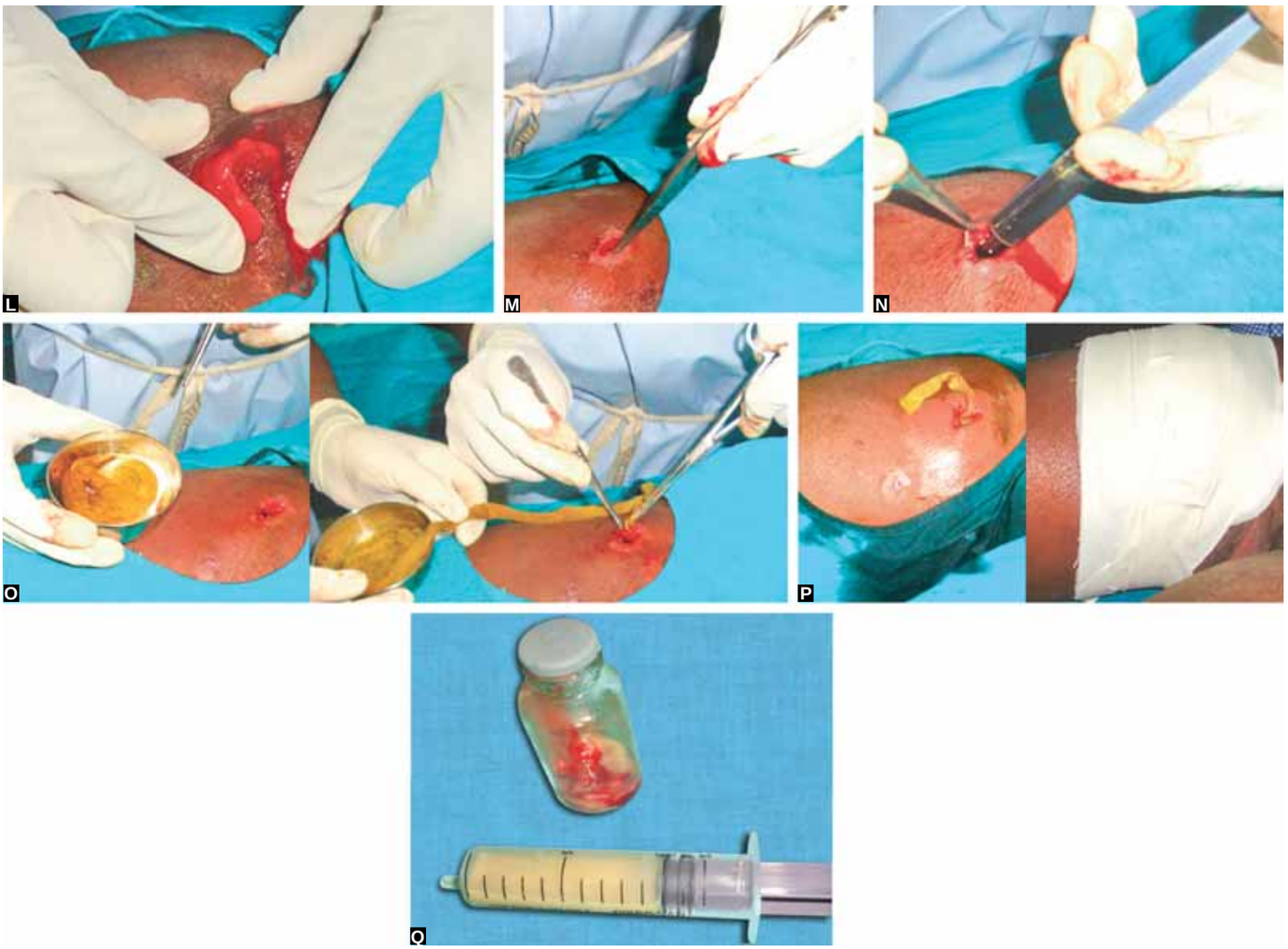
Axillary Abscess

Axillary abscess is drained under general anaesthesia with axilla in hyperextended position and a sandbag under the shoulder. A 5 cm incision is made under the anterior axillary fold longitudinally. Skin and superficial fascia is incised. Using sinus forceps deep fascia is opened in parallel to the line of the axillary vessels. Care is taken not to injure axillary vessels (vein). After draining pus and saline wash, gauze/corrugated drain is placed. Antibiotics are continued. Complications are sinus formation, bleeding, shoulder stiffness.

Ischiorectal Abscess

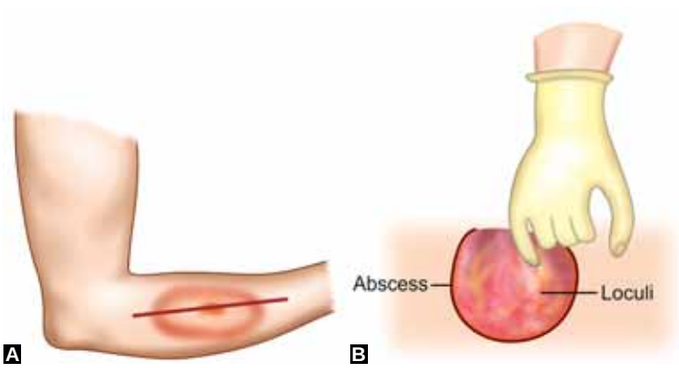
It is drained under general/spinal anaesthesia. Procedure is done in lithotomy position. After cleaning and draping, cruciate incision is placed over more indurated/more prominent area of the ischiorectal fossa. Incision is deepened. Parts of the angles of the flaps are excised (diamond shaped wound) so as to prevent it to close to form recurrent

Figs 7.4A to K



Figs 7.4L to Q

Figs 7-4A to Q: Technique of draining pyogenic abscess. 11 number blade is used to make incision. Lister's sinus forceps is used to drain abscess. Often scoop is used gently to remove unhealthy tissues from the wall of the abscess cavity. Cavity is packed with gauze. Dressing placed. Pus sent for culture.



Figs 7-5A and B: Incision should be longitudinal along the line of neurovascular bundle. Loculi should be broken using little finger or blades of sinus forceps.

Fig. 7-6: Aspiration of abdominal wall abscess. Aspiration of abscess prior to making incision is absolute need.

Figs 7-7A to C: Abscess in the perineum which is drained and packed.

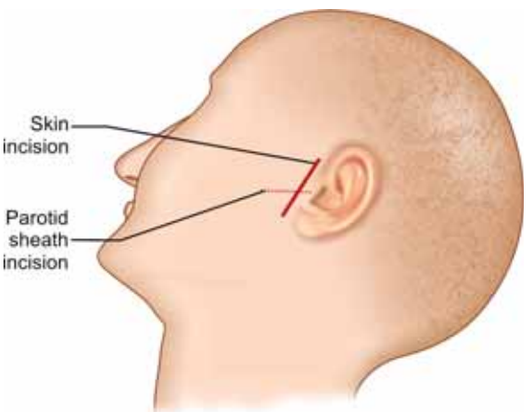


Fig. 7-8: Blair incision used to drain the parotid abscess.

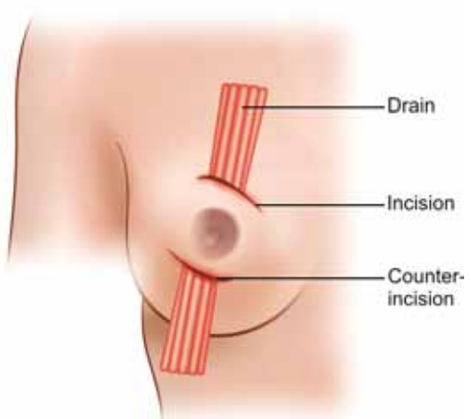


Fig. 7-9: Incision and counter incision for breast abscess.

Fig. 7-10: Photo showing placement of drain in breast abscess.

Figs 7-11A to C: Typical breast abscess showing features of acute inflammation. Drain should be placed after incision and drainage in such abscesses. Often gauze drain can be used.

Fig. 7-12: Breast abscess in a male patient. Breast abscess even though is uncommon in male, it can occur during puberty.

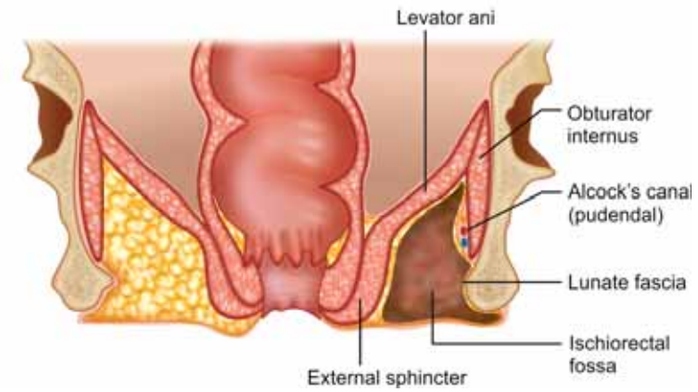
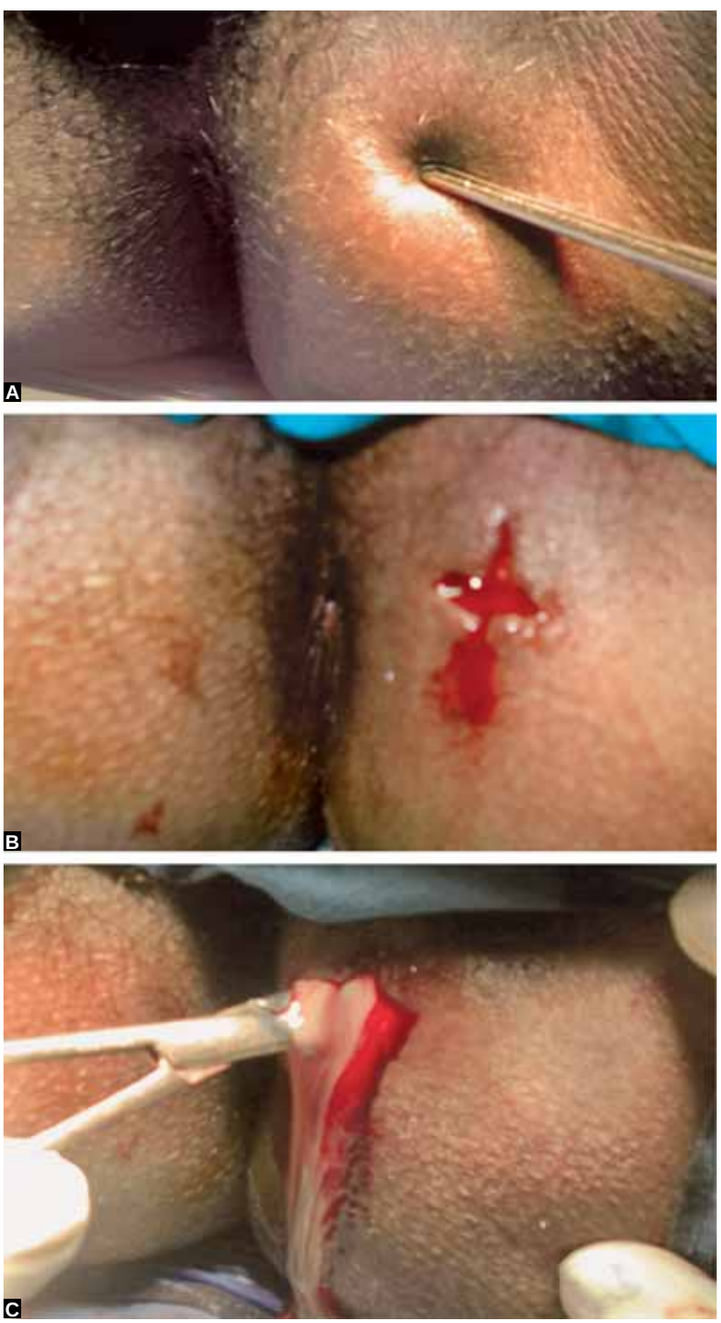


Fig. 7-13: Anatomy of ischiorectal fossa. Note the boundaries and Alcock's canal.



Figs 7-14A to C: Ischiorectal abscess drainage under general anaesthesia. Note the cruciate incision placed and pus is gushing out.

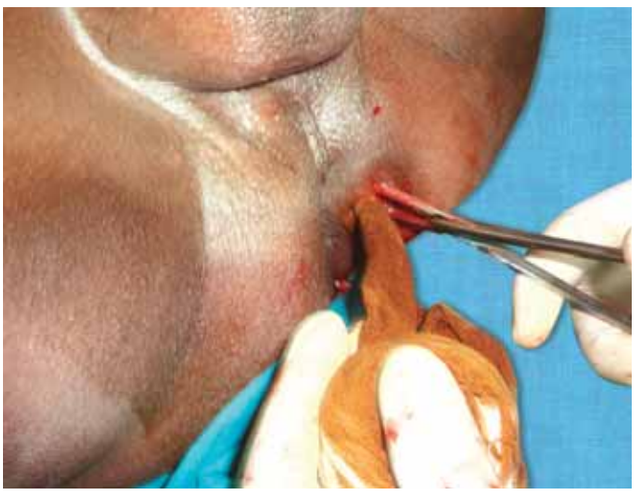


Fig. 7-15: Ischiorectal abscess cavity packed after drainage. Cruciate incision and creation of diamond shaped wound is essential.

abscess formation. Sinus forceps is inserted to enter the fossa and to drain the pus. Using finger all loculi are broken. Rectal examination is done to find out the possibility of existing fistula. Cavity is packed with gauze and dressing is done using 'T' bandage. Antibiotics and regular dressings are required **(Figs 7-13 to 7-15)**.

Digital examination of the rectum should be done to see for fistula. If fistula is present, fistulectomy is done at same or later period.

Ludwig's Angina

It is an inflammatory oedema of submandibular region and floor of the mouth, commonly due to streptococcal infection. There is bilateral brawny cellulitis of sublingual and submandibular region. It is common in severely ill and in advanced malignancy, causing *trismus, laryngeal oedema.* Extension of infection into *parapharyngeal space* may lead to dreaded internal *jugular vein thrombosis.*As the infection is deep to the deep fascia in a closed fascial plane; it spreads very fast causing dangerous complications.

Clinical features: Fever, toxicity, diffuse swelling, dysphagia, dyspnoea, and trismus.

Treatment: Antibiotics-penicillns (high dose 20 lacks 4th-6th hourly), cefaperazone, sulbactum, metronidazole-antimicrobial; IV fluids for adequate hydration **(Figs 7-16 and 7-17).**

Decompression of the submandibular region is done, by making a deep incision extending into the deep fascia and also *cutting both the mylohyoid muscles.* Either it is left open or *delayed suturing is done,* (better option) or it is loosely sutured with a drain in situ.

Complications—Laryngeal oedema and respiratory distress may require tracheostomy; septicaemia; Extension of infection into parapharyngeal space.

Cold Abscess

It is due to caseation necrosis and localisation due to tuberculous infection. There will not be any signs of inflammation. It is well localized, soft, cystic, non-tender swelling without any warmness. It is commonly due to tuberculous lymphadenitis, but can occur in tuberculosis of spine, kidney or other areas. FNAC shows caseation necrosis, macrophages and typical epithelioid cells. Cold abscess is drained using *non-dependent incision.* After drainage wound is sutured without placing a drain **(Figs 7-18A to D)**.

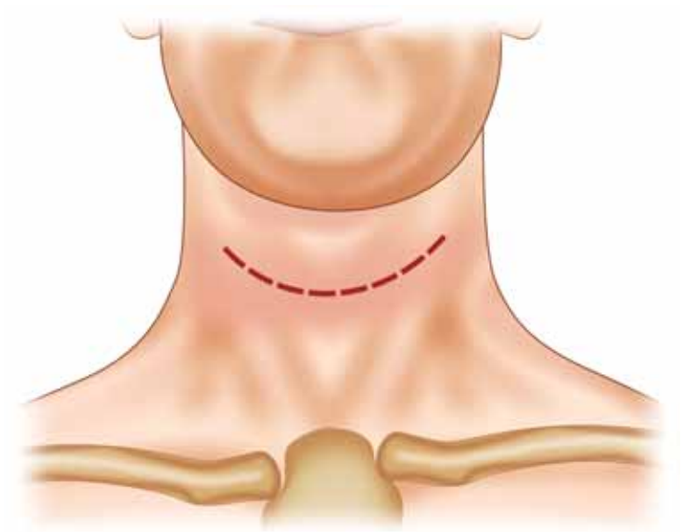


Fig. 7-16: Incision for draining Ludwig's angina.

Treatment of cold abscess—When there is cold abscess; initially it has to be aspirated. [Needle is introduced into the cold abscess in a nondependent site along a *'Z' track* (in zigzag pathway) so as to prevent sinus formation]. But if it recurs, then it should be drained. Drainage is done through *a* nondependent *incision***.** After draining the caseating material, *wound is closed without placing a drain***.** *Surgical removal of tuberculous lymph nodes*- It is done by raising skin flaps and removing all caseating material and lymph nodes. Care should be taken not to injure major structures.

Indications for surgical removal of tubercular lymph nodes

- There is no local response to chemotherapy
- When sinus persists.

TRACHEOSTOMY

Tracheostomy is making an opening in the anterior wall of trachea and converting it into a stoma on the skin surface. It is done for airway maintenance. It is a life saving procedure.

Figs 7-17A to C: Ludwig's angina is drained by decompression incision in the submandibular region with cutting of both mylohyoid muscles. Patient after recovery could open the mouth.

Figs 7-18A to D: Cold abscess and abscess with a sinus in two different patients. It is aspirated in a zigzag track manner. Open drainage is done through non-dependent incision; wound later closed without placing any drain.

Types

- Emergency tracheostomy
- Elective tracheostomy
- Permanent tracheostomy.

High tracheostomy—above the level of isthmus. It can cause tracheal stenosis. It is above 2nd tracheal ring.
Mid-tracheostomy—ideal and commonly used. It through 2nd and 3rd rings behind isthmus. It is approached by dividing thyroid isthmus.
Low-tracheostomy—below the isthmus level. It is deep and impinges the suprasternal notch. It can cause torrential bleed which is difficult to control.

Tracheostomy Tubes

1. ***Fuller's bivalved tracheostomy tube***: It has got a outer tube and an inner tube. Outer tube is biflanged and so insertion is easier. Inner tube is longer with an opening on its posterior aspect. Inner tube can be removed and re-inserted easily whenever required. Using inner tube patient can speak. It is not used in radiotherapy.
2. ***Jackson's tracheostomy tube***: It has got outer tube, inner tube and an obturator. Outer tube has got lock mechanism for inner tube with holes on either side for straps and shield for protection. Inner tube is longer than outer tube. Obturator guides insertion of tube. It is not used in radiotherapy. With tube in place patient cannot speak.
3. Red-rubber tracheostomy tube.
4. ***PVC tracheostomy tube.***

Tubes can be cuffed or noncuffed. It can be fenestrated or nonfenestrated. It can be metal or polyvinyl chloride. Metal tubes are commonly used for permanent tracheostomies. Inner tube can be removed for cleaning purpose. They don't prevent patient from developing aspiration. It is not used for mechanical ventilation purpose.

Shiley's fenestrated tube has got inner and outer tube. Outer cannula has got cuff which can be inflated if mechanical ventilation is needed. Inner tube is changeable and can be nonfenestrated or fenestrated. Nonfenestrated tube is used when mechanical ventilation is needed (outer tube cuff should be inflated). Fenestrated inner tube is used when needs to speak (with deflated outer tube). One way speaking valve may be used along with this to allow air to enter from atmosphere but air exits through fenestra into upper airway. Oxygen can be attached to this speaking valve **(Figs 7-19 to 7-22).**

Modern tracheostomy tubes are made of plastic. They are soft, least irritant and disposable. They have inflatable cuff which makes it easier to give assisted ventilation. Cuff should be deflated at regular intervals to prevent tracheal pressure necrosis. For assisted ventilation, endotracheal tube can be kept for 10-14 days. Beyond that period patient needs tracheostomy for further ventilation as endotracheal tube *in situ* beyond this period may be damaging to trachea, larynx and also precipitate life threatening sepsis.

Indications for Tracheostomy

In head, neck and facial injuries; tetanus; tracheomalacia after thyroidectomy or bilateral recurrent laryngeal nerve palsy; laryngeal oedema/spasm; major head and neck surgeries like Commando's operation, block dissection; acute laryngitis as in diphtheria; carcinoma larynx, foreign body larynx, burns mouth, pharynx, larynx; respiratory paralysis like bulbar palsy; respiratory failure due to asthma, ARDS.

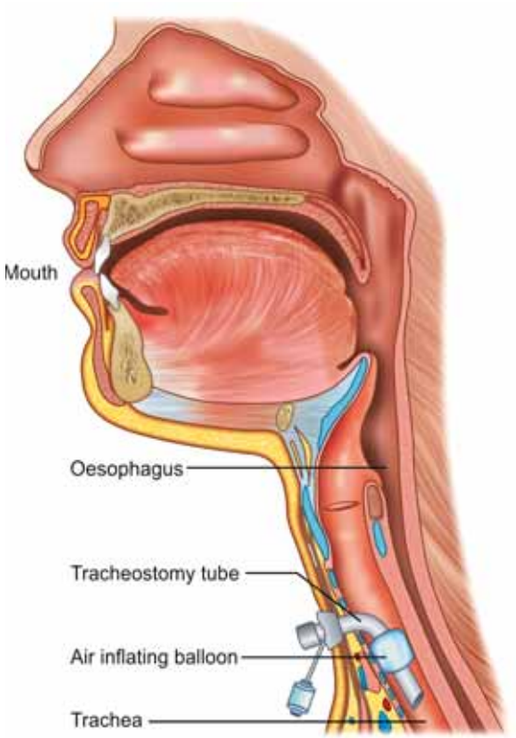


Fig. 7-19: Figure showing the position of tracheostomy tube.

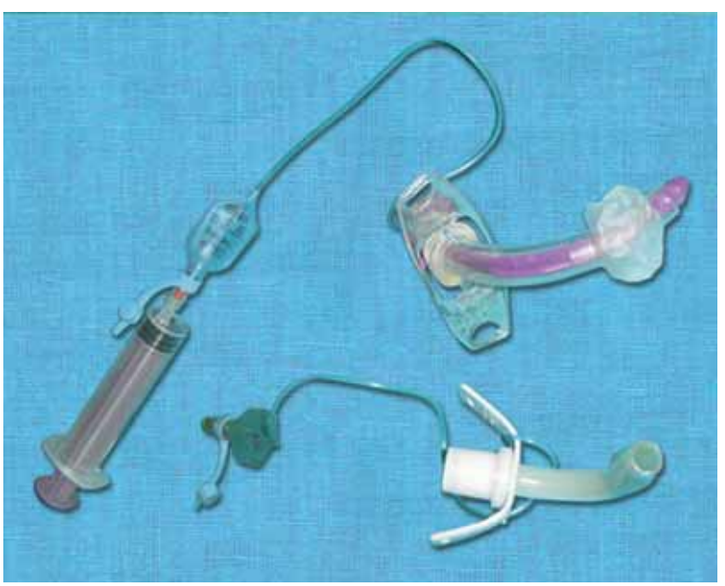


Fig. 7-20: Tracheostomy tube with inflation part and syringe (inflated with air)—polyvinyl chloride.

Technique of Tracheostomy

Approaches—(1) *Vertical midline* incision—It extends from cricoid cartilage to sternal notch. It is used in emergency and often in

Fig. 7-21: Fuller's biflanged tracheostomy tube.

Fig. 7-22: Chevalier Jackson's tracheostomy tube.

Indications for tracheostomy

Respiratory obstruction due to:

- Acute infections causing oedema larynx.
- Trauma
- Neoplasms- benign/malignant
- Foreign body
- Bilateral abductor palsy
- Congenital causes.

Respiratory secretions due to:

- Inability to cough-tetanus, head injury, neurological causes, strychnine poison
- Painful cough in chest injuries, pneumonia
- Aspiration of secretions.

Respiratory insufficiency due to chronic lung diseases like emphysema, chronic bronchitis, bronchiectasis.

elective tracheostomy. Tracheal stenosis less likely in this incision and spontaneous closure is much rapid in this compared to horizontal incision. It gives rapid access with less dissection but leads to poor scars. (2) *Horizontal* incision—It can be used in elective tracheostomy. It is placed two—three finger breadths/midway between cricoid cartilage and suprasternal notch with a length of about 5 cm transversely. It has got a better cosmetic scar. Need for more dissection is the drawback but is commonly used now for elective tracheostomy. (3) *Percutaneous approach* using a needle, cannula, guidewire, and serial plastic dilators then tracheostomy tube is inserted **(Fig. 7-23)**.

Neck of the patient is *hyperextended* by placing sandbags under the shoulder. Vertical (midline) or horizontal incision is made. Deep fascia is opened. Strap muscles are retracted laterally. Isthmus is divided or retracted *upwards.* Inferior thyroid veins may cause bleeding and needs careful ligation. A few drops of lignocaine are instilled into the trachea to suppress the cough reflex. Trachea is fixed with tracheal hook. 2nd and 3rd or 3rd and 4th tracheal rings are opened and circular opening is made or a tracheal flap (*B'jork flap*—flap sutured to inferior margin of the incision) with base downwards is made. In elderly with calcified stiff tracheal, cartilage rings are excised otherwise flap is commonly used. Tracheostomy tube is placed. It is tied around the neck. Usually 8.0 or 8.5 sized tracheostomy tubes are used. If the patient is having endotracheal tube as it is common in many situations, anesthetist will remove the endotracheal tube and tracheostomy tube is inserted and connected to ventilator immediately. Proper suctioning of the trachea prior to insertion of the tube is better. Skin incision is sutured or packed to prevent formation of subcutaneous emphysema **(Figs 7-24A to I)**.

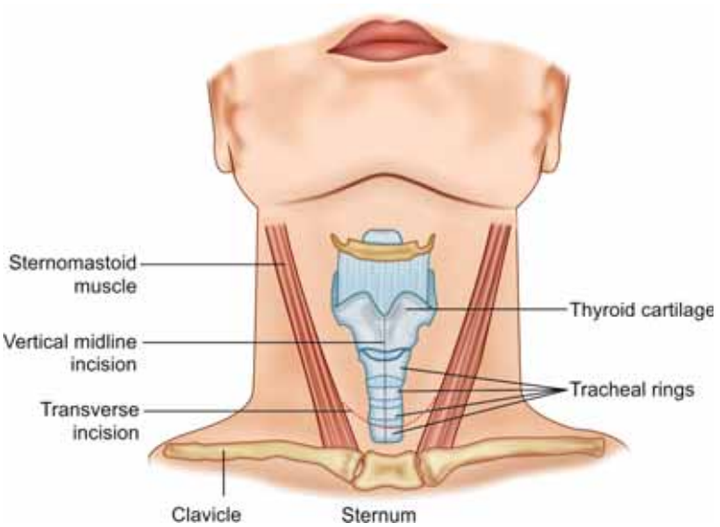
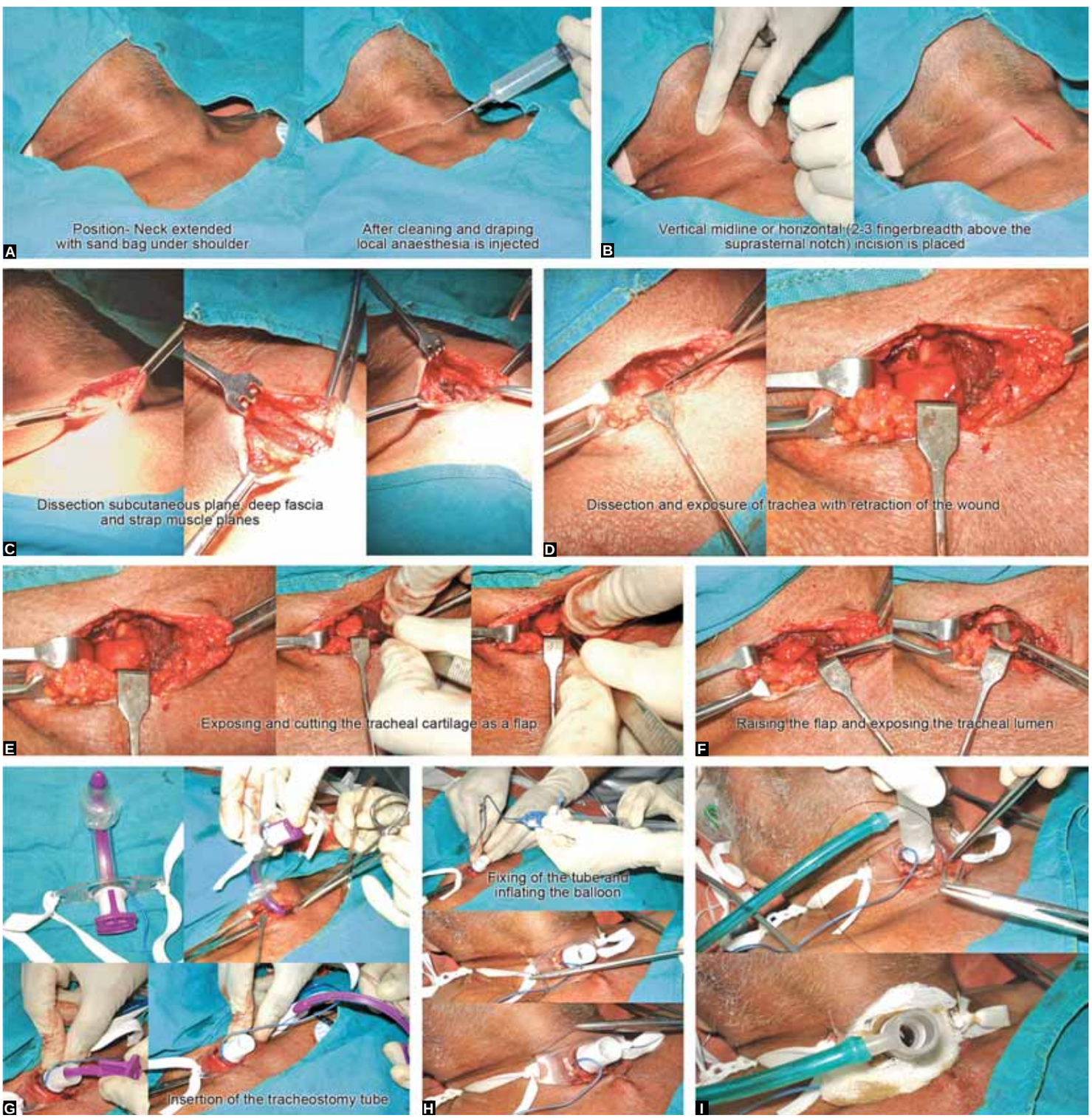


Fig. 7-23: Vertical midline or transverse incisions are used for tracheostomy. ***Vertical midline*** extends from cricoid cartilage to sternal notch. It is used in emergency and often in elective tracheostomy. Tracheal stenosis less likely in this incision and spontaneous closure is much rapid in this compared to horizontal incision. It gives rapid access with less dissection but leads into poor scar. ***Transverse incision*** can be used in elective tracheostomy. It is placed two–three finger breadths/midway between cricoid cartilage and suprasternal notch with a length of about 5 cm transversely. It has got a better cosmetic scar. Need for more dissection is the drawback but is commonly used now for elective tracheostomy.

Note

- First tracheal ring should never be used to do tracheostomy as perichondritis of cricoid cartilage with stenosis can occur—subglottic stenosis.
- Skin should not be sutured or loosely sutured to prevent development of subcutaneous emphysema.
- Cautery should be used during tracheostomy as much as possible to prevent oozing/bleeding from places like muscles, tracheal cut edge. Often torrential haemorrhage known to occur which may need a reexploration to control bleeding.
- In children trachea is soft and compressible and may get displaced easily and dissection may injure recurrent laryngeal nerve or carotid. Procedure is done under general anaesthesia with endotracheal tube in place or after insertion of bronchoscopy. Neck extension in children may cause innominate vein, thymus and pleura to pull upward allowing their possible injury. Silk sutures should be placed on the trachea prior to incising it. Trachea should


Position- Neck extended with sand bag under shoulder
After cleaning and draping local anaesthesia is injected
A
Vertical midline or horizontal (2-3 fingerbreadth above the suprasternal notch) incision is placed
B
Dissection subcutaneous plane, deep fascia and strap muscle planes
C
Dissection and exposure of trachea with retraction of the wound
D
Exposing and cutting the tracheal cartilage as a flap
E
Raising the flap and exposing the tracheal lumen
F
Fixing of the tube and inflating the balloon
H
Insertion of the tracheostomy tube
G
I

Figs 7-24A to I: Steps in tracheostomy.

not be excised in children; only it should be incised. Tracheostomy tube size should be carefully selected. Too lengthy tube will impinge on carina. Only portex tube should be used. Metallic tube is not advisable in children.

Tracheostomy Care

Regular suctioning and cleaning of the tube is needed. Humidification of the inspired air is done using normal saline/ringer lactate/acetylcystine mucolytic agent to liquefy secretions or crusts so as to prevent blockage. Constant observation of the patient for block, bleeding, and periodic deflation of the cuff of the tube for short period to prevent pressure necrosis of tracheal mucosa, prevention of infection are the other care required.

Decannulation of tracheostomy should be done with care especially in children as sudden respiratory distress can occur and in such occasion emergency re-insertion of the tube should be done. Cuff deflation and decannulation is done when patient is able to maintain airway and regains adequate swallowing reflex. Initially it can be changed to metal tracheostomy tube. Once patient breathes well properly, regains normal cough reflex tracheostomy tube is entirely removed and wound is sealed with dressing. Opening closes spontaneously in few days on its own. Tracheostomy set is kept ready at bedside for emergency insertion in case if patient finds difficult to breathe again. Post-decannulation respiratory distress may be due to sustenance of existing pathology; tracheal obstruction due to granulation tissue, oedema, subglottic stenosis, tracheomalacia, tracheostomy dependency.

Flexible bronchoscopy may be needed to clear the lower airway through the tracheostomy tube **(Figs 7-25 to 7-28)**.

Functions of the tracheostomy

- Alternate pathway for respiration bypassing the upper airway.
- It decreases the dead space by 50% and reduces the resistance to airflow so as to improve the ventilation.
- It prevents aspiration in bulbar palsy, coma, and haemorrhage from larynx/pharynx.
- In injuries of head, chest, abdomen, in respiratory paralysis lower airway is kept clean and patent by doing suction of the secretions through the tracheostomy tube.
- Tracheostomy is better and ideal for intermittent positive pressure respiration (IPPR).
- To give general anaesthesia when endotracheal intubation is not possible.

Complications of Tracheostomy

Bleeding, aspiration of blood and secretions, sudden apnoea which is due to sudden washing out of CO_2 (sudden removal of the respiratory stimulant). 5% CO_2 in oxygen is administered in such situation, Pneumothorax, surgical emphysema in the neck, mediastinal emphysema, injury to adjacent structures like oesophagus, recurrent laryngeal nerve, thyroid gland, tracheal stenosis, laryngeal stenosis due to perichondritis of cricoid cartilage, tracheitis/tracheobronchitis, displacement/blockage of the tube or erosion of the tube into major vessels, tracheooesophageal, tracheoarterial fistula.

In children thymus and innominate vein may be in the lower neck crossing the trachea which may be injured during tracheostomy.

Fig. 7-25: Advanced secondaries in neck with tracheostomy tube to control respiratory stridor.

Fig. 7-26: Permanent tracheostomy is done in a patient who underwent total laryngopharyngectomy for carcinoma larynx. Patient is on nasogastric tube for feeding purpose.

Fig. 7-27: Tracheostomy in position connected to ventilator.

Fig. 7-28: Tracheostomy track without tube in situ.

Nursing care

- Consent should be taken
- Materials like tracheostomy tubes (8.5 size), sterile gown, drapes, gloves, cap, mask, tracheostomy sterile set, gauze, local anesthetic agent, suction apparatus and tubes, connecting tubes to ventilator, sterile syringes should be kept ready.
- During procedure the patient is monitored for vital signs.
- Proper nursing care of the tracheostomy tube is done like, humidifying, cleaning, suction, care of the wound, checking of cuff pressure.
- Tracheal dilator and additional tracheostomy tube should be kept ready at bedside in case of blockage of existing tube/balloon not getting inflated to replace with a new one.
- Absolute asepsis like scrubbing hands, using sterile equipments are essential.
- Sterile suction tubes should be used.
- Care of inner tube is essential in case of metal tracheostomy tube.
- Regular dressing of the wound is needed. Antibiotics are required to prevent pulmonary sepsis.

CIRCUMCISION

Indications

- Religious.
- Phimosis.
- Paraphimosis after doing initial dorsal slit.
- Balanitis and balanoposthitis (common in diabetics).
- Early carcinoma of prepuce or glans penis - both diagnostic as well as therapeutic purpose.
- Certain sexually transmitted diseases, e.g. Herpes infection.

Procedure

In children it is done under general anaesthesia. In adults it is done under local anaesthesia.

After cleaning and draping, Local anaesthesia (1% lignocaine *(plain)* is injected circumferentially near the root of the penis (ring block). Dorsal skin is cut up to the corona and later circumferentially and ventrally. The skin is cut with inner layer. Care is taken to see that only optimum (less) skin is cut ventrally to prevent the occurrence *of chordee*. Frenular artery is transfixed and ligated ventrally using chromic catgut (2-0 or 3-0). Small bleeders are also ligated. Skin is apposed to the cut edge of corona using interrupted chromic catgut sutures—3 zero. Postoperatively, antibiotics and analgesics are given **(Figs 7-29 and 7-30)**.

Plastic Cap—Hollister Bell Cap Technique

This cap is fitted over the glans penis and prepuce is rolled over it. A tight ligature is tied over it near base of the prepuce. In 7 days skin and prepuce sloughs off and is shed with the cap. Bleeding will not occur due to thrombosis of prepuceal vessels. Technique can be used for religious circumcision/balanoposthitis without phimosis. It is contra-indicated in phimosis and paraphimosis.

Complications

(1) Reactionary haemorrhage due to slipping of ligature from frenular artery or dorsal vein—Here patient presents with pain, swelling, dressing soaked with blood. Vitals are normal. Wound reopened under local anaesthesia; bleeder is identified after removal of the clot; it is securely ligated and wound closed again. (2) Infection. (3) Stricture urethra near the external meatus in children. (4) Chordee due to removal of excess skin on the ventral aspect. (5) Rarely priapism can occur.

DORSAL SLIT OF PREPUCE

Indications

Paraphimosis; to do biopsy from a growth underneath the prepuce either in the glans or in prepuce itself.

After cleaning and draping, xylocaine plain (1%) is injected into the root of the penis circumferentially. Using two mosquito forceps oedematous prepuceal skin is held. Dorsally skin in midline is cut. Fibrous ring/constriction ring proximally is identified and is cut. Once released properly skin will move freely. 'V' shaped cut edge is sutured with continuous plain/chromic catgut. Dressing is placed over the wound. Patient needs formal circumcision at a later period (after 3 weeks) once oedema subsides **(Figs 7-31 and 7-32)**.

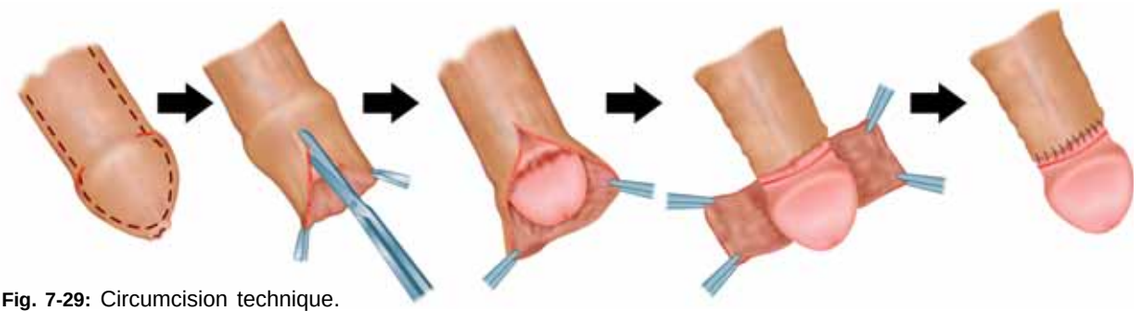
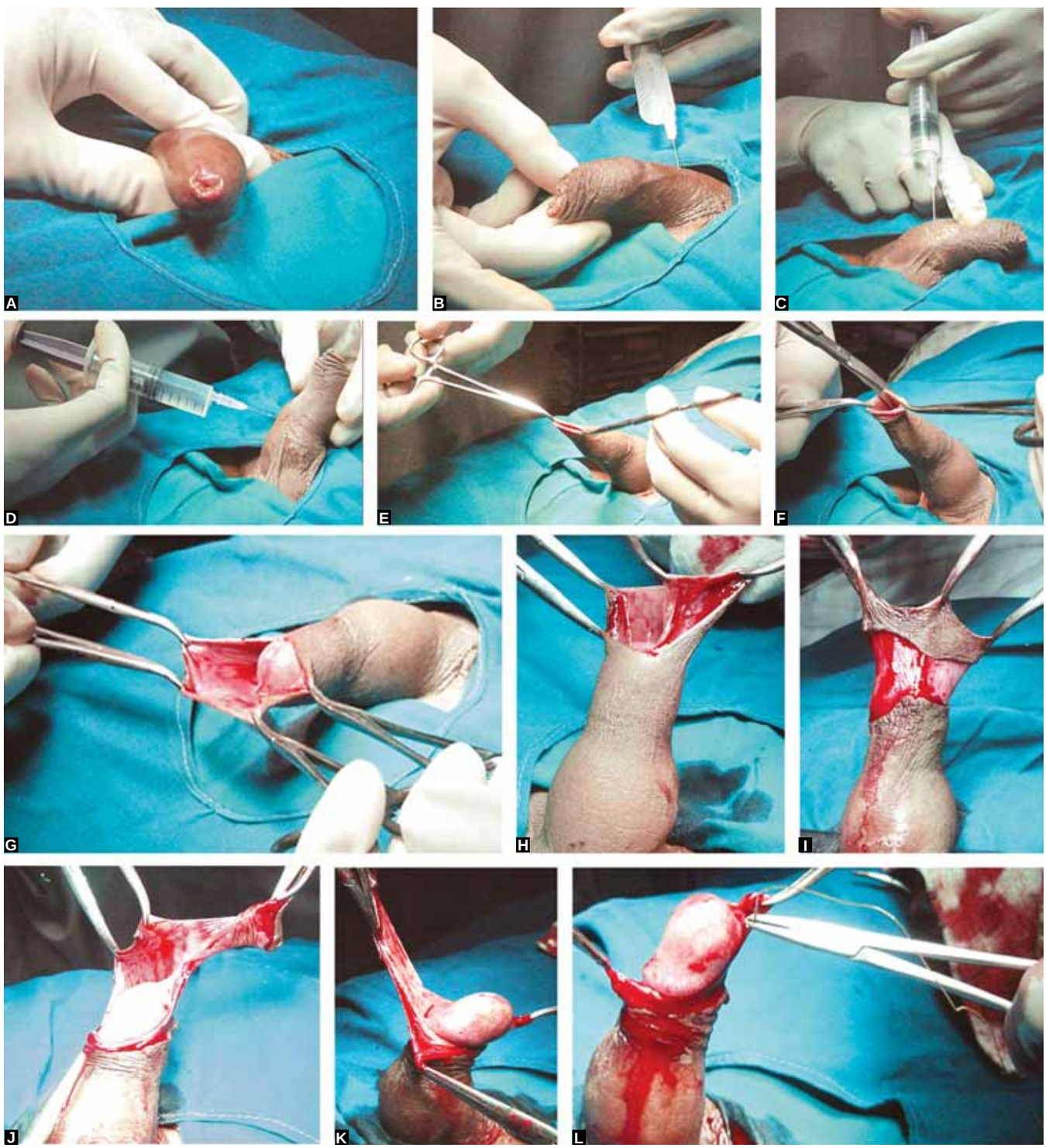


Fig. 7-29: Circumcision technique.



Figs 7.30A to L

Figs 7.30M to X

Figs 7-30A to X: Operative steps of circumcision.

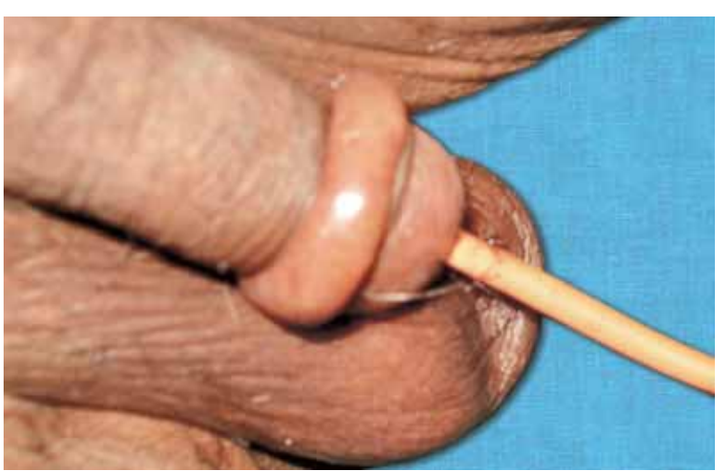


Fig. 7-31: Paraphimosis developed after urethral catheterisation. It needs manual reduction using lignocaine jelly or dorsal slit to release it by cutting the constriction band on the dorsum of the penis.

EXCISION OF THE SWELLING

Swellings like sebaceous cyst, lipoma, pyogenic granuloma, papilloma are excised usually under local anaesthesia. Dermoid cyst which is extending into the deeper plane should be excised under general anaesthesia.

After cleaning and draping, xylocaine 1% injection is infiltrated around the swelling and underneath the swelling by lifting the swelling.

Incision

The following incisions are indicated in different situations **(Figs 7-33 to 7-36):**

- In sebaceous cyst *elliptical incision* is placed encroaching the punctum.
- In swellings like lipoma/ganglion *linear incision* is placed.
- In swelling like papilloma/pyogenic granuloma *circumferential elliptical incision* covering the entire lesion is placed.

Figs 7-32A to C: Paraphimosis showing constriction ring and dorsal slit over the ring.

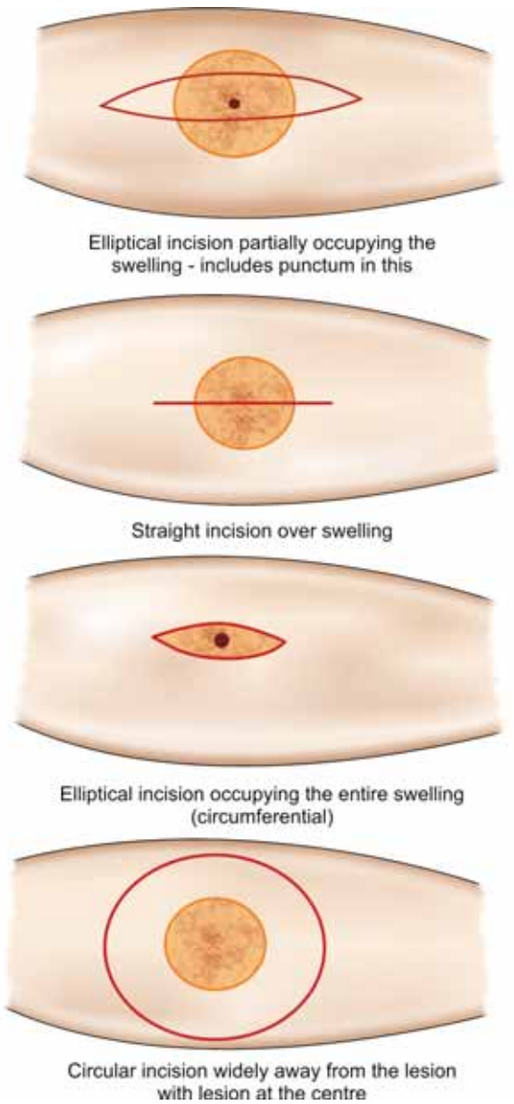

Elliptical incision partially occupying the swelling - includes punctum in this
Straight incision over swelling
Elliptical incision occupying the entire swelling (circumferential)
Circular incision widely away from the lesion with lesion at the centre

Fig. 7-33: Different incisions used as surgical approaches to remove swelling.

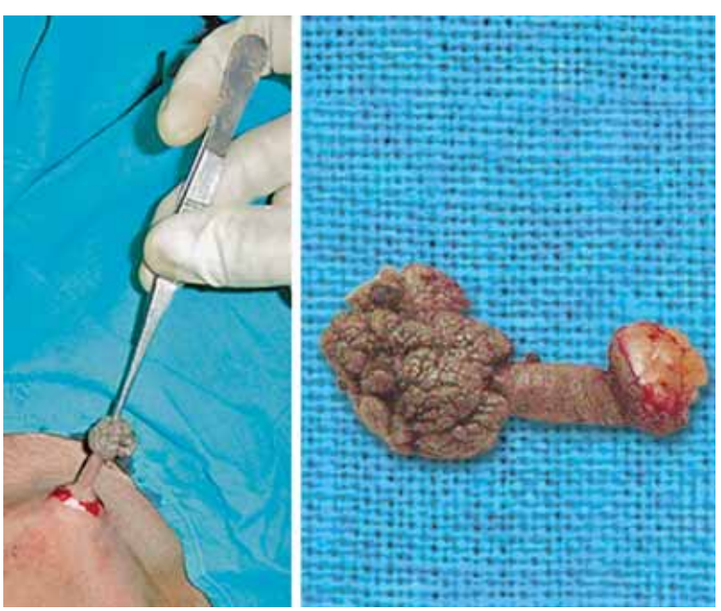


Fig. 7-34: Excision of papilloma with circumferential incision.

Figs 7-35A to E: Steps in excision of ganglion.

- *Circular or oval incision* is used whenever wide excision is needed or skin grafting is planned over it like excision of basal cell carcinoma lesion, etc. Such excision once done it is often difficult to close the defect primarily but needs skin grafting or flap locally.

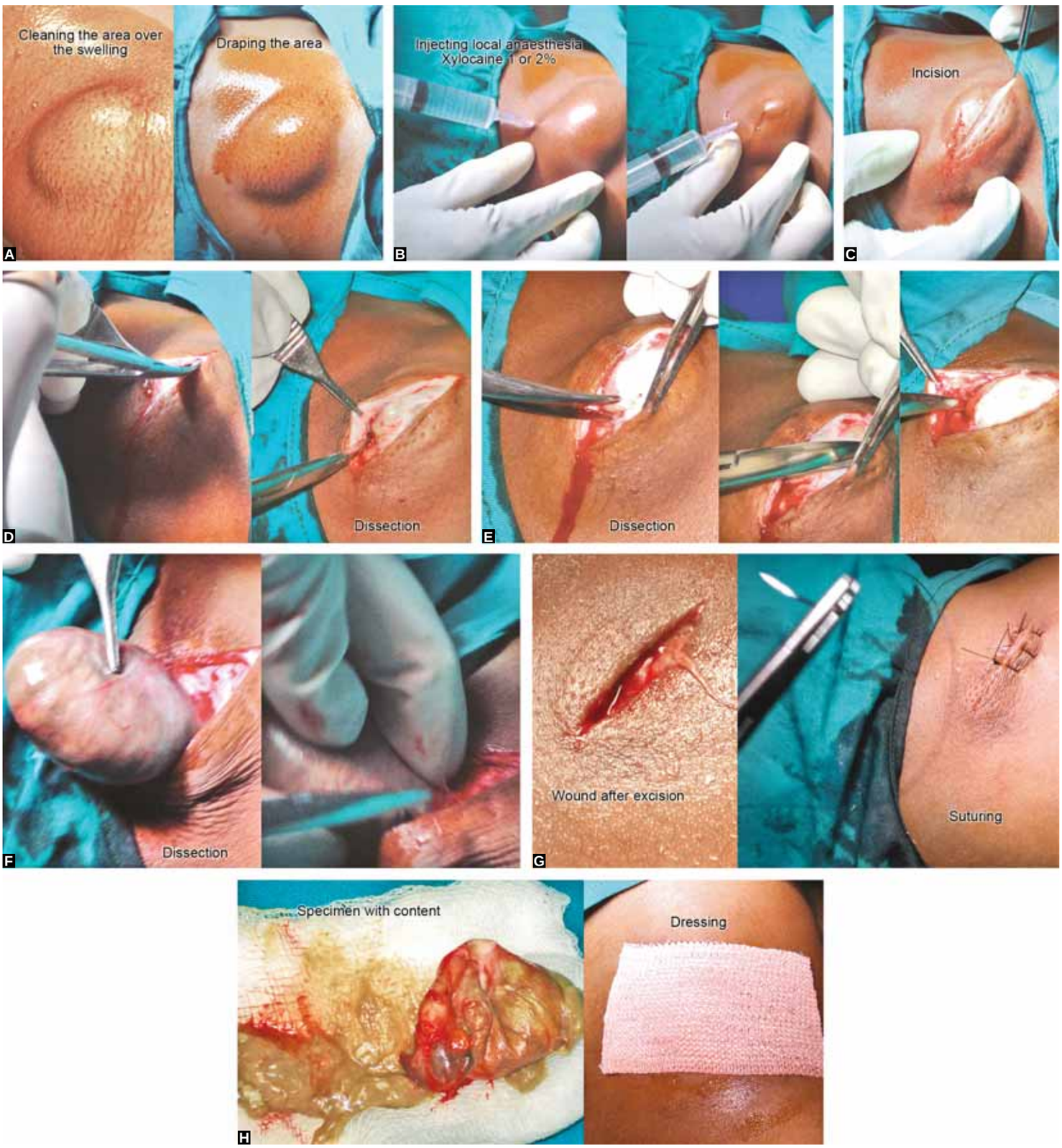
Procedure

Skin flaps on either side are raised adequately until edge of the swelling is clearly seen. Using scissor sharp dissection is done to remove the entire swelling. Bleeding points are cauterised/ligated. Skin is closed using non-absorbable monofilament polypropylene/polyethylene 3-zero sutures.

In a ***sebaceous cyst***, capsule should be removed completely otherwise recurrence can occur. Often avulsion of the capsule also is done to complete the procedure. Punctum should be in the centre of the elliptical incision; length of the ellipse should be equal to the diameter of the cyst. Width of the incision varies, depends on the proper skin apposition achievement during closure. Stretched skin over the cyst (scalp, face) allows wider ellipse; in unstretched skin like in back, narrow ellipse is made. It is easier to begin the dissection at the ends of the elliptical incision than on the summit. Natural plane should be reached by sharp dissection and later blunt dissection can be used over the surface of the capsule. Sharp dissection is done using cautery or scissor or no 15 blade. Artery forceps or mosquito forceps (Halsted) are used to create the plane. Skin hook, fine retractors are needed. If cyst punctures, cyst wall is held up for traction to visualize the plane for dissection. Often cyst is deliberately punctured on the summit and traction is given to the cyst wall to proceed with dissection. If there is more inflammation, wound is left open to granulate and heal. In infected sebaceous cyst, excision is not done; only incision and drainage is done. It is difficult to identify the cyst capsule and poor scarring results if any attempt is made. Often it is observed that cyst wall lining gets destroyed completely causing no recurrence even by only drainage in severely infected cyst **(Figs 7-37 and 7-38)**.

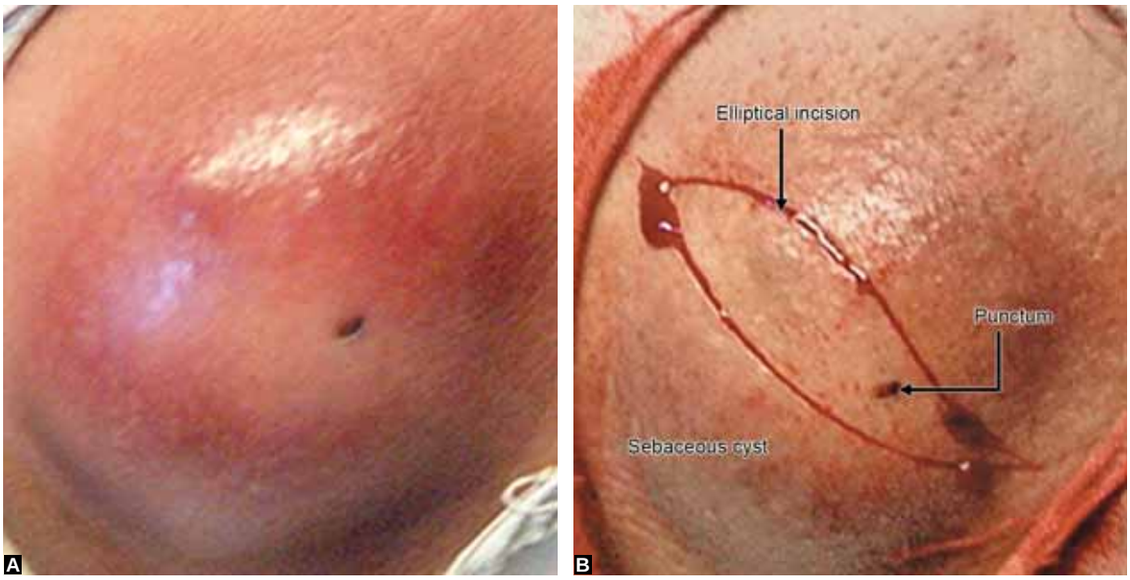
In lipoma linear incision is deepened until capsule of the lipoma is reached. Colour of lipoma is different from surrounding fat and lobules are larger. Squeezing out or winkling of lipoma through the incision can be done using finger which minimises the length of the incision. Retraction, counter traction, sharp and blunt dissection is needed for excision. Large lipoma also can be easily excised under local anaesthesia. Diffuse lipoma needs general or regional anaesthesia for excision. Lipoma in certain locations like back often is adherent to muscles or has extension into muscle plane. In such occasion, muscle should be spilt and small vessels should be ligated or cauterized for proper complete excision (general anaesthesia is needed). In a large swelling like of large lipoma drainage tube may be kept for 48 hours. Dressing is placed. Antibiotics and analgesics are given. Suture removed in 5-8 days. Liposuction for removal of lipoma is not ideal.

In wide excision of basal cell carcinoma (BCC), circular incision around the lesion is made with 5 mm clearance. Deeper plane should have 3 mm clearance. Depth clearance is very important as BCC is locally invading tumour. Frozen section biopsy to confirm the clearance of the margin and deeper layer is important. After excision raw area is covered with split skin grafting or by local flaps, depends on the extent and site of raw area. Rhomboid flap, transposition flap, other local flaps, skin grafting are the methods used to cover the defect. Recurrence rate for BCC is 2%. *MOHS*—Microscopically oriented histographic surgery is used often in BCC, SCC and solar keratoses which is described by Mohs. It is excision in layers with horizontal frozen section control. BCC is sensitive for radiotherapy but lesions in pinna, lacrimal canaliculi and those in close proximity to eye are contraindicated for radiotherapy **(Figs 7-39A to I).**

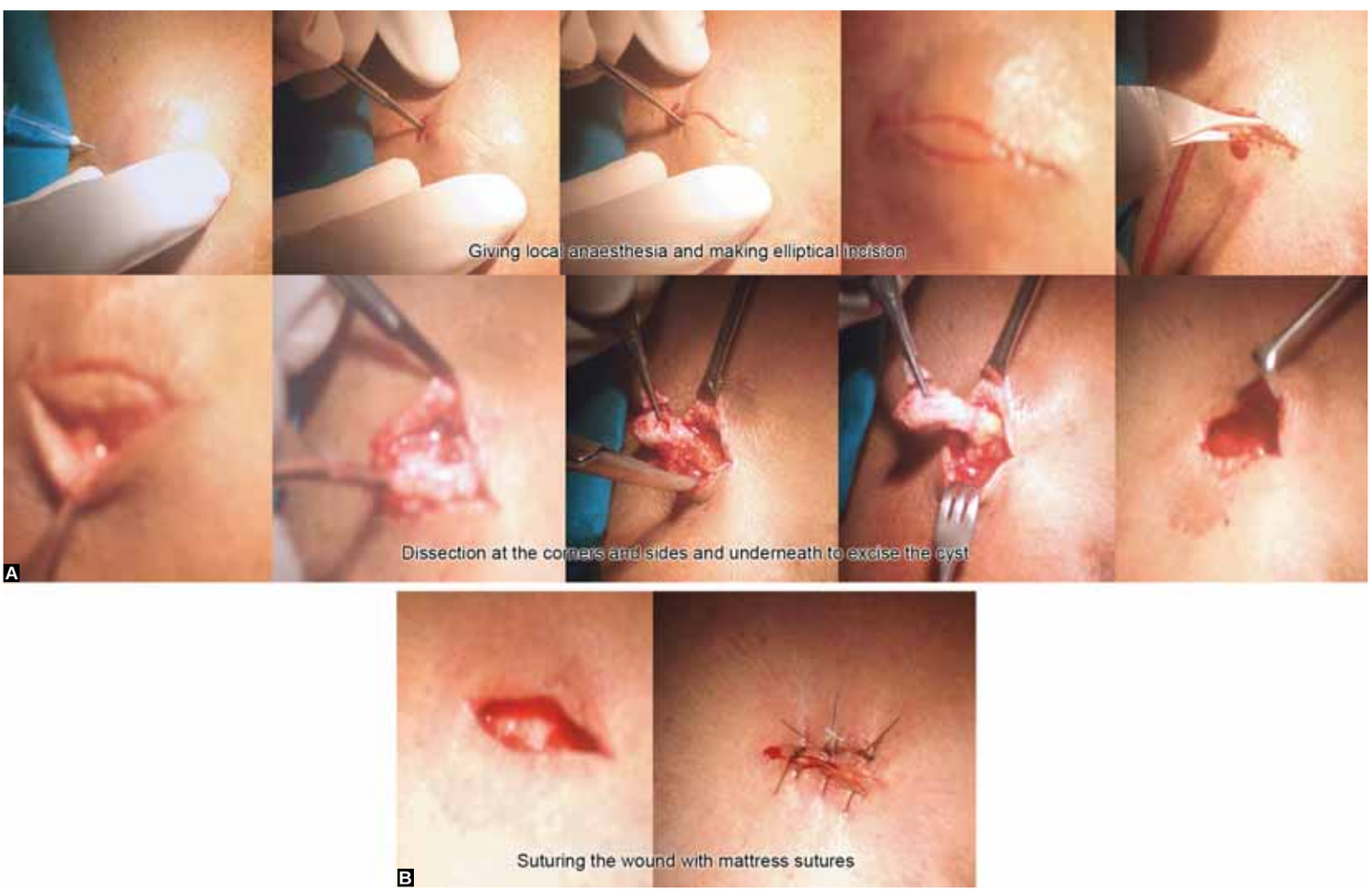


Figs 7-36A to H: Excision of cyst—steps. Often it is necessary to place elliptical incision around the punctum in case of excision of sebaceous cyst with punctum.

In wide excision of squamous cell carcinoma it is similar like BCC. Clearance margin kept is 1 cm. Frozen section biopsy for confirmation of clearance from margin and depth is a must. Defect is closed by transposition/rotation flap/skin grafting depends on location of the carcinoma. Disarticulation of the toe/ray amputation/forefoot amputation/below knee amputations are done for recurrent or wider or deeper or aggressive disease. Regional lymph node block dissection is done (ilioinguinal/axillary/neck) if nodes are positive by FNAC. It is usually/ideally done in same sitting now; but may be postponed for 3 weeks. Radiotherapy/cryosurgery/laser are other methods used



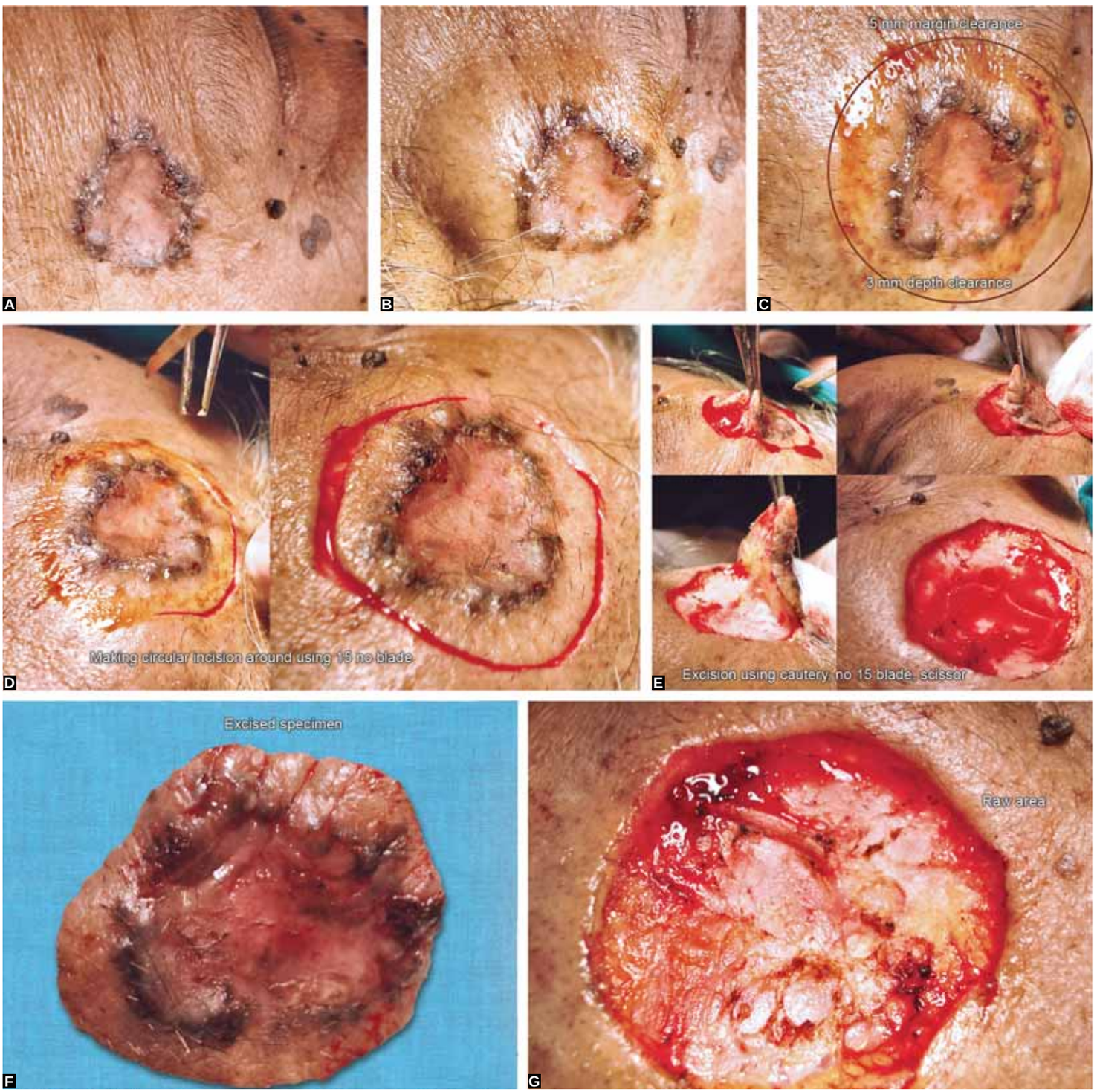
Figs 7-37A and B: Sebaceous cyst with elliptical incision encroaching the punctum.


Giving local anaesthesia and making elliptical incision
Dissection at the corners and sides and underneath to excise the cyst
A
Suturing the wound with mattress sutures
B

Figs 7-38A and B: Steps in sebaceous cyst excision.

for primary disease. Chemotherapy using 5 fluorouracil/adriamycin/vincristine/cis platin are also added **(Figs 7-40A to D)**.

Mohs surgery, also known as **chemosurgery**, originated by a general surgeon, ***Dr Frederic E Mohs***, is microscopically controlled surgery (*Microscopically oriented histographic surgery*) used to treat common types of skin cancer. Complete *circumferential peripheral and deep margin* assessment is the key feature. *Mohs micrographic surgery* is an advanced treatment process for *non-melanotic skin cancer* (basal cell cancer, squamous cell cancer, sebaceous carcinoma, extramammary Paget's disease, dermatofibrosarcoma



Figs 7.39A to G

protuberans, etc.) that offers the highest possible cure rate for many skin cancers and simultaneously minimises the sacrifice of normal tissue. Mohs section should include 100% of the epidermal margin, but greater than 95% is often accepted. Ideally 100% of the epithelial margin should be available to be reviewed on serial sectioning of the Mohs specimen. The team consists of the Mohs surgeon, histotechnician, pathologist and the reconstructive surgeon. The *Mohs surgeon* identifies the cancer and its margin, often with the aid of dermatoscopy. He removes the cancer under local anaesthetic and prepares it for histology processing. This is accomplished by cutting the specimen (if required), staining the specimen for orientation, and sending it to the lab. The *histotechnician* prepares the tissue for Mohs processing by flattening the surgical margin on a flat surface first. Then the flat surgical surface is mounted on a cryostat to be sectioned and prepared for glass slides to be read by the pathologist. The *pathologist* examines the slide for residual tumours, and marks the location of the tumour on the pathology report and sends it back to the Mohs surgeon. Completion of surgery with margin clearance is informed to Mohs surgeon by the pathologist. Defect is covered by a reconstructive/*plastic surgeon.*

Figs 7.39H and I

Figs 7-39A to I: Wide excision of BCC and split skin grafting over it with tie over dressing. Graft has taken up well when seen after 5 days.

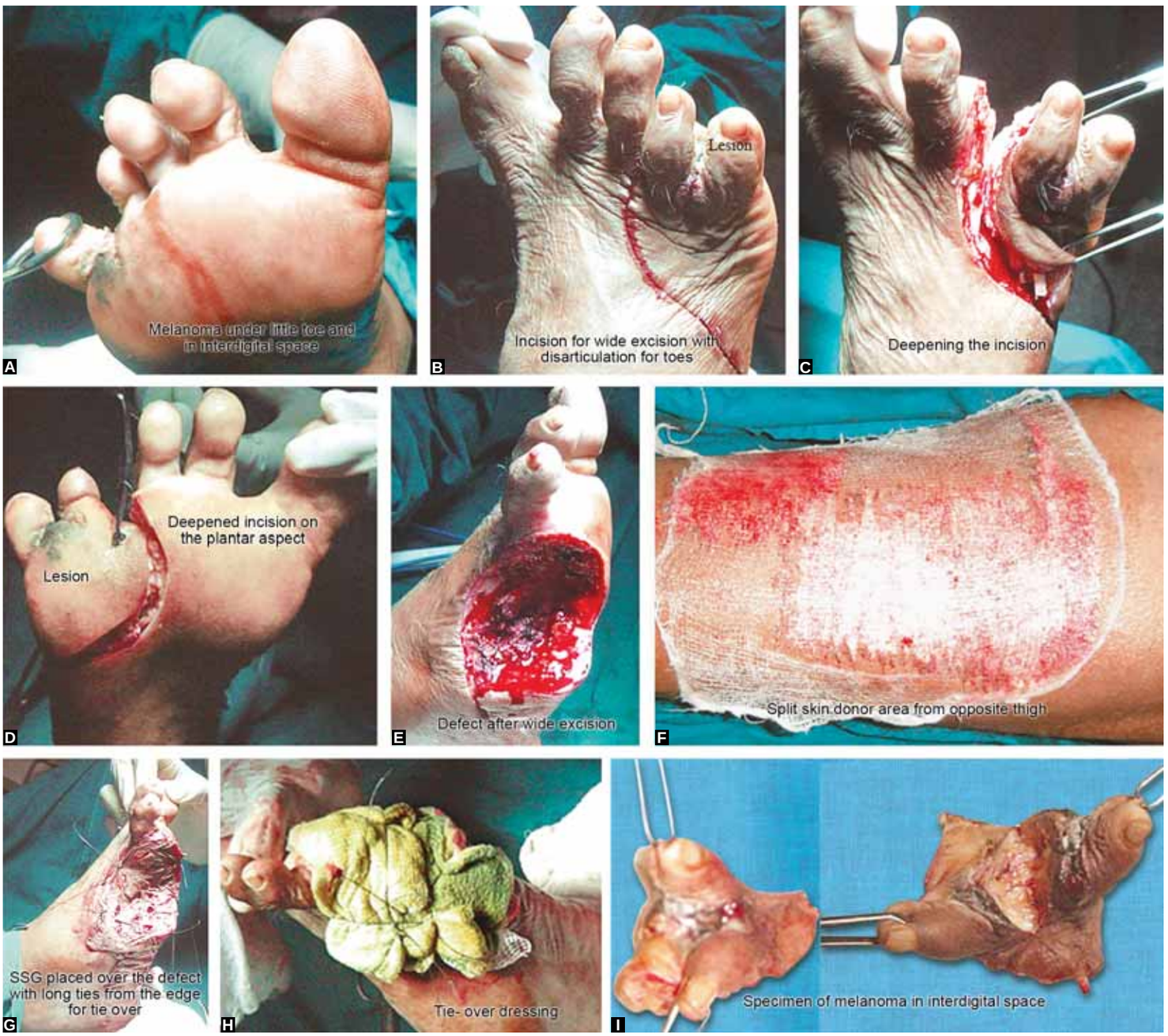
Mohs surgery is performed *in four* levels—(1) Surgical removal of tissue (Surgical Oncology). (2) Mapping the piece of tissue, freezing and cutting the tissue between 5 and 10 micrometers using a cryostat, and staining with hematoxylin and eosin (H&E) or other stains (including T. Blue). (3) Interpretation of microscope slides (Pathology). (4) Reconstruction of the surgical defect (Reconstructive Surgery). The procedure is usually performed under local anaesthesia, can be as day care surgery. A small scalpel is utilised to cut around the visible tumour. A very small surgical margin is utilised, usually with 1 to 1.5 mm of free margin or uninvolved skin. The amount of free margin removed is much less than the usual 4 to 6 mm required for the standard excision of skin cancers. After each surgical removal of tissue, the specimen is processed, cut on the cryostat and placed on slides, stained with H and E and then read by the Mohs surgeon/pathologist who examines the sections for cancerous cells. If cancer is found, its location is marked on the map (drawing of the tissue) and the surgeon removes the indicated cancerous tissue from the patient. This procedure is repeated until no further cancer is found. Anticoagulants are commonly used along with Mohs surgery.

Mohs procedure is very useful for BCC (98-100% cure rate). It is also useful in SCC (90-94% cure rate).

In excision of melanoma—clearance is needed is more than BCC/SCC as it is more aggressive. Clearance to be achieved is decided based on thickness and penetration of the lesion. 1 cm clearance is done for less than 1 mm thickness lesion; 1-2 cm clearance for 1-2 mm thickness; 2 cm clearance for 2-4 mm thick lesion. As incision biopsy of the primary lesion is not done, in clinically suspected lesion initial 2 mm clearance excision of suspected lesion is done with immediate *paraffin section* study. Once report confirms the diagnosis with depth/thickness accurately in mm definitive wide excision and reconstruction is done at a later period. Frozen section

Figs 7-40A to D: Squamous cell carcinoma scalp. Wide excision is done. Transposition flap is done to cover the defect. Flap donor area is covered with split skin graft.

is of no use for depth/thickness assessment, paraffin section study is essential to plan the final clearance and predict the prognosis. Thickness in mm is the most essential factor in melanoma as far as primary is considered. Reconstruction may be by flap or ski grafting depending on the location of the lesion. Donor area should be from opposite side limb in case of lesion in the limb as secondary deposit may occur over the denuded donor raw area. Digital amputation/disarticulation are needed for digital melanoma. Amputation of proximal phalanx may be sufficient if lesion is in the subungual site otherwise disarticulation is needed. Presently prophylactic regional node dissection is not done as systemic spread is also deciding factor in melanoma prognosis. Sentinel node biopsy is better and ideal to decide for block dissection. Radiolabelled colloid is injected to the lesion around day before the surgery. Preoperative scintigraphy is done or node is identified using hand held gamma camera. Radiolabelled colloid slowly reaches the node but stays there long time. It is often done in combination with blue dye injection intraoperatively which reaches the node rapidly in 10 minutes but disappears from the node early. Positive sentinel node biopsy indicates regional block dissection. Melanoma is not radiosensitive and so it is used only in intracranial and spinal secondaries. Chemotherapy has also got fewer roles but is commonly used postoperatively using melphalan and DTIC. Isolated limb perfusion even though practiced in many centers, its benefits are not proved. Laser, MOHS, cryosurgery has not commonly used in melanoma **(Figs 7-41 and 7-42)**.



Figs 7-41A to I: Wide local excision of melanoma with disarticulation of toes. Skin grating is done to cover the defect. Flap is ideal in many places like plantar aspect of the foot but technically difficult.

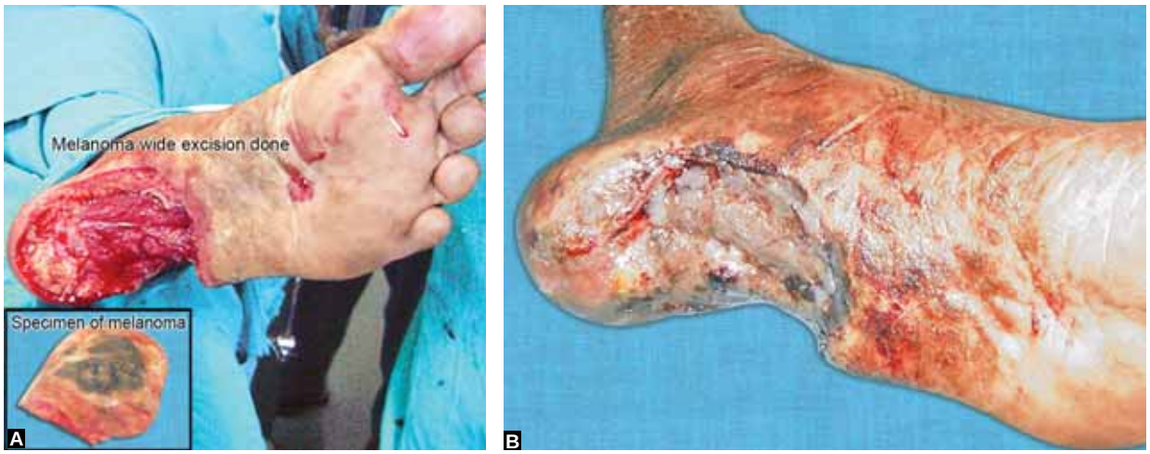
Note:

- *Enucleation* is removal of the swelling within the tissue of origin with normal part of tissue of origin is being retained. Example—Enucleation of prostate in benign prostatic hyperplasia (BPH).
- *Excision* is removal of tissue/tumour entirely with its capsule.
- *Wide excision* is removal of tumour with surrounding tissue margin adequately for clearance.
- *Compartment excision* is removal of tumour/diseased tissue with all adjacent soft tissues in one compartment except neurovascular bundle. It is done in limbs for soft tissue sarcoma as a curative but limb saving procedure.
- *Radical excision/radical block dissection* is removal of tumour widely with adjacent soft tissues with lymph node dissection.
- *Retraction, traction/counter traction, sharp* and *blunt* dissection is needed for excision. In inflammatory area or adherent area sharp dissection using diathermy or scissor or no. 15 blade is done. When there is proper plane with loose areolar tissue, blunt dissection is done using finger or peanut. Blind dissection should be avoided.

LYMPH NODE BIOPSY

Indications

- Lymphoma to find out the grade, type of lymphoma.
- Secondaries in the lymph node only when FNAC is inconclusive but clinically node is significant. Significant node is one which is based on size (variable in different locations and type of primary



Figs 7-42A and B: Wide excision of a melanoma in sole with split skin grafting.

but hard node > 1 cm is significant) and texture (hard) probably harbouring tumour spread. FNAC is the first choice in secondaries as biopsy of node may block the lymphatics and may allow spread of tumour to next level of nodes.
- Tuberculosis of lymph node.
- Rare lymphatic diseases.

Site of Node Selection for Biopsy

- Neck nodes—superficial/deep.
- Axillary node.
- Groin node—these nodes can often be non-specific because of repeated recurrent inflammation. Hard, large sized node can be considered as significant.
- Abdominal nodes are biopsied using laparoscopy. Thoracoscopic biopsy or mediastinoscopic biopsy of lymph node is also done.

Procedure

Lymph node biopsy *ideally* should be done under *general anaesthesia*. Superficial nodes/nodes in upper posterior triangle may be removed under local anaesthesia—xylocaine 1%.

After cleaning and draping, incision is placed. Incision is decided depending on the site of the lymph node. It is usually horizontal in the neck over the lymph node. It is better to mark the incision line using marking ink. Adequate incision is a must otherwise technique will be difficult. After skin incision, fascia is incised. Lymph node is identified based on shape, color and texture. Node is separated from adjacent structures. Node is held using Lane's tissue holding forceps. One should avoid breaching the capsule as much as possible to retain the lymph node architecture. After removal haemostasis is maintained. Diathermy or ligation using fine absorbable sutures (polyglactic acid) is used. (Earlier surgeon used to cut the node to see the interior texture and to get imprint cytology over a slide; but now pathologists prefer to send the node without cutting). It is fleshy in Hodgkin's lymphoma. It is yellowish caseating in tuberculosis and dark, haemorrhagic in secondaries. Skin is closed with interrupted sutures using monofilament non-absorbable sutures or absorbable subcuticular sutures. Sutures removed in 7 days.

Ideally entire one node with its intact capsule should be removed especially in lymphomas. Many times it may be difficult because of fibrosis and adherent lymph nodes **(Figs 7-43A to F)**.

Lymph node can be studied as histology slides, culture, AFB staining, AFB culture or other special staining for fungal infection. Immunohistochemistry has got major role in lymphoma.

Often when result is inconclusive repeat biopsy may be needed.

Complications and Difficulties

Bleeding is due to injury to small or major vessels (jugular veins in neck; femorals in groin; axillary vein or branches in axilla). Adjacent nerves also may get injured (accessory, intercostobrachial, femoral). Sepsis, haematoma formation, lymph ooze, fungation may be other problems.

LIVER BIOPSY

It is removal of bit of the liver tissue percutaneously for histological purpose.

Prerequisites

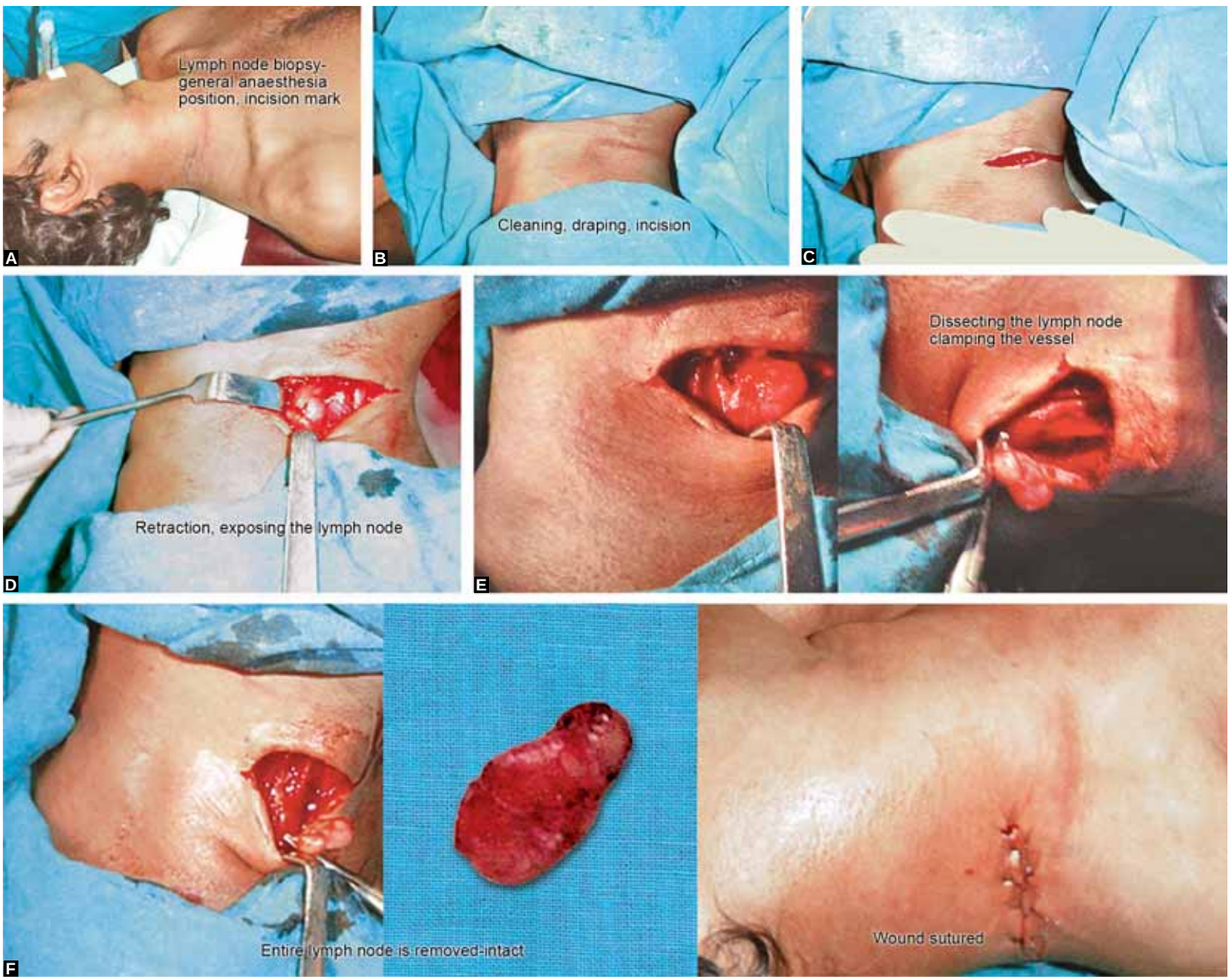
Prothrombin time should be normal before doing liver biopsy, otherwise severe bleeding can occur. Normal value of prothrombin time is 12-16 seconds (It is compared to control and difference should be less than 4 sec between test and control). It is corrected by giving injection vitamin K 10 mg IM for 5 days. Even after that if repeat PT is still high then fresh blood transfusion (FFP) is transfused to correct it.

If ascites is present, tapping should be done prior to liver biopsy.

Blood grouping and cross matching should be done.

Indications

(1) Cirrhosis, chronic hepatitis, haemochromatosis, Wilson's disease. (2) Hepatoma. In secondaries liver biopsy is usually not done as it may precipitate failure or ascites formation. (3) Granulomatous liver diseases, metabolic and storage diseases, familial diseases. (4) Unexplained long-term fever wherein all other usual investigations are normal. (5) Chronic hepatitis, biliary atresias.



Figs 7-43A to F: Technique of lymph node biopsy.

Contraindications

Bleeding diathesis, platelet count below 60,000, widened prothrombin time, Hydatid disease, wherein it will precipitate anaphylaxis, haemangiomas, ascites, infection in close proximity—lung/diaphragm/peritoneum and liver congestion.

Procedure

Patient should be nil oral for 6 hours. Injection atropine 0.6 mg intramuscularly should be given. Patient will be lying on his back very close to the edge. Often 30° propped up position is used. After cleaning and draping, 9th intercostal space in the midaxillary line is marked. Xylocaine 1% is injected into the skin, subcutaneous tissue, deeper tissues up to liver capsule. He or she is then asked to lie on the back with the right elbow to the side and the right hand under the head. The patient is instructed to lie as still as possible during the procedure. He or she is warned to expect a sensation resembling a punch in the right shoulder, but to hold still in spite of the momentary feeling. Needle used is either *Vim-Silverman needle or Menghini needle* (better option).

Using Vim Silverman's needle—It has got three parts—trocar, cannula and split (biflanged) needle **(Fig. 7-44)**. Trocar snugly fits properly into the cannula. Trocar with cannula is passed into the liver tissue when patient holds the breath in deep inspiration. Trocar entering

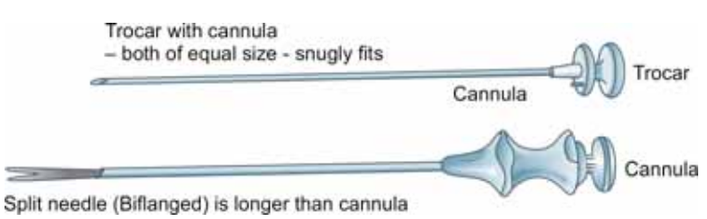


Fig. 7-44: Vim-Silverman needle.

the liver tissue can be felt. Patient is asked to breath comfortably relaxed. Trocar is removed. Split needle is much longer than cannula. It is held in the hand to keep ready for penetration into the liver. Patient is again asked to hold the breath properly. Split needle is passed fully to core the liver tissue beyond the existing cannula; cannula is pushed further over the split needle to include the cut liver tissue; cannula with split needle is rotated 180°; cannula with needle is removed entirely. Split needle is carefully removed and opened to collect the cut liver tissue for biopsy. Patient is asked to breath normally afterwards. Procedure can be repeated once again. Further repetitive procedure to get more tissue in the same sitting is not advisable due to risk of liver injury and bleeding. Tissue is often collected in *Bouin's solution* which contains 75% picric acid.

Presently guided liver biopsy is commonly recommended and popular i.e. U/S guided, CT guided, laparoscopy guided.

Menghini needle method—Percutaneous liver biopsy is done with a special hollow needle, called as Menghini needle, attached to a suction syringe. 3 ml sterile saline is taken into the syringe with specific Menghini needle **(Fig. 7-45)**. Once needle is inside the intercostal space after injecting local anesthesia, 2 ml of saline is injected to clear the skin fragments in it. Aspiration vacuum is created in the syringe and kept like that and needle is forwarded into the liver. Meantime patient should hold his breath completely in expiration. Needle is connected the syringe with already created vacuum and withdrawn immediately. It will contain sucked liver tissue which is carefully collected on a glass receptacle containing saline. This method is safer and reliable.

The traditional Menghini needle is 6 cm long with an oblique tip slightly convex towards the outside. A retaining device is incorporated into its proximal end to prevent liver tissue from being aspirated into the syringe. The diameter of the needle usually does not exceed 1.4 mm. A penetration limiter is often utilised in children and thin adult patients to limit the depth to which the needle advances. The patient is asked to inhale slightly and exhale maximally and then hold his breath in a maximum exhaled position. At this point, steady suction is applied to the syringe, which is connected to the needle, and the needle is advanced into the liver and withdrawn.

Features of biopsied liver tissue are—float in water in fatty liver; fragmented small pieces in cirrhosis; dull white coloured in malignancy; green coloured in biliary cirrhosis; chocolate coloured in Dubin-Johnson's syndrome.

Post-Procedure Observation

Complications develop commonly within 24 hours. Rest, observation with monitoring of pulse, blood pressure and respiration is essential. Heavy work and exercise should be avoided for 7 days. Routine work after 24 hours is safer. Shoulder pain on right side may be warning sign and needs evaluation using chest X-ray and ultrasound.

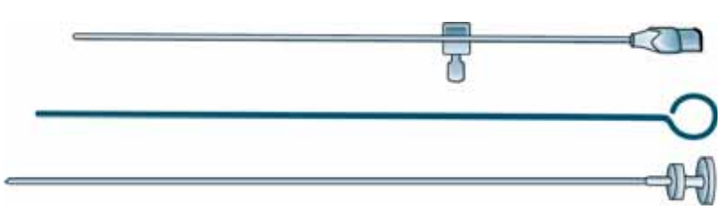


Fig. 7-45: Menghini needle.

Complications

Haemorrhage, bile leak and biliary peritonitis, infection, injury to gallbladder, colon, kidney. Hepatic coma/failure may be precipitated in cirrhotic patients

Causes of Failure in Liver Biopsy

Cirrhosis, emphysema, uncooperative patient, improper technique.

KIDNEY BIOPSY

Kidney biopsy is done as diagnostic or prognostic indications.

Indications are—asymptomatic proteinuria, nephritic syndrome, glomerulonephritis. It is mainly used in medical causes.

Contraindications are—unilateral kidney, totally shrunken kidney, infections, cystic diseases, hypernephroma, bleeding diathesis. Prothrombin time and platelet count should be assessed. X-ray KUB, ultrasound is done to assess the size of the kidney.

Procedure is done *in prone lying down position* under ultrasound guidance. Procedure is done on the diseased side; in bilateral disease *left side* is preferred. Point of entry of needle is decided under US guidance. Xylocaine local anaesthesia is injected. Needle is passed across skin, subcutaneous tissue, and muscles. While patient is asked to hold the breath, needle is entered into the kidney. When patient breathes back needle moves with respiration. Tissue is aspirated with negative pressure. Needle is removed. Post-procedure period patient is observed for pain, haematoma and bleeding. Bed rest is needed for 24 hours.

Complications

Pain, haematuria, infection, abscess formation, perirenal haematoma, injury to colon, etc.

BONE MARROW ASPIRATION

It is done for diagnostic and prognostic purpose in various conditions aplastic anaemia, aleukaemic leukaemia, lymphomas, myeloproliferative diseases, myelofibrosis, multiple myeloma, agranulocytosis. It can be done in refractory or iron deficiency anaemias, leukaemias, tropical diseases, storage diseases. Bone marrow transplantation is a therapeutic method. Blood dyscrasias are contraindications.

Usual *site* is sternum (mid manubrium). Other sites are—spinous process of lumbar vertebra, iliac crest. After injecting local anaesthesia, bone marrow aspiration needle with the guard at 1.5 cm from the tip of the needle is punctured through the skin at sternum perpendicularly. *Guard* prevents inadvertent deeper penetration of the needle. Needle is pushed in boring/screwing movements. Sudden giving way suggests the entry of the needle into the bone marrow. Stillete is removed. 0.5 ml of bone marrow fluid is aspirated using 1 ml syringe. Material is smeared in slides also. After removal of the needle, pressure is applied over the site to prevent bleeding and haematoma formation.

Complications

Bone pain, haematoma, infection, injury to great vessels. Normal compositions of bone marrow are—blood cells, blood vessels, reticulum and fatty tissue.

Causes for *dry tap*—technical; myelosclerosis, carcinoma, hyper or hypoplasias. *Analysis of bone marrow is done for*—erythropoiesis, leukopoiesis, megakaryocytes; cellularity, myeloid-erythroid ratio (3:1); presence of parasites and different bodies.

LUMBAR PUNCTURE

It is aspiration and collection of cerebrospinal fluid (CSF) from the spinal subarachnoid space by passing a needle into the space between lumbar 2nd and 3rd vertebra or 3rd and 4th vertebra.

Indications

Meningitis, subarachnoid haemorrhage, neurosyphilis, unexplained coma, Guillain Barré syndrome, multiple sclerosis, during myelography, to introduce drugs into the CSF, for spinal anaesthesia, in hypertensive encephalopathy.

Contraindications

In raised intracranial hypertension if lumbar puncture is done, herniation of brain trough foramen magnum can develop leading into sudden death. Suspected cord compression is also a contraindication. Back pain, sciatica, syringomyelia, sepsis, allergy are other contraindications.

Procedure

Patient is positioned in lying down side position with knee fully flexed and head flexed. Sitting and bending forward is another position often used. 3rd lumbar vertebra is at the level of highest point of iliac crest. Entire back is cleaned with savlon/povidone iodine and draped. Xylocaine injection is infiltrated (5 ml) subcutaneously and up to ligamentum flava. Lumbar puncture needle with stillete is introduced into the space. Cutting edge of the bevel of the tip of the needle should be parallel to fibres of ligamentum flava. It is directed upwards and forwards at 5° through resistance of supraspinous ligament. Needle is then passed through interspinous ligament, ligamentum flavum and dura mater of spinal cord. Giving way sensation of entering the subarachnoid space is typical. Stilette is withdrawn. *Spinal fluid* is collected for biochemical, cytological and serological studies. Fluid will be clear with continuous drops (0.5 ml/second flow rate). A manometer is attached to lumbar puncture needle; pressure is applied over one jugular vein and then the other which causes raise in intracranial venous pressure and then intraspinal venous pressure which reflected in manometer. There is raise in fluid level in manometer quickly for about 100 mm and falls down slowly. It is possible only if pathway between lumbar puncture site and cranium is patent. Delay in this means spinal block—*Queckenstedt's test* **(Figs 7-46 and 7-47)**.

Normally CSF is formed at choroids plexus of lateral ventricle (95%), of 3rd and 4th ventricle, perivascular spaces of brain. It circulates from choroids plexus of lateral ventricle → foramen of Monro → lateral ventricle → Sylvian duct → 3rd ventricle → 4th ventricle → foramen of Luschka and Magendie → subarachnoid space → basal cisterns → circulations over brain and spinal cord. CSF is *absorbed* by arachnoid villi. *CSF* maintains intracranial pressure, gives shock absorption to cranium, and gives nutrition and excretion. *Normal CSF* formation is—1500 ml/day; total volume of CSF is 150 ml; clear in colour; 60-150 mm is the pressure in lying down and 200 mm in sitting position; pH is 7.35; specific gravity is 1.007; proteins is 20-40 mg%; sugar is 40-60 mg%; chlorides is 720-750 mg%; cells are 0-5 epithelial lymphocytes like cells. In CSF sugar, proteins, cholesterol, urea, calcium and phosphorus are less than that of blood; chlorides and magnesium are more than that of blood. Antibodies and enzymes are not seen in CSF. Penicillins, streptomycin will not cross blood-brain barrier and so not found in CSF.

Findings

CSF is turbid in pyogenic meningitis; cobweb in tuberculous meningitis; bloody in subarachnoid haemorrhage/trauma/bleeding disorders. Yellow CSF *(xanthochromia)* is seen in haemorrhage in CSF, high protein content like Guillain-Barré syndrome, spinal block or neurofibroma; jaundice patients; spinal tumours. *Proteins* in CSF are raised in meningitis, Guillain-Barré syndrome, intracranial tumours, spinal cord compression, disseminated sclerosis. Sugar in CSF is increased in diabetes mellitus, encephalitis. It is decreased in meningitis. Chlorides in CSF are decreased in meningitis and metabolic conditions.

Cohen's law of meningitis—Substances which are more in CSF than blood will reduce in meningitis and substances which are low in CSF than blood will raise with exception of sugar (sugar is less in CSF than blood normally; it reduces further in meningitis).

While giving *spinal anaesthesia* (xylocaine 5% in 6% dextrose of 2 ml; or bupivacaine 0.5% in 5% dextrose of 3 ml), bevel should face upwards (360° rotation). Syringe is aspirated to get clear CSF into it and the anaesthetic drug is injected. Needle is removed, area is cleaned and sealed.

Complications

Headache is the commonest complication. Plenty of oral fluids, intravenous fluids, head down position, bed rest, and analgesics are used to control it. Back pain, infection, meningismus, coning, bleeding, rarely paraplegia, converted to total spinal in spinal anaesthesia are other complications.

PLEURAL TAP (THORACOCENTESIS)

Indications

Pleural effusion both diagnostic as well as therapeutic. The fluid is sent for culture, cytology, microscopy, specific gravity, biochemical analysis like proteins for diagnosis of tuberculosis, malignancy. In empyema thoracis, for diagnostic purpose before placing an ICT, intrapleural administration of drugs pleural tap is being done.

Position

In sitting position, leaning forward over a wooden support.

Site

Tip of scapula at 7th intercostal space (posteriorly—scapular line), in midaxillary line.

Procedure is done in sitting and leaning forward over a support. Tapping is done from behind. After giving local anaesthesia (xylocaine 2% into skin, subcutaneous tissue, up to parietal pleura) wide bore needle (Abraham needle) is used to tap the fluid. Needle is passed

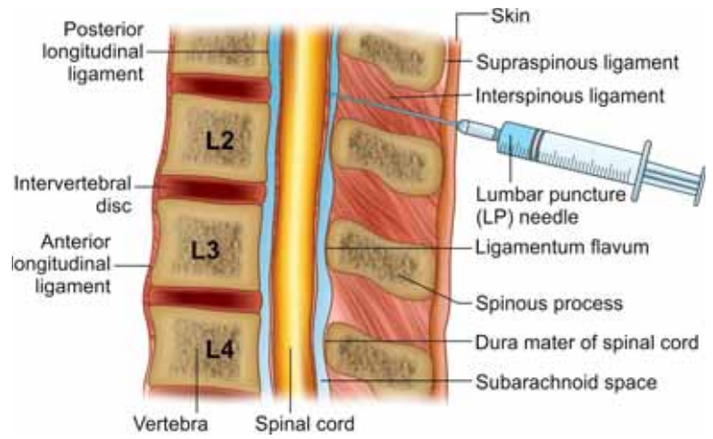


Fig. 7-46: Diagram showing lumbar puncture needle passing through different layers.

Fig. 7-47: Photo showing position and aspirating the CSF through lumbar puncture.

at right angles to the skin; in the intercostal space between two ribs; typical '*giving way*' feel of puncturing the parietal pleura is felt. Needle with stopcock (3-way) is used. 50 ml syringe is connected to the stopcock. Fluid is aspirated to syringe from pleura with stopcock in straight position. Then knob is turned right angle to empty the syringe to reservoir. Procedure is repeated to clear the fluid **(Fig. 7-48)**.

For diagnostic tap, 50 ml of fluid is aspirated to send for biochemical/cytological analysis and culture.

For therapeutic aspiration—750-1000 ml per day is aspirated. If more quantity is aspirated rapidly, pulmonary oedema may develop leading to often ARDS which may be life threatening.

Post tapping, patient should be monitored for change in breathing, tachycardia **(Fig. 7-49)**.

Fig. 7-48: Pleural tap. Note the position of the patient and placement of the needle.

Complications

Complications are Infection, dry tap or bloody tap, bleeding, development of pneumothorax occasionally, sudden vagal shock, pain and respiratory distress.

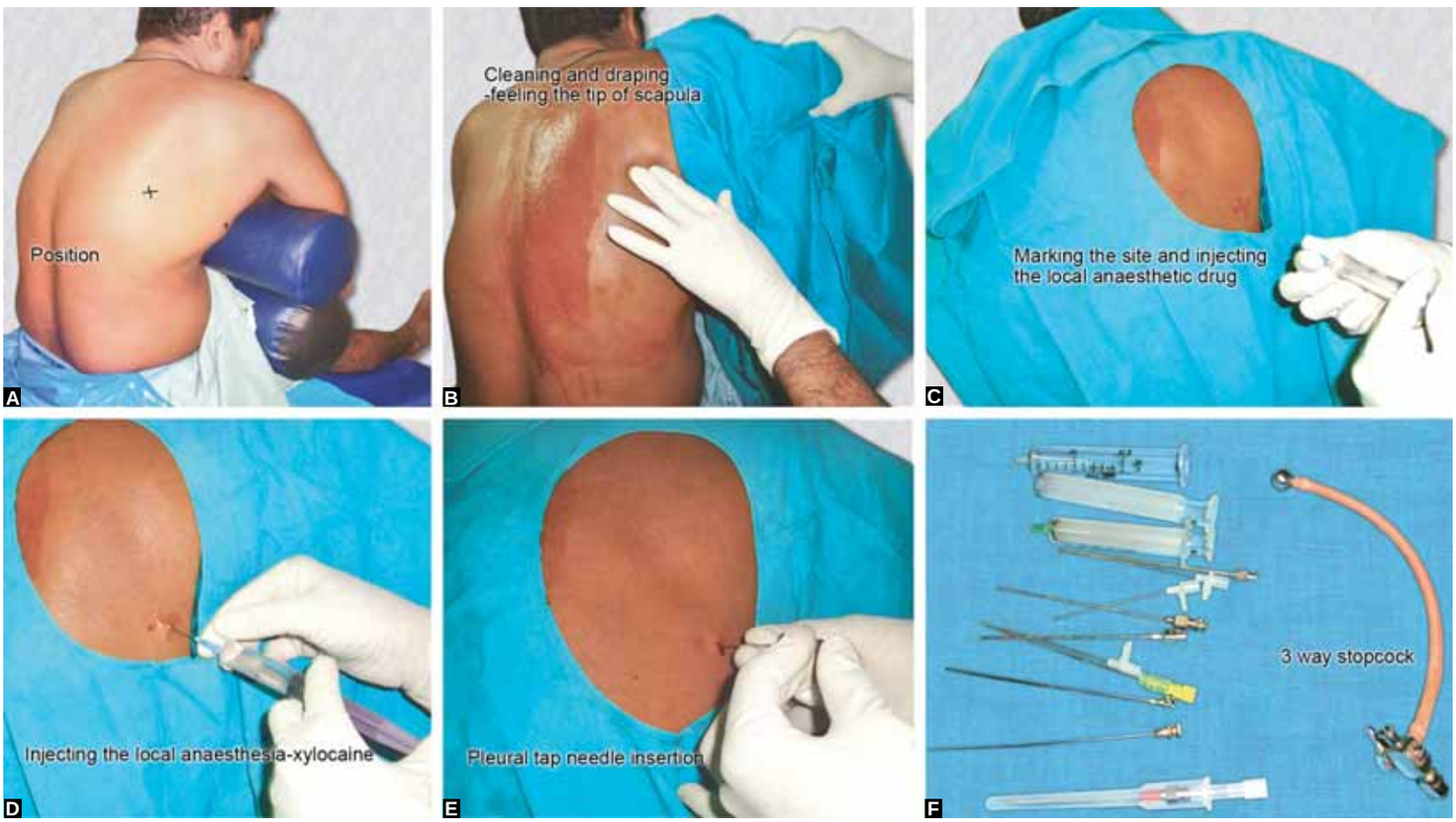
PERICARDIAL TAP (PERICARDIOCENTESIS)

Indications

Pericardial effusion due to any cause—viral, tubercular, rheumatic (rapidly progressive or not regressing in 4 weeks); haemopericardium; purulent pericardium **(Fig. 7-50)**.

Procedure

Atropine injection 0.6 mg with injection pethidine 100 mg intramuscularly half an hour prior to tapping is given. In supine position after giving xylocaine local anesthesia 1-2% needle is passed. A 16 or 18-gauge needle is passed into the pericardium just below the xiphoid process directing upwards and backwards towards left side—in the direction of midclavicular line with an angle of 45° to the surface. Under ECG and US guidance needle position is confirmed. Negative deflection in the ECG means needle is touching the heart and so needle should be withdrawn a little. ECG should show normal tracing. Post procedure monitoring is a must.



Figs 7-49A to F: Steps in pleural tapping with instruments used—needle, syringes, 3 way stopcock.

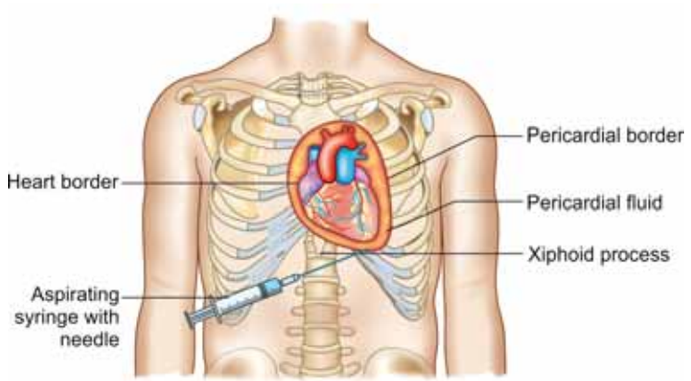


Fig. 7-50: Pericardial tap—diagrammatic look.

This site is used because it is - most dependent for aspiration; unlikely to traumatize heart; pleura is not punctured; coronary vessels are not injured. Occasionally other sites are used—anteriorly in the left 5th intercostal space just outside the apex beat but within the cardiac dullness; posteriorly near inferior angle of scapula; in the left 4th intercostal space lateral to the sternum.

Presently U/S guided aspiration is commonly done. Procedure should be done under ECG monitor.

Complications

Injury to heart causing bleeding/ventricular fibrillation; infection; injury to coronary vessels. Life threatening haemopericardium may develop which may need immediate thoracotomy, pericardiotomy by cardio-thoracic surgeons. Air embolism, pulmonary oedema, vagal shock, circulatory collapse, injury to intercostal vessels, pneumothorax are other complications.

PERITONEAL TAP (ASCITIC TAP)

Indications

For diagnosis—abdominal tuberculosis, peritoneal secondaries, ascitic fluid study.

For therapy—in massive ascites to relieve distress and cardiopulmonary discomfort by removing fluid—in malignancy, portal hypertension. It is done in refractory ascites with failure of medical line of therapy.

Site

In the spinoumbilical line lateral to rectus abdominis muscle **(Fig. 7-51)**.

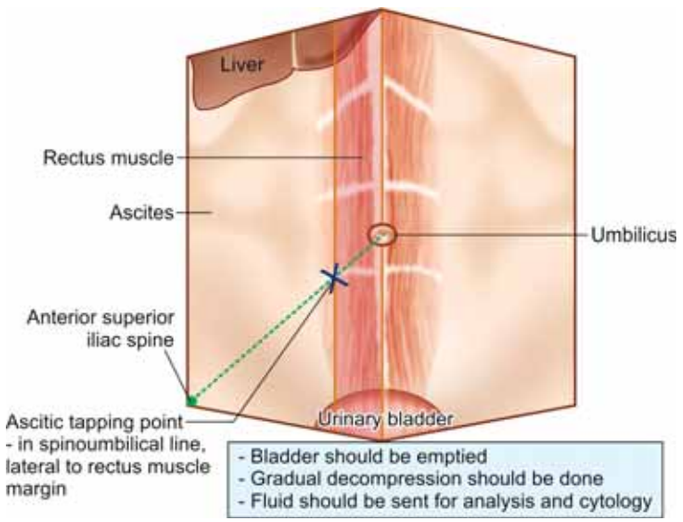

Liver
Rectus muscle
Ascites
Umbilicus
Anterior superior iliac spine
Urinary bladder
Ascitic tapping point - in spinoumbilical line, lateral to rectus muscle margin
- Bladder should be emptied
- Gradual decompression should be done
- Fluid should be sent for analysis and cytology

Fig. 7-51: Ascitic tap.

Procedure

Patient is asked to *empty the urinary bladder* or should be catheterized. Abdomen is percussed to confirm the dullness in the flank. Site of tapping is marked. Xylocaine 1% injection local anaesthetic is infiltrated. 20 gauge long needle is inserted into the peritoneal cavity. Ascitic fluid comes into the syringe. Syringe is connected to the 3 way stopcock to have controlled tapping.

For diagnostic purpose 50 ml of fluid is aspirated. Fluid is sent for culture/cytology/AFB/biochemical analysis.

To relieve distress 1500 ml/day is aspirated. If more quantity is aspirated sudden hypotension and cardiac arrest can occur. It is always safer to do procedure with an intravenous line with fluids flowing.

Complications and Difficulties

Infection and peritonitis can occur. Bleeding from the puncture site into the peritoneal cavity causing haemoperitoneum. Puncture into the bowel causing bowel injury. Protein depletion occurs after tapping of large quantity of fluid. Tapping may precipitate hepatic failure and coma in jaundice and severe liver cell dysfunction patients.

Negative tapping—In *loculated ascites* due to (commonly) abdominal tuberculosis, fluid may not get aspirated and so ultrasound guidance is needed to aspirate fluid. In females tense ascites should be differentiated from *large ovarian cyst* before tapping.

INTERCOSTAL TUBE DRAINAGE (ICT DRAINAGE)

It is the method of draining collections in the pleural cavity safely so as to make the lung to expand.

Indications

Haemothorax (trauma/malignancy), pneumothorax, haemopneumothorax, empyema thoracis, traumatic lung contusion, after thoracotomy to drain pleural cavity.

Procedure

Patient is in 30°-45° partial lying positions with backrest support. Under local anaesthesia (5 ml of 1% xylocaine injection), an ICT is placed in 6th intercostal space in case of haemothorax and pyothorax and in pneumothorax ICT is placed in 2nd or 3rd space.

A small (3 cm) transverse incision is made in midaxillary line (as the muscle bulk is less here and so passage of ICT is easier), parallel to intercostal space (above the rib, i.e. lower part of intercostal space to avoid injury to neurovascular bundle which are located in the groove in the lower part of rib). By blunt dissection using a haemostat, deeper layer is dissected; pleura is punctured. Air/blood/pus may gush out. Finger is inserted into the pleural space to confirm that pleural cavity has reached. 20 French size tube for air; 32 French size tube for blood is used. Tube with side openings is pushed into the pleural cavity. Other end is connected *to under water seal (200 ml of sterile water). Air –water column moving* with respiration can be observed. Tube is fixed with skin sutures. *Heimlich valve* is a plastic container with collapsible rubber tube that acts as a one way rubber tube also can be used. Ultrasound or CT guided placement of chest tube is done in loculated posterior or inferior pleural collection. Patient should be in sitting position in this posterior tube placement. *Three bottle chest drain system* is also often used **(Figs 7-52 and 7-53)**. First one is fluid collection chamber; second one is under water seal to prevent air entering into the pleura; third one acts as manometer for adjusting the suction transmission to the patient. Moulding disposable plastic units are available.

Usually for pneumothorax ICT is kept for 2-3 days (until lung expands—confirmed by check chest X-ray and air leak is not observed). For haemothorax and pyothorax it is kept for 4-6 days or until it stops draining (less than 100 ml/24 hours) and lung expansion is confirmed by repeat chest X-ray. To have a proper expansion of lungs patient is asked to blow football bladder/spirometer (balloon) breathing exercise). If there is broncho-pleural fistula, ICT should be placed for longer time until fistula heals **(Fig. 7-54)**.

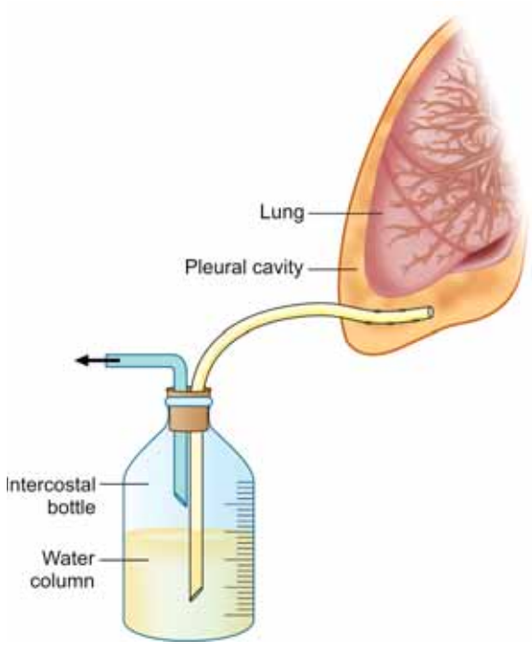


Fig. 7-52: Intercostal tube drainage with under water seal.

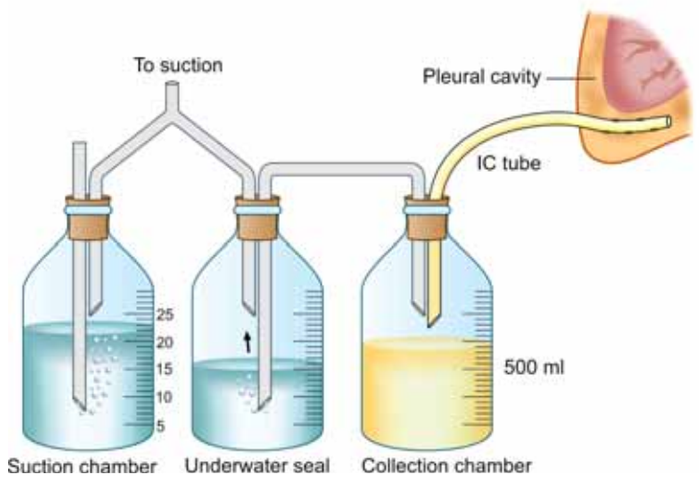


Fig. 7-53: Intercostal tube drainage using three bottle thoracic drainage.

Fig. 7-54: Intercostal tube drainage in a patient with haemothorax.

Complications and Problems

Different complications are—Infection, displacement and inadequate functioning, injury to intercostal vessels and bleeding, injury to intercostal nerves, lung and mediastinum and pain at the site of ICT placement.

BRONCHOSCOPY

Indications

Diagnostic: To take biopsy in carcinoma lung, lung abscess, pulmonary tuberculosis.

Therapeutic: To remove foreign body, to suck out the bronchial secretions, tracheobronchial stenting in fistulas like tracheooesophageal fistula, malignancy, etc. **(Fig. 7-55)**.

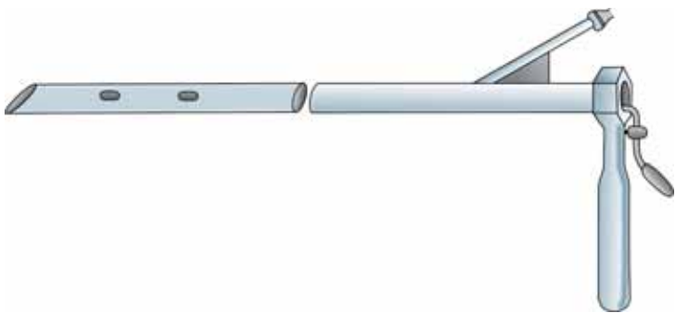


Fig. 7-55: Bronchoscope.

Types

Rigid bronchoscopy (Negus type)—It is used for removal of foreign body, bronchial wash, etc. It reaches up to the third generation bronchioles. It is useful to take biopsy from carcinoma of proximal divisions but not from carcinoma of peripheral lung. Rigid scope has got multiple holes to allow ventilation during procedure (oesophagoscope does not have side holes). It is done under general anaesthesia. *Negus* type has got proximal illumination. *Chevalier Jackson* type has got distal illumination. 2.4/3.5/4.5 are paediatric sizes available. 6.5/7.5/8.5 are adult sizes available.

Flexible bronchoscopy—It reaches up to 5th generation bronchioles. It can be done under local anaesthesia. It is mainly used for diagnosis, biopsy and suctioning, removal of clot from the trachea, endotracheal tube clearing, clearing of tracheobronchial tree through tracheostomy. It is also used to facilitate difficult endotracheal intubation.

Complications

Bleeding, infection, perforation of trachea and bronchospasm.

VASECTOMY

Indications

Vasectomy is done commonly for family planning purpose. Consent of both partners is needed. One should look for any hernia/hydrocele—if present vasectomy should be done along with specific surgeries for these conditions. Previously while doing prostatectomy vasectomy was the procedure used to prevent retrograde infection of testes. Occasionally, in specific diseases like tuberculosis of vas, vasectomy may be done for biopsy purpose.

There are no specific contraindications for vasectomy but if patient is having hernia or hydrocele, it is better to do vasectomy along with surgery for hernia or hydrocele.

Types

Classical method—Scalpel technique.
No scalpel technique (Shunqiang Li-China).

Classical method: After cleaning and draping the scrotum, 2-5 ml of xylocaine plain 1% is injected into root of the scrotum lateral aspect. Skin, dartos are incised (1-2 cm vertical incision). Once spermatic fascia is incised cord structures are identified. Vas deferens is seen and felt as thickened whitish cord like structure. It is dissected using mosquito artery forceps. It is held using Babcock's forceps as loop outside the wound. Vas is clamped in two different places with a gap in between using two artery forceps. A piece of the vas (5 -10 mm) is excised. Cut ends are ligated using non-absorbable sutures like silk. Skin is closed with sutures. Procedure is repeated on the other side. Dressing is placed. Sutures removed after 7 days **(Fig. 7-56)**.

No scalpel technique: Two special instruments are used here. An extracutaneous ring clamp and Chongquing's sharpened curved mosquito clamp. After cleaning and draping, xylocaine 2% of 2-3 ml is injected under the skin of midline raphe proximal aspect. Vas deferens of one side is felt and pushed under the raphe. It is carefully held with extracutaneous ring clamp. Skin is incised using sharp tip of the curved mosquito clamp. Whitish cord-like vas which is held with ring clamp is dissected → clamped → a small piece of 5 mm is cut. Cut ends are ligated using silk. Opposite vas is also similarly brought into the same wound by manipulation and clamped and ligated after cutting. Skin is not closed. It gets apposed automatically and heals on its own. Postoperatively antibiotics and analgesics are given **(Fig. 7-57)**.

Excised small pieces of both sides should be sent for histology for confirmation.

Advice: Contraception should be used to have protected intercourse for a minimum of 6 weeks/15 ejaculations.

Complications

Infection, pyocele, bleeding, haematoma, haematocele, sperm granuloma, recanalisation and failure

VASO-VASOSTOMY (RECANALISATION PROCEDURE)

Indications

Patient who has undergone vasectomy earlier if needs fertility (one more child) again.

Technique

Under general/spinal anaesthesia incision over the front of the scrotum is made. Cord is dissected. Cut ends of the vas are identified. Both ends are carefully mobilised. Cut ends are trimmed to see the clear lumen. Fine 3 zero polypropylene suture material is passed through the lumen to act as a stent. Cut ends are sutured using 4 zero polypropylene continuous sutures. Stent is brought out through vas and through scrotal skin away from main wound. Skin is closed with sutures. Procedure is commonly done on both sides. Stent is kept for 3 weeks and removed. Success rate of vaso-vasostomy is 30%.

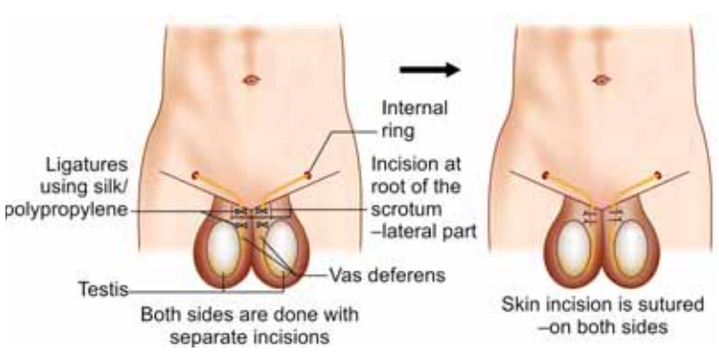

Internal ring
Ligatures using silk/ polypropylene
Incision at root of the scrotum –lateral part
Testis
Vas deferens
Both sides are done with separate incisions
Skin incision is sutured –on both sides

Fig. 7-56: Classical method of vasectomy.

Complications

Infection, haematoma and failure

STAPLERS IN SURGERY

Staplers are used for apposition of tissues. It is used in skin, bowel, lungs, etc. It is useful in depth and quick surgery. It is equal to suturing as far as final outcome is considered (neither better nor worse).

Types

Cutaneous staplers give clean apposition. It is faster and technically easier. Problem is removal as it requires specific instrument and costlier than sutures **(Fig. 7-58)**.

Linear staplers are used to close the bowel either completely or partially.

Circular staplers also called as E.E.A. Stapler—**E**nd to **E**nd **A**nastomosis. It is commonly used for colorectal anastomosis in anterior resection for carcinoma rectum, oesophagogastric anastomosis after oesophagogastric resection in case of carcinoma at O-G Junction.

Parts are *stapler gun,* and *cartridge* with two rows of stapler pins for apposition. Loaded cartridge is detachable. Cut ends of bowel are placed over *gun and cartridge*. Once gun is shot, cartridge moves to the gun and creates anastomosis **(Fig. 7-59)**.

GIA stapler (Gastrointestinal anastomosis stapler) for *side to side* anastomosis like small bowel or ileocolic anastomosis.

Stapler for lung apposition.

Endostaplers: Staplers used during laparoscopic surgeries. It is commonly used for bowel anastomosis. ***Endovascular staplers*** are used to ligate vascular pedicles like renal pedicles during laparoscopic nephrectomy.

Disposable staplers are available but are costly.

Advantages

It is technically easier and faster. Main advantage is speed. Stapler gastrointestinal anastomosis takes 2-5 minutes which saves lot of time especially in critically ill patients. It is useful in the depth.

Disadvantages

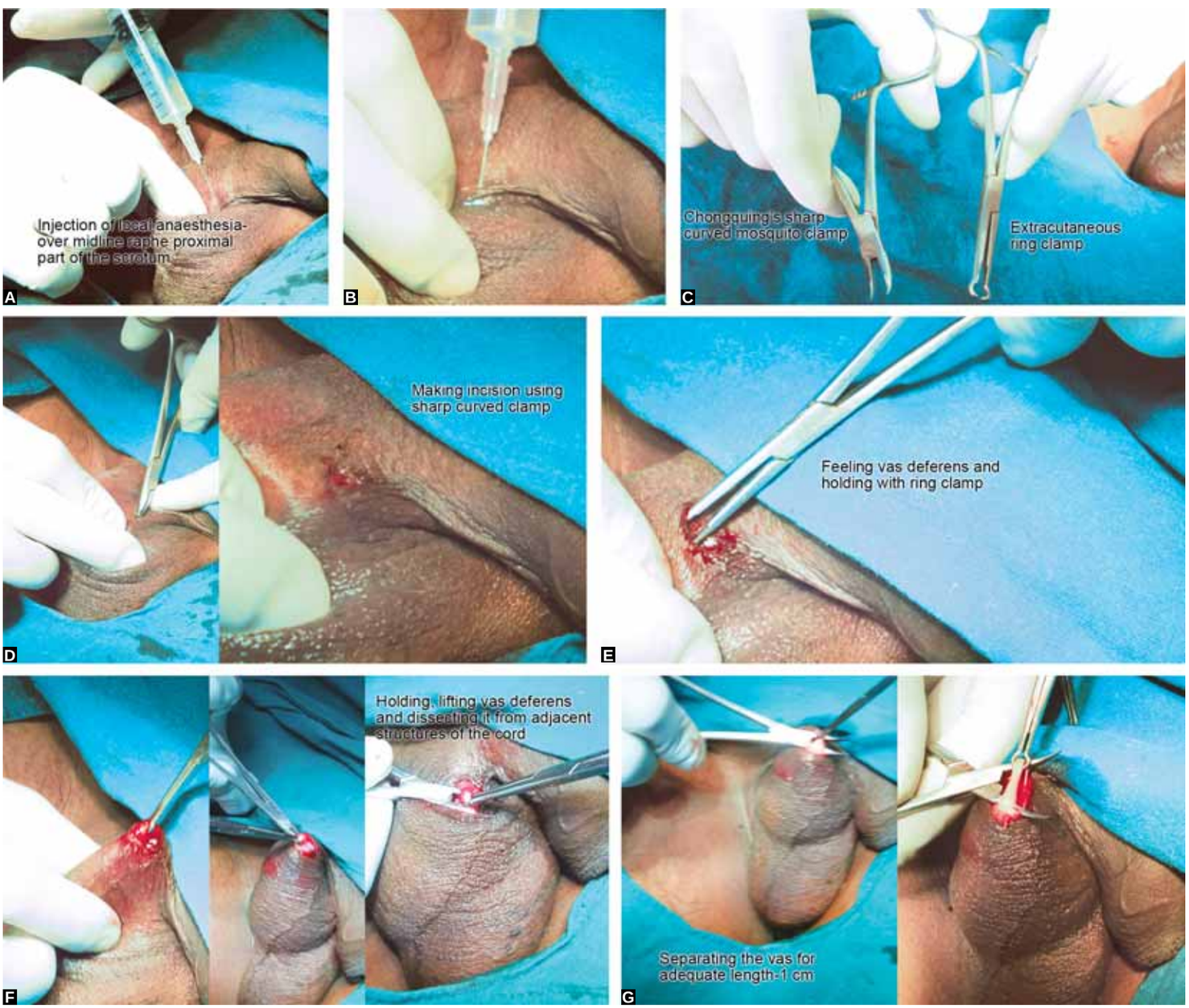
Cost factor, availability are the problems. It is not completely haemostatic and so bleeding can occur. Leak from anastomosis, improper apposition, intestinal obstruction are other problems. It is uncomfortable to use stapler in biliary anastomosis, pancreatic anastomosis. Staplers are not safer in too thick or too diseased bowel like in Crohn's disease. Suture anastomosis is more appropriate and accurate in such situations.

Principle

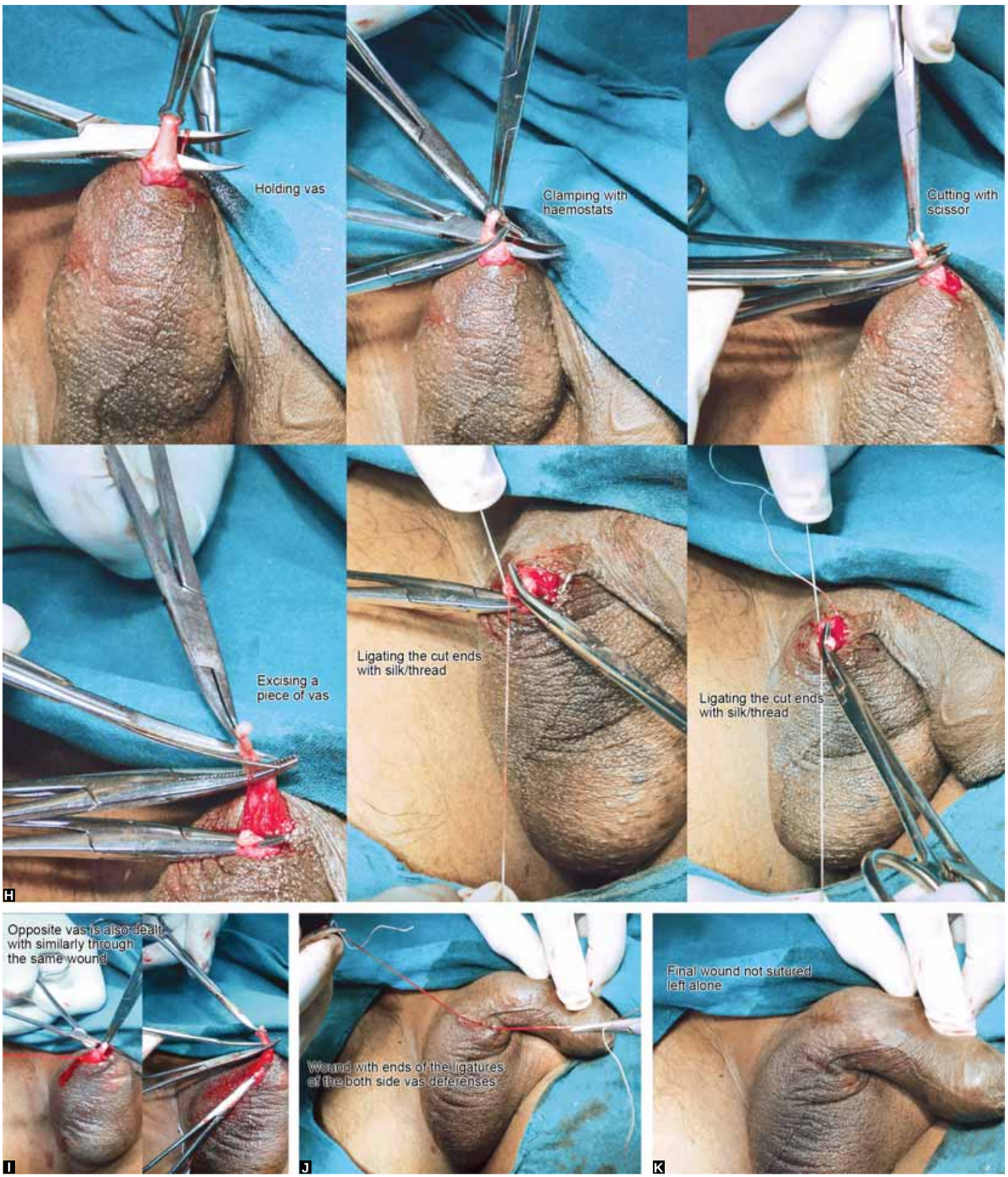
Staples enter the tissue straight and then made to bend to 'B'. Blood flow to tissues is maintained through the gap. Standard linear stapler is available in two standard staple sizes—3.5 mm and 4.8 mm size. Each is 4.0 mm in width and 3.5 mm and 4.8 mm leg length respectively. 4.0 mm × 3.5 mm closes to a size of 1.5 mm (used for small and large bowel); 4.0 mm × 4.8 mm closes to 2 mm size (used for stomach). These cartridges are coloured differently for identification purpose. Endoscopic linear stapler compresses tissues up to 1.75 mm thickness. Stapling can be done in inversion or in eversion. Circular and linear cutting stapler creates inverted staple line. Stapling in eversion is used in anastomosis **(Fig. 7-60)**.

Linear Devices

Linear stapling devices are of 55 mm or 90 mm or rarely 30 mm (smaller only for short sutures). Each applies two staggered row of staples of 55 mm/90 mm/30 mm length respectively. Staples could be 3.5 mm or 4.8 mm depending on need and thickness of the tissue. Aligning pin on the tip confirms the proper meeting of the anvil accurately on either sides of the tissue which device is holding. The device that just staples without cutting is called as a linear stapling device without cutting. It is used in closure of duodenal stump, during partial gastrectomy and gastrojejunostomy in creation of new lesser curve, closure of bowel in end to side or side to side anastomosis, during ileostomy, creation of gastric pouch in morbid


Injection of local anaesthesia over midline raphe proximal part of the scrotum
A
B
Chongquing's sharp curved mosquito clamp
Extracutaneous ring clamp
C
Making incision using sharp curved clamp
D
Feeling vas deferens and holding with ring clamp
E
Holding, lifting vas deferens and dissecting it from adjacent structures of the cord
F
Separating the vas for adequate length-1 cm
G

Figs 7-57A to G


Holding vas
Clamping with haemostats
Cutting with scissor
Excising a piece of vas
Ligating the cut ends with silk/thread
Ligating the cut ends with silk/thread
H
Opposite vas is also dealt with similarly through the same wound
Wound with ends of the ligatures of the both side vas deferenses
Final wound not sutured left alone
I
J
K

Figs 7-57H to K

Figs 7-57A to K: Technique of no scalpel vasectomy—it is done with single incision as sutureless procedure.

Fig. 7-58: Skin stapler, technique and stapler extraction instrument. Note the shape of the removed staples.

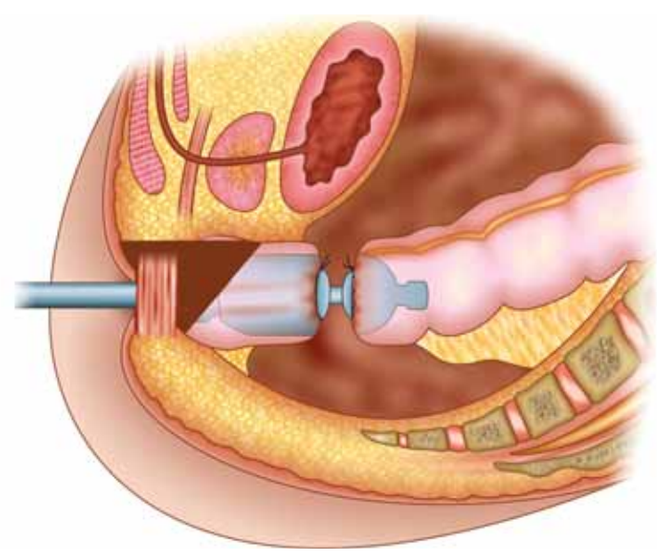


Fig. 7-59: Circular stapler is used for colorectal anastomosis.

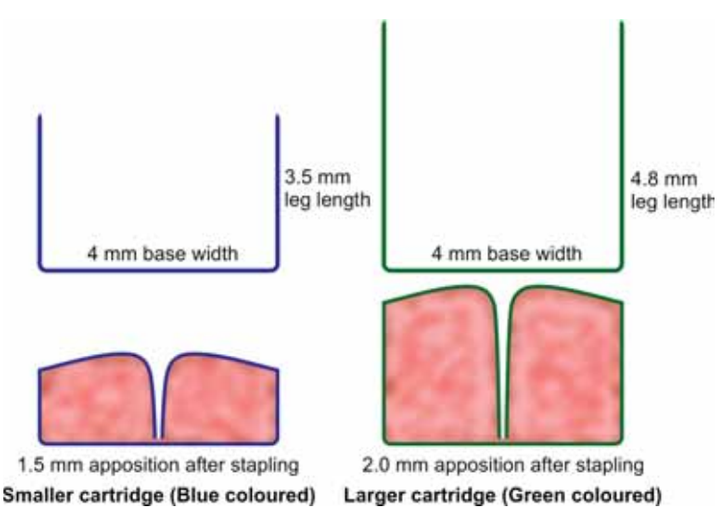


Fig. 7-60: Usually two sized stapler pins are available. 4 mm × 3.5 mm is smaller sized, blue coloured. 4 mm × 4.8 mm is larger sized, green coloured.

obesity. Laparoscopic linear stapling device is used stapled ligation and division of the vessels.

Linear cutting stapler device is used for cutting and anastomosis simultaneously. Knife within it divides the tissue; cartridge places two rows of staples on either side of the cut tissue. This linear cutting device is used for side to side anastomosis. It is very useful for gastrojejunostomy, colonic anastomosis, pouch creation, etc. Incisions made to pass the blades into bowel parts need to be closed **(Figs 7-61 and 7-62)**.

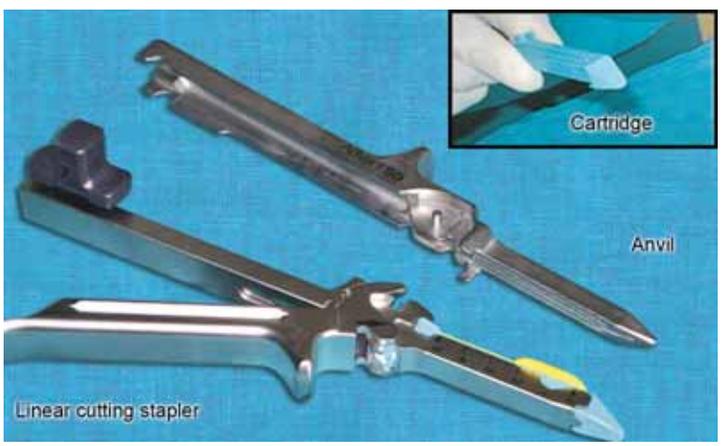


Fig. 7-61: Linear cutting stapler device.

Circular Stapling Device

It is used for end to end anastomosis. It creates a two layered stapled anastomosis with inversion, with a circular knife inside the device cutting the tissue between, completing the anastomosis. It is very useful for low colorectal anastomosis after low anterior resection for carcinoma of rectum, sigmoid resection, oesophagogastric/oesophagojejunal anastomosis, gastroduodenal anastomosis (Billroth I). Device is available at varying sized ranges from 12 to 24 mm. Usually 20 mm is used. Thickness of apposition achieved is usually 2.0 mm. Thickness here in some devices can be adjusted. It has got two parts—head/anvil and cartridge which fires and cuts. Head is inserted into the cut end of the colon in colorectal anastomosis from above **(Fig. 7-63)**. Bowel is firmly fixed into the proximal part of head using purse string suture or using a device called furnace through which polypropylene suture is passed. Large main instrument is passed through the anal canal above towards the abdominal cavity. Distal rectal stump is fixed to this using spike in the instrument or by another purse string suture. Care should be taken not to leave excess tissue protruding to prevent incomplete stapling. Two spikes on either side are locked; two parts are apposed; device fired for completing the anastomosis. Device with head is removed through the anus. Doughnut should be carefully removed from the device for inspection for completed circular intact piece which suggests proper anastomosis.

Stapler haemorrhoidopexy (PPH) instrument is a circular stapling device.

Prerequisites for Stapling

- Adequate blood supply in the tissue is the essential part of stapling.
- Thickness of the tissue stapled is also important factor. Thicker the tissue, more chance of tissue strangulation.
- Selection of the size of the cartridge and size of the staple should be proper for ideal stapling result.

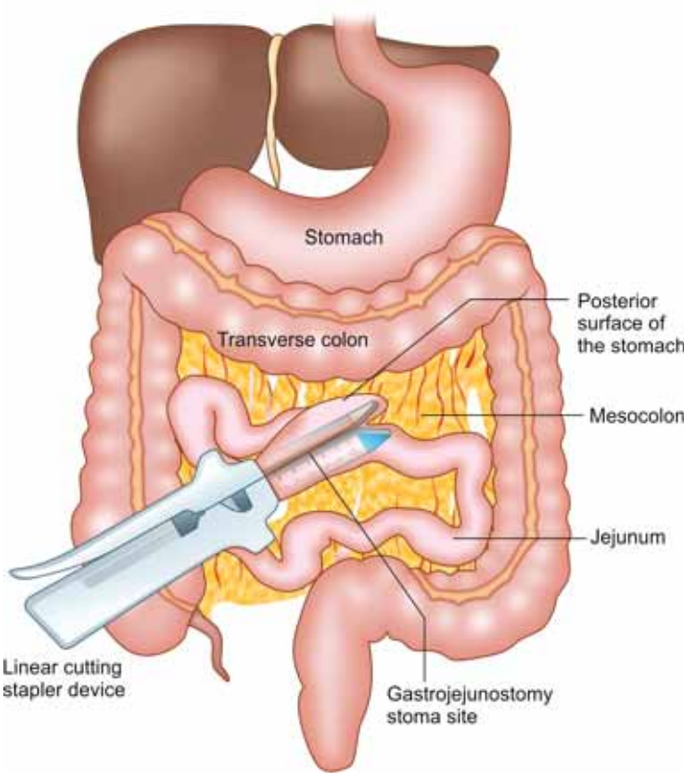


Fig. 7-62: Posterior gastrojejunostomy is being done using linear cutting stapler device.

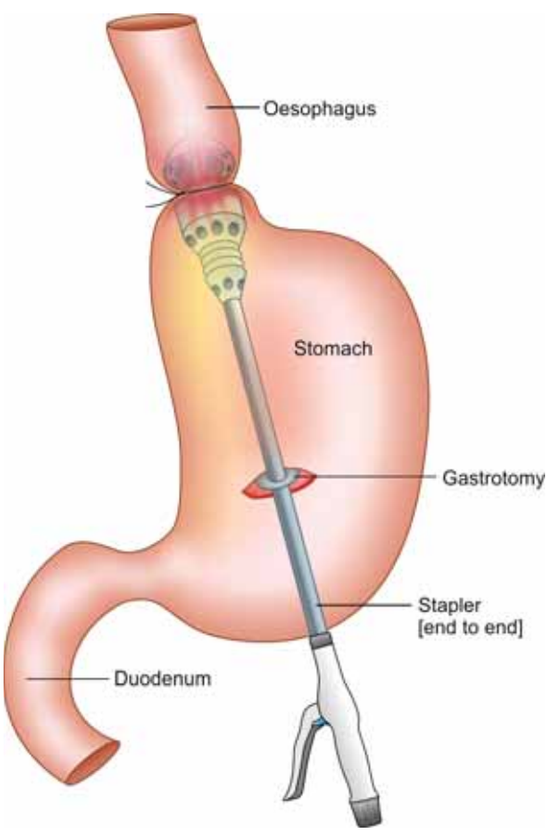


Fig. 7-63: Oesophagogastric anastomosis with resection using end to end circular stapler device.

- Avoidance of linear tension, if needed additional supportive few seromuscular sutures over stapled line makes often a big difference.
- Technical problems in the instruments which may occur rarely may cause failure in spite of proper stapling. Improper firing of the staples may cause anastomotic leak.
- Often knife in cutting device may cut the tissue partially leading into narrow lumen and obstruction at the anastomotic site.
- Avoid incorporating mesentery or mesenteric fat in the anastomosis.
- After stapling, if there is bleeding point on the staple line one should place additional sutures using 3 zero polyglycolic suture or PDS.
- One should avoid bunching of the tissues between cartridge blades in linear device or between head and main instrument in case of circular device. If it occurs it causes improper stapling and leak.
- Stapled stoma has difficulty in dilating naturally while food/stool passes through it and so adequacy of stoma size is important. In sutured anastomosis, stoma can dilate, accommodate and allow passage of content significantly better.
- Doughnut in circular stapling should be inspected. Entire circumference of the stapled line should be inspected. Lumen patency should be checked by invaginating the bowel into the stoma using index finger.

GRAFT

It is transfer of tissue from one area to other without its blood supply or nerve supply. *Autograft* is tissue transferred from one location to another on the same patient. *Isograft* is tissue transfer between two genetically identical individuals, i.e. between two identical twins. *Allograft* is tissue transfer between two genetically different members, e.g. Kidney transplantation. *Xenograft* is tissue transfer from a donor of one species to a recipient of another species. Composite graft is graft with skin, fat and other tissues like cartilage.

Skin Grafting

It is transfer of skin from one area (donor area) to the required defective area (recipient area). It is an autograft.

Types

1. Partial thickness graft (Split thickness graft, SSG)

It is also called as **Thiersch graf**t, which is removal of full epidermis + part of the dermis from the donor area. It may be *thin* SSG, *intermediate* SSG or *thick* SSG - all depends on the amount of thickness of dermis taken. Thick SSG withstands late trauma to recipient area better than thin SSG. *Indications:* (1) Well granulated ulcer. (2) Clean wound or defect which cannot be apposed. (3) After surgery to cover and close the defect created, e.g. After wide excision in malignancy, after mastectomy, after wide excision of squamous cell carcinoma, etc. Graft can survive over periosteum or paratenon or perichondrium. *Pre requisites:* (1) Healthy granulation area. (2) Streptococci load less than 10^5 per gram of tissue, otherwise graft failure will occur. *Contraindications:* SSG cannot be done over bone, tendon, cartilage, joint, etc. *Donor areas used are*—commonly *thigh,* occasionally arm, leg and forearm. Knife used is *Humby's Knife*. Blade is *Eschmann blade*, Down's blade **(Figs 7-64 to 7-68)**.

Different instruments used to harvest the skin graft

- Humby knife.
- Watson modification of Humby knife.
- Power dermatome is also used (Brown).
- Sterilised razor blade can be used with a specialised device to harvest small grafts under local anaesthesia—Silver knife.

Fig. 7-64: Commonest donor area for spilt skin grafting is thigh.

Fig. 7-65: Donor area of split skin graft immediately after harvesting graft showing punctate bleeding.

Fig. 7-66: Donor area dressing is not removed for 10 days. If soakage is observed an over dressing is done on earlier dressing without removing it.

Fig. 7-67: Split skin graft donor area—10 days after removal of the dressing. Dressing from donor area is removed only after 10 days and left open after that.

Fig. 7-68: Instruments needed for split (Thiersch) skin grafting. Humby's knife, Eschmann blade; skin spreader; wooden boards; scoop; kidney tray; saline to keep harvested split skin; forceps; scissors.

Donor Area

Donor area and recipient area is cleaned and draped properly. If recipient area is a raw area after wide excision of malignant lesion in the lower limb, then donor area should be on opposite side as there are chances of deposition of malignant cells over donor area through opened up cutaneous lymphatics. Selected blade is placed on the slot of the knife. Blade and gap in the sliding rod is adjusted by markings on the knob on the handle. Markings are made to select thin/intermediate/thick split thickness graft. Knobs are tightened properly. Assistant holds the thigh on its posterior aspect using both his hands firmly making anterior aspect or donor area convex and firm. Usually graft knives are made for right hand. Blade and guard rod of the knife is soaked with Vaseline. Using wooden board soaked with Vaseline to facilitate smooth movements of the boards, stretched donor skin is held apart with a gap in between. In the gap graft knife is placed. Initially blade is deepened to pierce the epidermis and part of the dermis and with continuous firm constant pressure knife is moved to and fro repeatedly with sliding progressively forward to get a required split skin graft. Once graft is taken, *punctate bleeding* is observed which says that proper graft has obtained. High density small bleeding points are features of thin graft; low density larger bleeding points are the features of thick graft. In the thigh, lateral and distal area gives thicker graft than medial and proximal. Clinically on table thickness is assessed based on translucency of the graft. Thinner the graft more it is translucent. Donor area is dressed (using Sofra-Tulle/bactigras, absorbent gauze, roller cotton, crepe bandage/bandage), and *after 10 days* dressing is opened, not earlier than that. Commonly the donor area and dressing becomes hard, dry and adherent to donor area. Ideal donor dressing should be moist, absorbent to promote epithelial migration but such aseptic dressings are not available. Alginate dressings are better when available. (Moist area in temperate climate due to humidity may cause *Pseudomonas aeruginosa* infection). Dressing gets separated in 10-12 days spontaneously. Over dressing can be done if whenever needed but entire dressing should not be removed.

Resurfacing of the donor area occurs on its own. Remnants of the pilosebaceous apparatus are *active component* in epithelial regeneration than sweat gland remnants. Thin graft donor area contains more pilosebaceous glands making it to heal rapidly and early in 7-9 days; whereas thick split skin graft donor area contains mainly sweat gland components with less pilosebaceous glands making it to heal slowly in 14 days. Donor area infection may destroy the pilosebaceous or sweat gland remnants causing inability to resurface leaving a granulation tissue in the floor. Once donor area dressing is removed healing raw area is left open with application of emollients/oil for 4 weeks. *Problems in donor area* - Postoperative pain is more in donor area than recipient bed. Pain subsides in 5-7 days. Deep raw area when not epithelialised leave an ulcer which may require regular dressing later. Pigmentation, colour changes and hypertrophic scar formation are the usual problems **(Fig. 7-69)**.

Recipient Area

Recipient area is scraped well and graft is placed after making *window cuts* (fenestrations with multiple cuts; it is not mandatory to place such cuts; it is optional) in the graft to prevent seroma development. Graft is fixed and *tie-over* dressing is placed. If graft is near the joint, then part is immobilised to prevent friction which may separate the graft. On 5th *day* dressing is opened and observed for graft take up**.** *Healthy granulation tissue* in recipient area with red, flat, vascular look with good marginal healing is essential for proper graft take up. Presence of *Streptococcus pyogenes* is absolute contraindication for skin grafting. It causes gelatinous glaze granulation tissue. Slough excision, systemic antibiotics, local application of chlorhexidine is effective way of eradicating it (only systemic antibiotics may not be adequate). It causes *100% graft failure*. Even raw area looks healthy clinically but culture shows positive for *Streptococcus pyogenes*, then grafting is contraindicated as graft will not take up. *Streptococcus pyogenes* should be completely eliminated prior to grafting. *Pseudomonas aeruginosa* infection reduces the graft take up by *10%* but not like of *Streptococcus pyogenes* infection. One has to remember that positive culture of Pseudomonas in the discharge is not a contraindication for skin grafting. If granulation tissue clinically looks healthy skin grafting can be done. If granulation tissue is pale with greenish discharge then grafting is not done. Once healthy granulation tissue forms area should be grafted earliest otherwise infection, fibrosis of area can occur causing recurrent problems.

Stamp graft is in perineum, axilla, etc. It is small, sized grafts placed in the recipient bed. Such grafts are usually not fixed.

Mesh graft is used in wide areas like burn wounds. It takes up well. But cosmetically it is poor. Fixing of mesh is cumbersome.

Figs 7-69A to H: Technique of split skin grafting. Graft harvesting from donor area—thigh; making window cuts; placing graft over recipient area.

Quilted grafting—It is commonly used in places where immobilisation is impossible like in oral cavity (cheek) and tongue after wide excision. Split skin graft is placed over the defect. Edge is sutured to the margin of the defect. Multiple additional sutures are placed through the graft to the muscle underneath to anchor both together. It looks like a 'quilt'. Fenestrations/window cuts in the graft prevent seroma formation and mobility of tongue or cheek can be undertaken without graft displacement **(Figs 7-70 to 7-73)**.

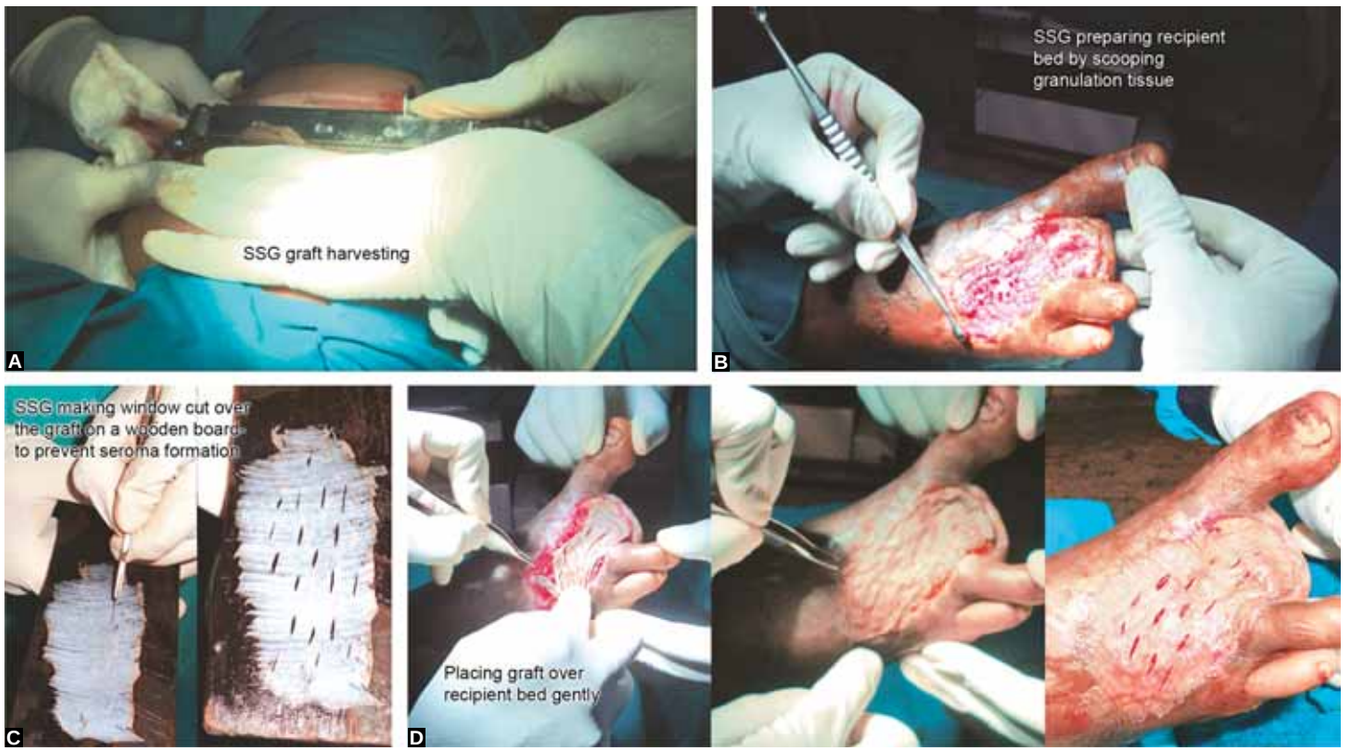
Causes for poor graft take up/contraindications for skin grafting

- Unhealthy granulation tissue.
- Infection—*Streptococcus pyogenes* mainly, *Pseudomonas aeruginosa* less severely.
- Haematoma and seroma formation.
- Graft over the joint surface—not immobilised.
- Poor blood supply.
- Haemoglobin of patient if less than 10 gram%.
- Poor nutrition, hypoalbuminaemia (Albumin level less than 3 gram %).

Graft Application

Applied graft is stabilised into the recipient bed by various methods (or dressings). They are:

Bolus dressing/bolus grafting—If there is ooze and chances of haematoma or seroma formation, commonly observed over granulation tissue, then pressure dressing is used. It is done using 'tie over' dressing and crepe bandaging. Tie over dressing over a graft is called as *bolus grafting*. Crepe bandage over 'tie over' gives immobilisation and additional pressure. In full thickness grafting, graft edge is properly apposed exactly over the recipient area without any overlapping. Few of sutures all round are kept long to place tie over. In split thickness grafting graft is kept *overlapping over the defect* and tied over from the defect edge. Overlapped skin is trimmed during graft inspection in 5th postoperative day. After placing the tie over sutures all round the edge, tulle gras layer is applied. Later bolus material consisting of cotton soaked in saline dilute povidone iodine or cotton soaked in liquid paraffin or polyurethane or flavine wool material (flavine


SSG graft harvesting
A
SSG preparing recipient bed by scooping granulation tissue
B
SSG making window cut over the graft on a wooden board to prevent seroma formation
C
Placing graft over recipient bed gently
D

Figs 7-70A to D: Harvesting skin graft; scooping the granulation tissue from the recipient bed; making window cuts over the graft to prevent seroma formation; placing the harvested skin.

SSG dressing using sofratulle/bactigrass
Tie over dressing
SSG-recipient area dressing with immobilisation and pressure dressing- dressing will be opened in 5 days to check graft take up

Fig. 7-71: Split skin grafting and covering the grafted area with sofratulle, povidone iodine soaked dressing pads, tie over dressing, bandaging, crepe bandage or immobilisation using plaster of Paris slab/cast.

Fig. 7-72: Split skin graft in the leg - taken up well observed in 5 days.

Fig. 7-73: Split skin grafting taken up which is observed after one month.

emulsion, Gamgee, cotton wool are used here. Cotton wool sheet is soaked with warmed flavine emulsion to impregnate over it and Gamgee is placed over it and dried and autoclaved) placed firmly. Long sutures tied over it at different places. Further cotton roll is placed over it. Roller bandaging and crepe bandaging is done over it to diffuse equal effective pressure and also immobilisation. Bolus grafting is used in limbs and face. It is often difficult to place in trunks and groin. *Tie over also can be* achieved in limbs by placing continuous circular ties circumferentially over the dressing pads kept on the graft. It is quicker and easier. It does not require placement of any sutures over the edge **(Fig. 7-74)**.

Exposed grafting: It is often used in trunk and groin. By exposed method shearing movements between recipient bed and graft are prevented. Here natural fibrin formation prevents to and fro movement between bed and graft. Exposed grafting is used mainly in raw area created after excision of a lesion wherein haemostasis is achieved properly by cautery or ligation. Often after initial excision of the lesion, dressing is done for 48 hours and then graft is placed with *delayed exposed grafting*. As haematoma and seroma formation *can not* be prevented in this method it is not usually used in ulcer bed. Patient cooperation is essential in his type of graft management. This method is useful for single safe surface. It is not useful in circumferential or wide raw areas.

Stages of Graft Intake

Stage of Plasmatic imbibition: Thin, uniform, layer of plasma and fibrin forms between recipient bed and graft. *Stage of inosculation*: Linking of host and graft which is temporary. *Stage of neovascularisation*: New capillaries proliferate into graft from the recipient bed which attains circulation later.

***Disadvantages of SSG*:** (1) Contracture of the graft—It is of two types: (A) *Primary contracture* means SSG contracts significantly once graft is taken from donor area (20-30%). Thicker the graft more is the primary contracture. (B) *Secondary contracture* occurs after graft has taken up to recipient bed during healing period, due to fibrosis. Thinner the graft more is the secondary contracture. (2) Seroma and haematoma formation will prevent graft take up. (3) Infection. (4) Loss of hair growth, blunting of sensation. (5) Dry, scaling of skin due to nonfunctioning of sebaceous glands. So after healing oil (coconut oil) should be applied over the area. (6) Graft failure.

Advantages: (1) It is technically easier. (2) Wide area of recipient can be covered. To cover large area like burns wound, graft size is increased by passing the graft through a ***Mesher*** which gives multiple openings to the graft which can be stretched on the wider area like a net. It can cause expansion up to 6 times. (3) Graft take up is better. (4) Donor area heals on its own **(Figs 7-75 and 7-76)**.

Note: Graft can be stored in low temperature 4° C for up to 21 days. It is stored in normal saline. But usually it is not used beyond 10 days.

Full Thickness Graft (Wolfe Graft)

It includes both epidermis + entire dermis. It is used over the face, hands, fingers, over the joints or for small defects like ectropion, eyelid/nasal/cheek defects and deformities, injury and contractures of fingers, syndactyly. It is removed using scalpel blade. Underlying *fat*

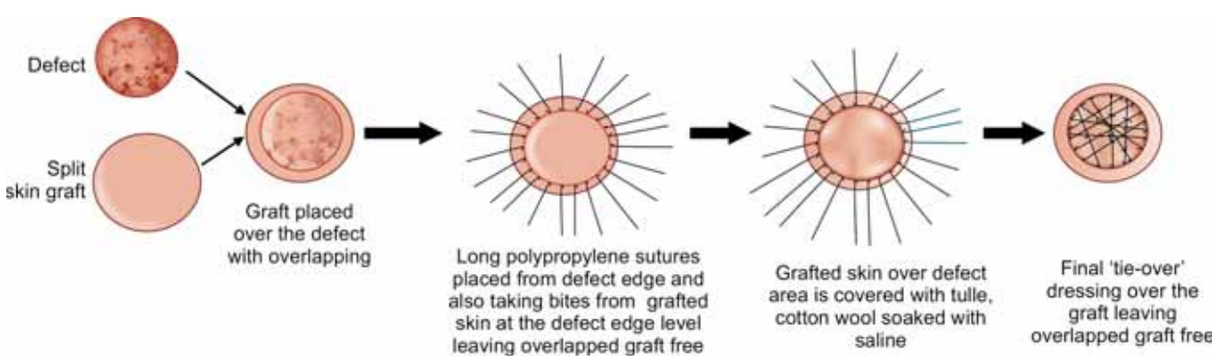
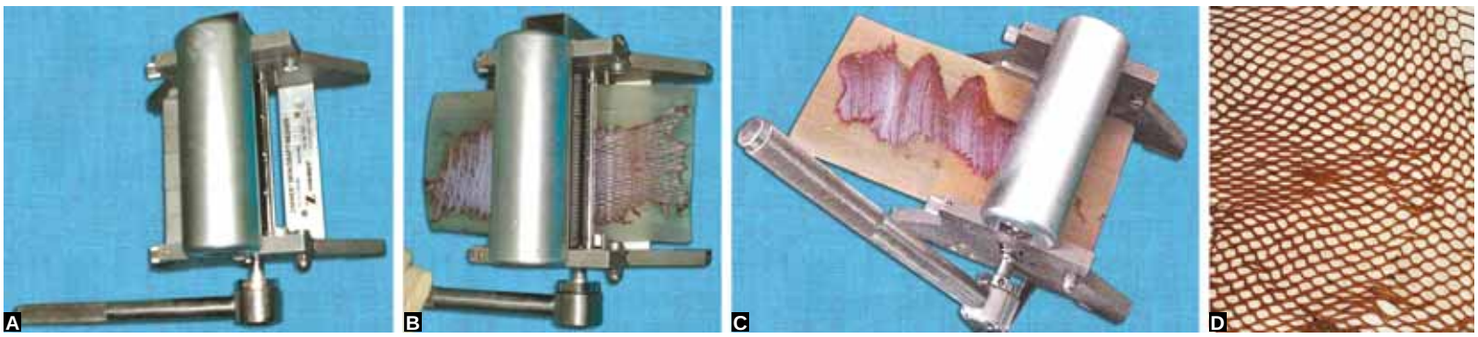

Defect
Split skin graft
Graft placed over the defect with overlapping
Long polypropylene sutures placed from defect edge and also taking bites from grafted skin at the defect edge level leaving overlapped graft free
Grafted skin over defect area is covered with tulle, cotton wool soaked with saline
Final 'tie-over' dressing over the graft leaving overlapped graft free

Fig. 7-74: 'Tie-Over' dressing after split skin grafting.



Figs 7-75A to D: Mesher used in split skin grafting to increase its surface area of coverage for wider areas like burns wound. A large defect can be covered by this. It can cause expansion upto six times. Photo also shows exact look of meshed split skin graft.

Fig. 7-76: Mesh grafts placed over donor areas and their take up look.

should be cleared of properly. No epidermal elements are found in left out donor area. So resurfacing of the donor area cannot take place on its own. Deeper raw area is closed by primary suturing. If larger area is taken then that donor area has to be covered with SSG which is a disadvantage in full thickness graft. Defect and donor required sized site should be marked using Bonney's blue properly. Size matching is important. Area may be infiltrated with normal saline with or without 1 in 200000 noradrenaline to balloon the skin which will facilitate the raising of the graft. While raising the graft using blade, with skin hooks, the edge of the graft should be held. Full thickness graft has

got colour and look of cadaver skin. Graft edge is properly apposed exactly over the recipient area without any overlapping. Few of sutures all round are kept long to place tie over. Tie-over dressing is a must in full thickness graft. Common sites of donor area are—(1) Postauricular area. (2) Supraclavicular area. (3) Other areas like—infraclavicular, lateral groin, upper eyelid part, antecubital fossa, inframammary area in females also often used **(Figs 7-77 to 7-79)**.

Advantages: (1) Colour match is good especially for face. (2) No contracture (unlike in SSG) and so remains in its original size. (3) Sensation, functions of sebaceous glands, hair follicles are retained better compared to SSG. Texture, colour, durability is better.

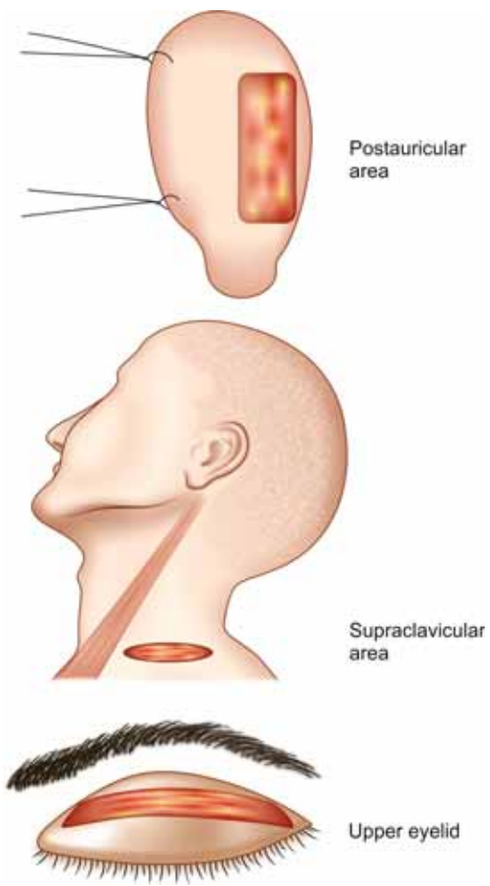


Fig. 7-77: Common donor areas for Wolfe graft.

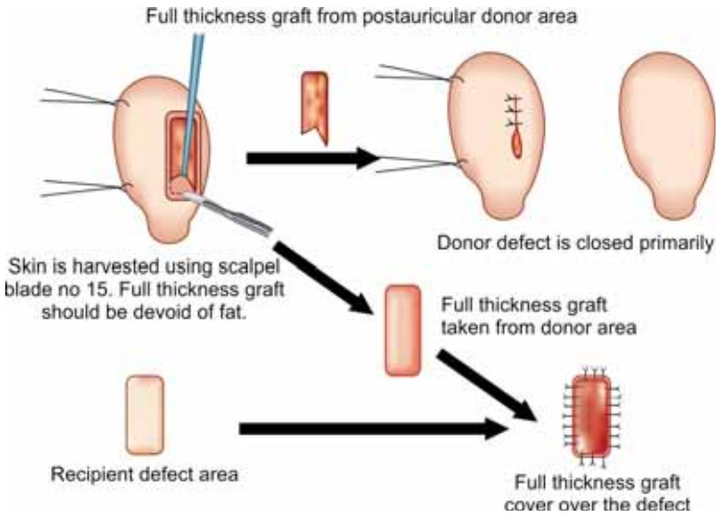

Full thickness graft from postauricular donor area
Donor defect is closed primarily
Skin is harvested using scalpel blade no 15. Full thickness graft should be devoid of fat.
Full thickness graft taken from donor area
Recipient defect area
Full thickness graft cover over the defect

Fig. 7-78: Technique of Wolfe—Full thickness graft.

Disadvantages: (1) Only for small area it can be used. (2) Wider donor area has to be covered with SSG to close the defect. (3) It cannot be used to cover ulcers.

FLAPS

Flaps are transfer of tissues from one area to another with their blood supply.

It is transfer of donor tissue with its blood supply to the recipient area.

Parts of flaps: Base, pedicle, tip of flap. Vasculature is usually through the pedicle in the centre of the flap. Tip is the place where often flap goes for necrosis **(Figs 7-80A to C)**.

Congruity, configuration, components, circulation, conditioning are the *different aspects* of the flap.

Indications

(1) To cover the wider, deeper defects. (2) To cover over bone, tendon, cartilage. (3) If skin graft repeatedly fails.

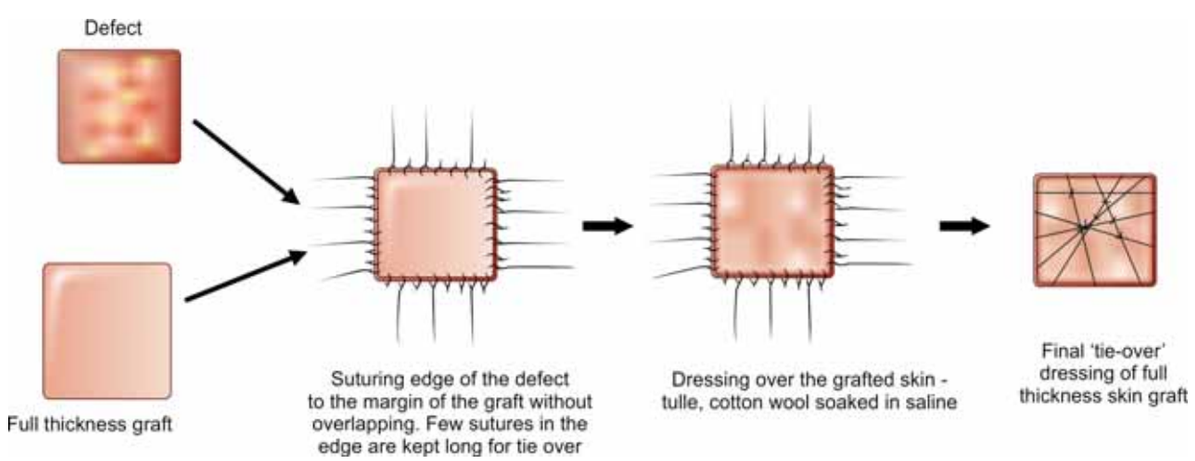
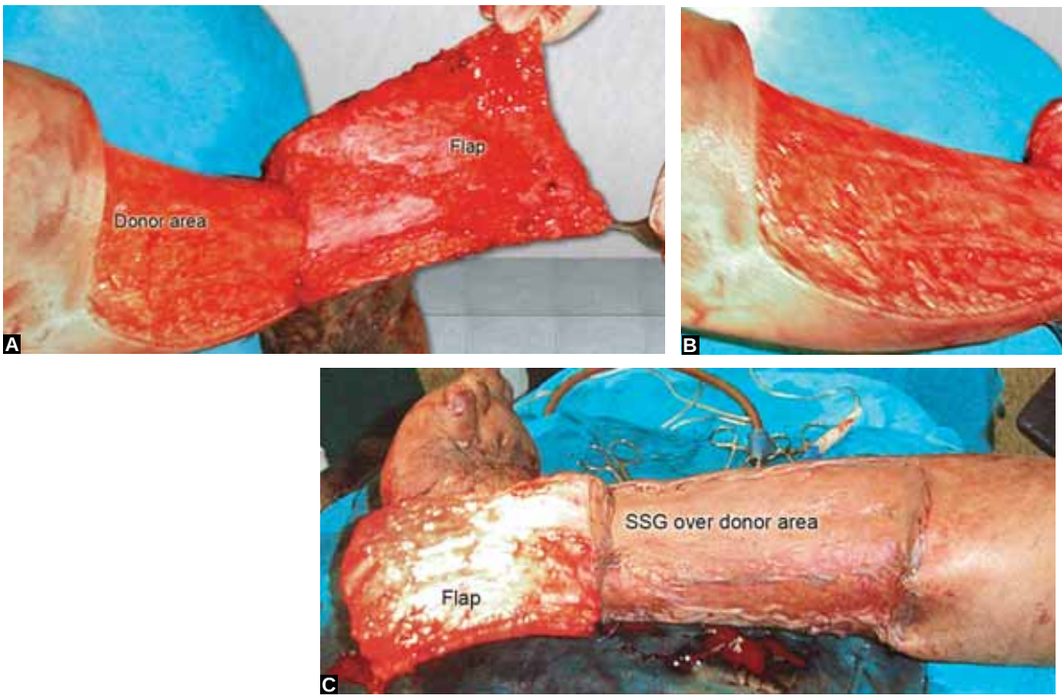

Defect
Full thickness graft
Suturing edge of the defect to the margin of the graft without overlapping. Few sutures in the edge are kept long for tie over
Dressing over the grafted skin - tulle, cotton wool soaked in saline
Final 'tie-over' dressing of full thickness skin graft

Fig. 7-79: 'Tie-over' dressing for Wolfe graft (full thickness graft).



Figs 7-80A to C: Typical flap, method of raising it; and donor area being wide is covered with split skin graft.

Types

(1) *Random pattern flaps*: Here vascular basis is subdermal plexus of blood vessels. Known blood supply is not present. It is usually a rectangular flap with length to width ratio is ***1:1*** or 1.5:1. This flap has got limitations in its dimensions. (2) *Axial pattern flaps*: Here superficial vascular pedicles pass along their long axes, e.g. Forehead flap, deltopectoral flap, groin flap. A known anatomical blood vessel supplies the flap. It is *long lengthy* flap **(Figs 7-81 to 7-84)**.

Anatomical Types Depending on the Types of Tissue in the Flap

(1) Cutaneous flap: Forehead flap, deltopectoral flap. (2) Fasciocutaneous flap: Radial forearm flap, scapular flap, lateral arm flap. (3) Muscle flap: Gluteus maximus muscle flap, gracilis flap, tensor fascia lata muscle flap. (4) Myocutaneous flap: Pectoralis major myocutaneous flap, latissimus dorsi flap. (5) Osteo myocutaneous flaps: Radius with brachioradialis and skin; rib with intercostal muscles and skin. (6) Local rotation flaps. (7) 'Z' plasty.(8) Free flaps: Vascular pedicle of the flap both artery and vein are anastomosed to recipient vessels using operating binocular microscopes.(9) Omental flaps. (10) Island flap **(Figs 7-85 and 7-86)**.

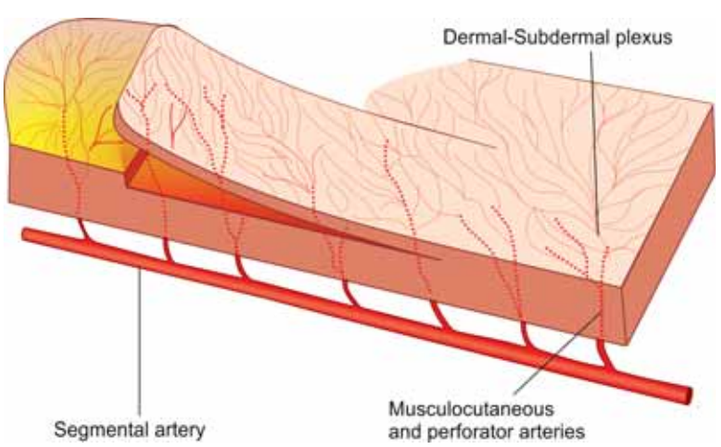


Fig. 7-81: Anatomy and blood supply of a skin flap.

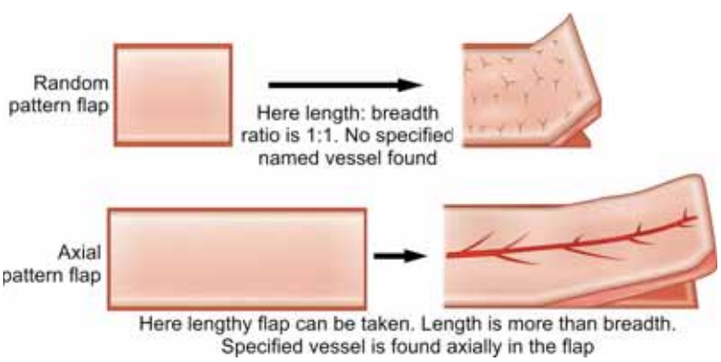

Random
pattern flap
Here length: breadth
ratio is 1:1. No specified
named vessel found
Axial
pattern flap
Here lengthy flap can be taken. Length is more than breadth.
Specified vessel is found axially in the flap

Fig. 7-82: Types flap based on vascular pattern—Random pattern and axial pattern.

Fig. 7-83: Flap which has taken up well placed over the defect on the bone with osteomyelitis.

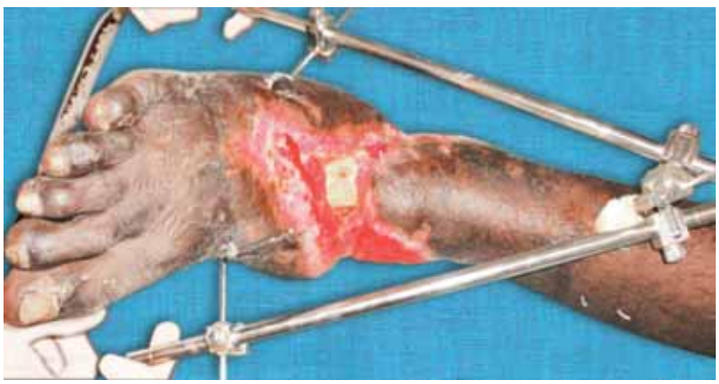


Fig. 7-84: Traumatic exposure of the bone. Flap is needed to cover this defect. It could be cross leg flap or rotation flap. Skin grafting is not possible in this situation.

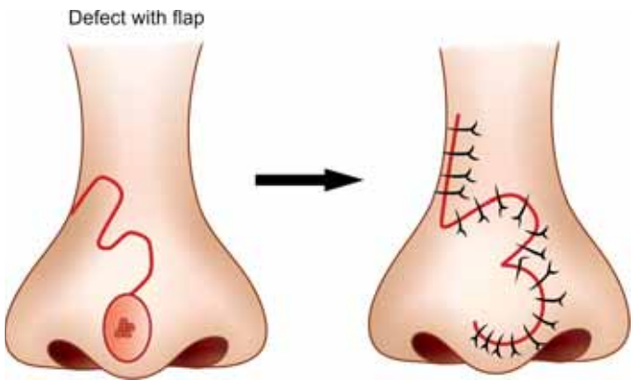


Fig. 7-85: Bilobed flap is used in lesions of the nose commonly.

Fig. 7-86: On table marking of glabellar flap to place after excising a lesion in the root of the nose.

Areas where Commonly Flaps are Used

Oral cavity, neck, breast, limbs (leg), buttock, bedsores, etc.

Flaps mobilised from donor area with its pedicle is placed and sutured to recipient area. Once flap gets taken up usually in 3-6 weeks, base of the flap is cut and sutured to recipient area.

Saltatory flap is mobilising the flaps in stages from distant donor area towards recipient area. It requires many staged surgeries and long-term hospitalisation. Intermediate tissue is used as '***carrier***' **(Figs 7-87 and 7-88)**.

Advantages of Flaps

(1) Good blood supply, good take up. (2) It gives bulk, texture, and color to the area. (3) Allowing the required movements in the recipient area, e.g. Jaw movements after pectoralis major flap after wide excision with hemimandibulectomy for carcinoma cheek. (4) Cosmetically better.

Disadvantages of Flaps

(1) Long-term hospitalisation is needed. (2) Infection. (3) Kinking, rotation and flap necrosis. (4) Staged procedure.

Positioning of the patient for long time is important to have a good flap take up which is a real discomfort to the patient.

Waltzing is a technique wherein flap is moved from donor area and attached adjacent to the recipient defect area. Later in 2nd stage it is moved towards the defect formally. It reduces the tension on the flap and increases the success rate **(Fig. 7-89)**.

Delaying of the Flap/Conditioning the Flap

Flap is raised properly as required and re-sutured to same place so as to allow the formation of reorientation of vasculature near the tip of the flap. *This delayed flap* is raised again in 10-14 days to place in required area. It is used both in random pattern as well as axial pattern flap. In random pattern flap delay improves the length-breadth ratio. In axial pattern flap, delaying enhances the blood flow across the distal attachment of the flap. It is often used in deltopectoral flap **(Fig. 7-90)**.

Different Flaps

Flap lying immediately adjacent to the defect is called as *local flap*. Flap moved from adjacent anatomical area is called as *regional flap*. Flap when moved from distant anatomical site is called as *distant flap*.

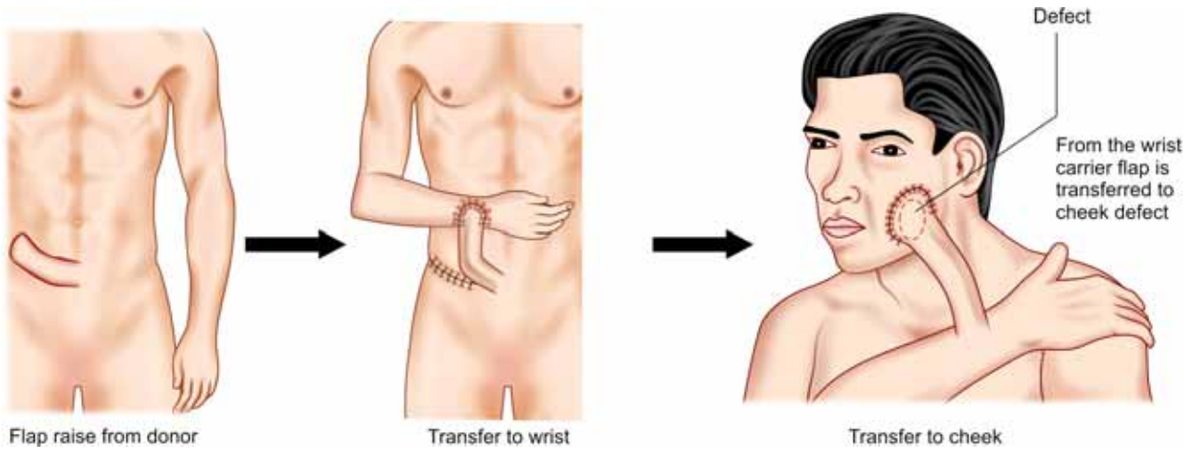

Defect
From the wrist carrier flap is transferred to cheek defect
Flap raise from donor
Transfer to wrist
Transfer to cheek

Fig. 7-87: Saltatory flap. Flap raised from the abdomen is reached to the cheek in stages—from abdomen to wrist; from wrist to cheek.

Groin flap trasferring to wrist carrier
Defect
From the wrist carrier flap is transferred to cheek defect
From the wrist carrier flap can be trasferred to a defect in leg to cover
Defect

Fig. 7-88: Transferring the groin flap to the defect area either in cheek or in leg using wrist as carrier. It is the staged procedure. In each stage flap is divided in 3 weeks period.

Fig. 7-89: Waltzing flap.

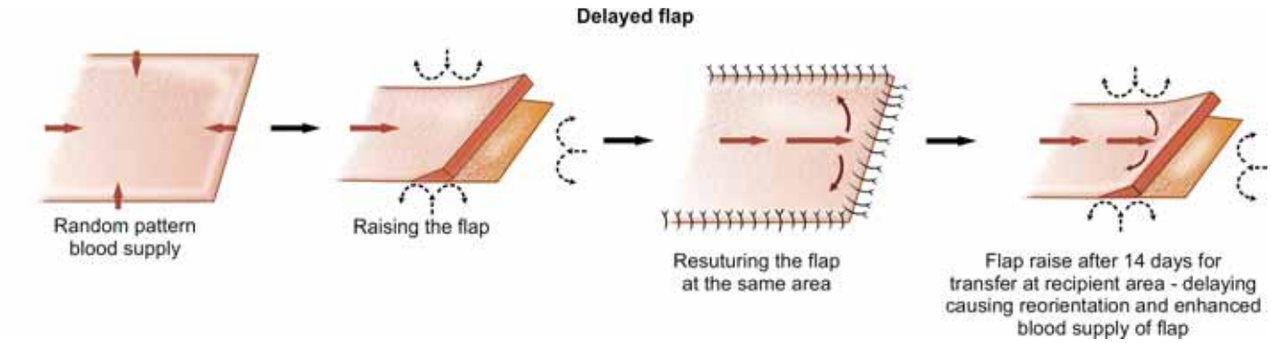

Delayed flap
Random pattern blood supply
Raising the flap
Resuturing the flap at the same area
Flap raise after 14 days for transfer at recipient area - delaying causing reorientation and enhanced blood supply of flap

Fig. 7-90: Delaying the flap for 10-14 days to reorient the blood supply. It is done in random pattern flap to improve length to breadth ratio or in axial pattern flap to improve distal blood supply.

Pedicled flap is flap which is moved with intact tissue bridge to support it. Deltopectoral flap is a pedicled flap.

Islanded flap is a flap which is moved to a site which is non-contiguous from the donor flap area but flap is moved under the skin bridge through a tunnel. Pectoralis major myocutaneous flap is an islanded flap. Localised flap is swung around a stalk from the donor area to the recipient area often with the pedicle buried underneath the skin bridge in between.

Transposition/rotation flap: When the flap moves laterally it is called as *transposition flap*. Transposition flap is squarely designed which moves laterally to close the defect creating a larger area on its original place which can be covered with split skin graft. Mobility of the transposition flap depends on the laxity, flexibility, mobilisation and blood supply. When the flap rotates laterally towards defect it is called as *rotation flap.* It is commonly used in covering bedsores in buttock and sacral region and also in scalp. Flap needed is much wider in relation to the size of the defect **(Figs 7-91 to 7-94)**.

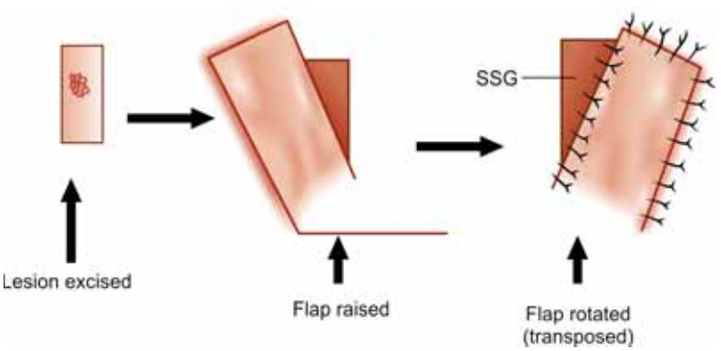


Fig. 7-91: Transposition flap.

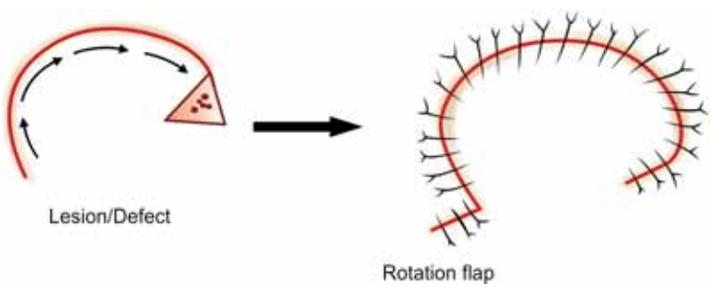


Fig. 7-92: Rotation flap. It is commonly used in gluteal region in managing bedsores.

Advancement flap: It is advancing the flap from one angle towards the defect in longitudinal direction. Here flap transferring area is less but useful. It is used commonly in fingers **(Figs 7-95 and 7-96)**.

'Z' plasty: It is a procedure which involves transposition of two interdigitating triangular flaps. There is change in direction as well as gain in length of the common limb of Z. Angle size and length of the limb is the most important factors. With an angle of 60° there will be increase in length by 75%. It is used in managing contracted scars, facial scars, Dupuytren's contracture and cover the excised defects like pilonidal sinus (example). There should be transverse skin slack available equal to the length between the axes of Z. It can be single or multiple Z plasty. Multiple Z plasty shows overall 2 cm lengthening but shortening only of 0.5 cm in transverse axis whereas single Z plasty causes 2 cm lengthening and 2 cm shortening in parallel line. Lateral tension is diffused in multiple Z plasty but it is concentrated in single Z plasty. Complications are flap necrosis near the angle tip, infection, failure. Vascularity of the flaps is essential need. Side limbs of the flaps can be curved and broadened to improve the blood supply **(Figs 7-97 and 7-98)**.

Deltopectoral flap (Bakamjian flap): It is a *fasciocutaneous flap* (axial pattern) based on first three perforating branches of the internal mammary artery (mainly 2nd perforator) **(Fig. 7-99)**. Flap runs horizontally across the chest wall anteriorly towards shoulder tip from its base over the sternal border. Its upper border is along the line of the clavicle; its lower border is along the anterior axillary fold line. Raw area often requires a spilt skin grafting. It is usually rotated upwards often with waltzing. It is tubed and attached above. Tube is drained to prevent any collection to occur. Rotation angle is important to prevent any kinking on the pedicle. It is usually used to cover the

Figs 7-93A to E: Rotation flap for gluteal defect/bedsore.

defects in cheek, chin, mastoid and parotid region. *Pivot point* of rotation is located in upper medial aspect. Often flap is delayed to get adequate length. Upper medial point is rotating pivot point. It moves a *quarter circle*. Flap can be reached as high as defect over the zygomatic region, as rotating lower border of the flap slack and lax (as it is near anterior axillary fold which is lax). Occasionally it is also used to transfer below to the chest or abdomen.

Groin flap: It is a *cutaneous flap* (axial pattern) based medially on *superficial circumflex iliac artery* which is 2-3 cm below and parallel to the inguinal ligament. Artery originates from femoral artery over medial border of the sartorius and ends at anterior superior iliac spine. Deep branch is at the margin of the sartorius and superficial branch continues towards anterior superior iliac spine. 1:1 rectangular flap with deep fascia is used. Dissection of raising the flap is done up to the medial border of the sartorius. Secondary defect can usually be closed with sutures. It is used mainly for defects in wrist/forearm where positioning is easier. Often *tubed groin flap* can be transferred to cheek or leg using wrist as carrier **(Figs 7-100 and 7-101)**.

Hypogastric flap: It is a *cutaneous flap* (axial pattern) based on superficial epigastric vessel directing upwards from the inguinal ligament in the lower abdomen. It is used for wrist similar like groin flap **(Fig. 7-102)**.

Latissimus dorsi muscle/myocutaneous flap: It is based on thoracodorsal artery, a branch of subscapular artery. Skin over the upper and anterior border of the muscle is used for transfer **(Fig. 7-103)**. It is commonly used to cover the defect after mastectomy. But it does not give the bulk. It is technically easier. It can be used as muscle flap also. It helps as skin cover. Prosthesis (submuscular silicone) is needed to place underneath to provide bulk in post-mastectomy defect. Muscle arises from iliac crest upwards to mid-thoracic spine. Muscle is like a fan below forming tendinous fibres above to insert into humeral shaft. Subscapular artery a largest branch derived from 3rd part of axillary artery runs along posterior wall of the axilla giving circumflex scapular vessels at 4 cm distance and later continuing as thoracodorsal artery for about 6 cm enters the muscle giving many branches. Flap is usually taken as myocutaneous flap with elliptical skin on the surface. Skin part is either horizontal ellipse when taken from upper margin of the muscle or vertical when taken from the anterior margin of the muscle. Point of origin of the subscapular artery is the pivot point of the flap. Artery accompanies the vein also. During raising the flap after islanding it with skin, only pedicle can be retained cutting muscle above to attain extra length (but commonly anterior attachment is retained) and flap is rotated to the needed area. Donor area can be sutured primarily or covered with a split skin graft. In LD flap nerve is not retained (as if retained it causes unpleasant muscle contractions) and so it will not maintain the bulk but gives well coverage of the defect. Flap harvesting is done in lateral position. Subscapular vessels maintain the adequate length and calibreand so it is often used as *free flap* based on subscapular vessels.

Pectoralis major myocutaneous flap (PMMF): It is based on the pectoral branches of *thoracoacromial artery*. Usually skin below and

Fig. 7-94: Bilobed flap taken from abdominal wall and placing to the hand and wrist area over two defects.

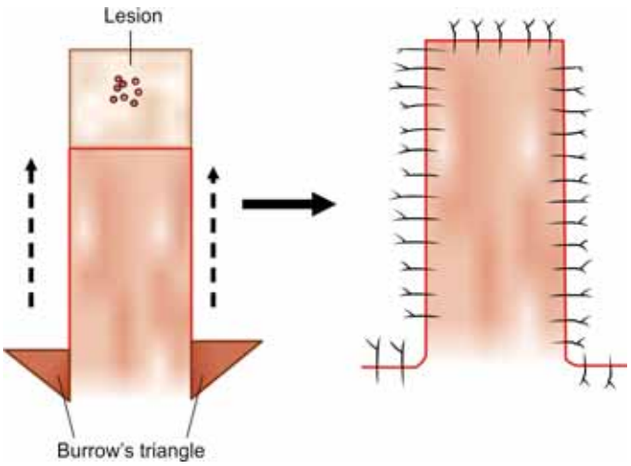


Fig. 7-95: Advancement flap is used in distal defects.

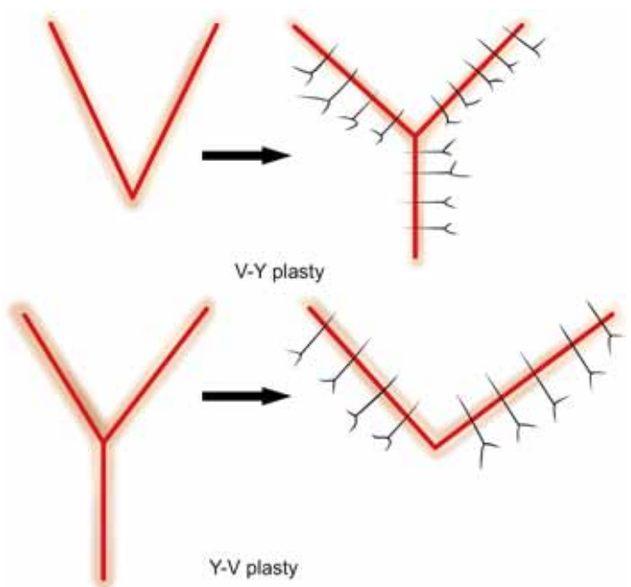


Fig. 7-96: Technique of V-Y plasty and Y-V plasty.

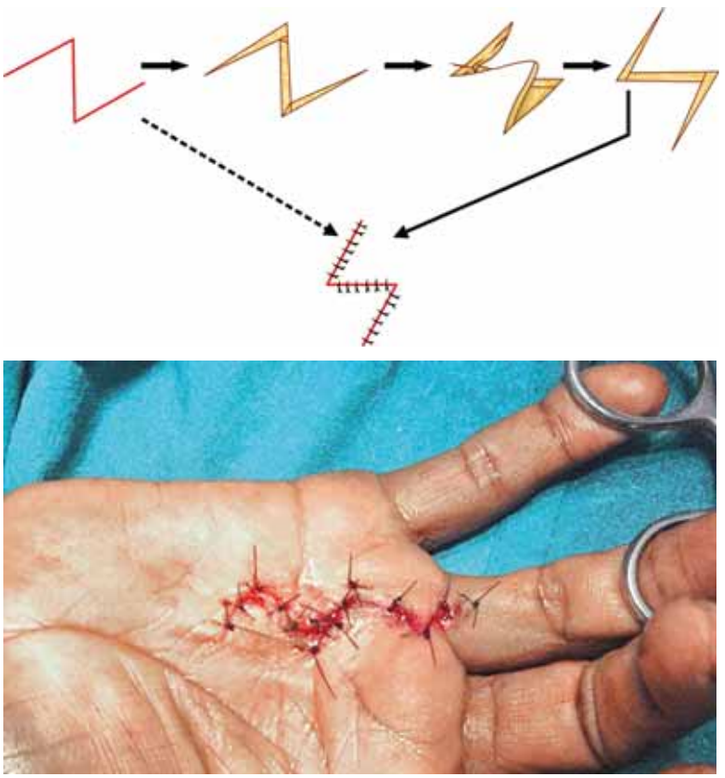


Fig. 7-97: Technique of 'Z' plasty. It is used in contracture release; Dupuytren's contracture and pilonidal sinus. Angle of rotation here is 60°. Note the z plasty done for Dupuytren's contracture. Fingers can be retracted using finger bows of the haemostats.

medial to nipple over the muscle is used. Muscle pedicle is made as broad as skin. It is used to cover the defect over the cheek/neck/pharynx/intraoral lesions after wide excision with removal of skin over the tumor. Vessel marking is 2 cm medial to coracoid process, obliquely below the clavicle at the junction between middle third and outer third. Line runs towards the xiphoid process. Oblique downwards incision is placed encroaching the ellipse of the needed skin in the flap. Often skin incision begins below the line of 3rd rib to retain the deltopectoral flap area in case of need in future. Lower border of the muscle is raised by dissecting beneath the pectoral fascia. While raising the flap of the chest wall thoracoacromial vessels can be visualised. Enough care should be taken not to injure it. Flap is raised over the medial and lateral margins of the pectoralis major muscle. In front it is dissected off from the deep fascia. Skin with muscle is dissected from the deeper structures like ribs, intercostal muscles and pectoralis minor. Flap is raised upwards up to the coracoid. Lateral pectoral vessels if possible are retained otherwise can be sacrificed. Pectoral nerves should be retained. Defect below is usually closed primarily with sutures. Often it needs spilt skin grafting. Flap is tunneled in subcutaneous plane towards neck or oral cavity. Postoperatively flap is observed for colour changes, seroma, and infection. Neck is flexed towards the flap side during postoperative period to prevent tension. Suction drain should be placed which is removed once drainage stops or in 72 hours. In the neck flap covers the carotids protecting it. In oral cavity if flap is of large sized, its skin can be split into half to cover both inner and outer aspect of the oral cavity. It gives bulk and adequate movements of the jaw. Pectoralis major flap can be used along with deltopectoral flap with proper planning **(Figs 7-104 to 7-106)**.

Gastrocnemius muscle flap: It is either medial or lateral and is commonly used to cover the upper part of the tibia and knee joint. It is technically easier and functional deficit occurring at donor area is insignificant. It is rarely used as myocutaneous flap.

Transverse rectus abdominis muscle flap (TRAM flap): It is either superior pedicle based on the superior epigastric vessels or inferior pedicle based on the inferior epigastric vessels. Superior pedicle based flap is used to cover postmastectomy area or chest wall defect. To cover post-mastectomy area opposite sided superior pedicle is used to reduce the arc through which flap has to rotate (but rotating from opposite side is technically difficult). Inferior pedicle flap is used to cover the defects in groin and thigh. Proper marking of the flap is essential **(Fig. 7-107)**. Skin incision is made like an ellipse. Anterior rectus sheath is cut in the line of incision and is raised upwards carefully of the rectus muscle up to the xiphisternum. Muscle is gently separated of the posterior rectus sheath with care not to injure the epigastric vessels. Once dissection is complete lower part of the muscle is cut in superior pedicle to rotate upwards carefully. In the upper

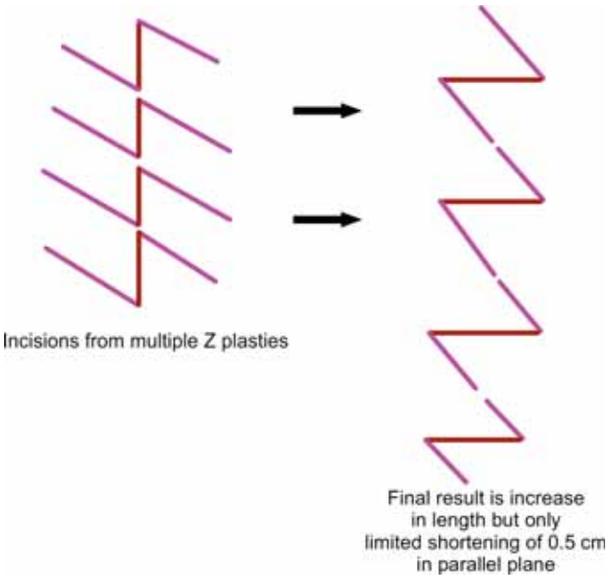

Incisions from multiple Z plasties
Final result is increase
in length but only
limited shortening of 0.5 cm
in parallel plane

Fig. 7-98: Multiple Z plasties are done to diffuse the tension and to improve the lengthening.

part again anterior rectus sheath is opened to pass the flap towards the defect in subcutaneous plane. TRAM flap gives bulk and contour to the defect. But it is technically difficult. Usually opposite side of the defect is taken as flap as it is easier to rotate from opposite side. Defect in the abdomen usually needs mesh to support and close. It is not possible to do this flap in obese and if patient has underwent laparotomy earlier (with a lengthy scar). Below the flap cut end of the inferior epigastric artery in superior pedicle flap can be anastomosed to a vessel in recipient bed to improve the perfusion *(supercharging)*. Inferior epigastric artery in inferior pedicle can be additionally perfused using opposite inferior epigastric artery *(recharging)*.

Radial forearm flap: It is perfused from the radial vessels and raised on the flexor aspect of the forearm. Perforating branches of these vessels supply deep fascia and skin over it. Flap can be fasciocutaneous or osteofasciocutaneous/osteomyofasciocutaneous if radial bone is also used as part of the flap. Radial forearm free flap is commonly used for mandible defects. It is technically easier and safer. Flap is raised along with skin, segment of the radius along its intermuscular septum through which vessels pass and brachioradialis as components. Care is taken in dissecting vessels of the bed

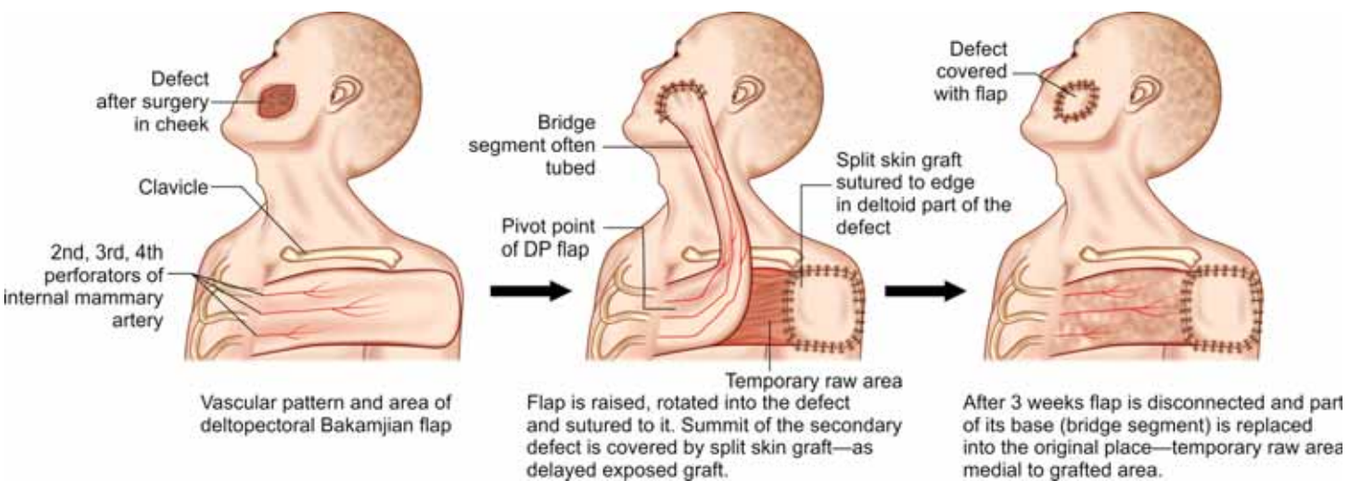
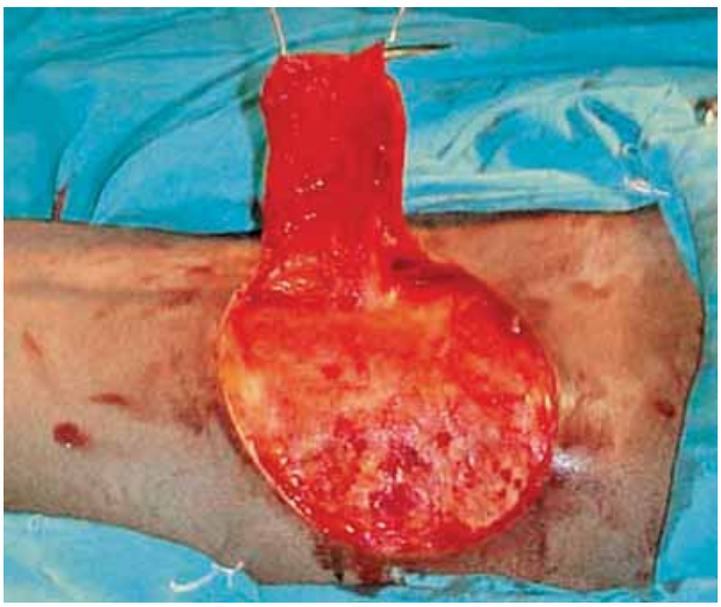


Fig. 7-99: Deltopectoral cutaneous flap (Bakamjian flap).



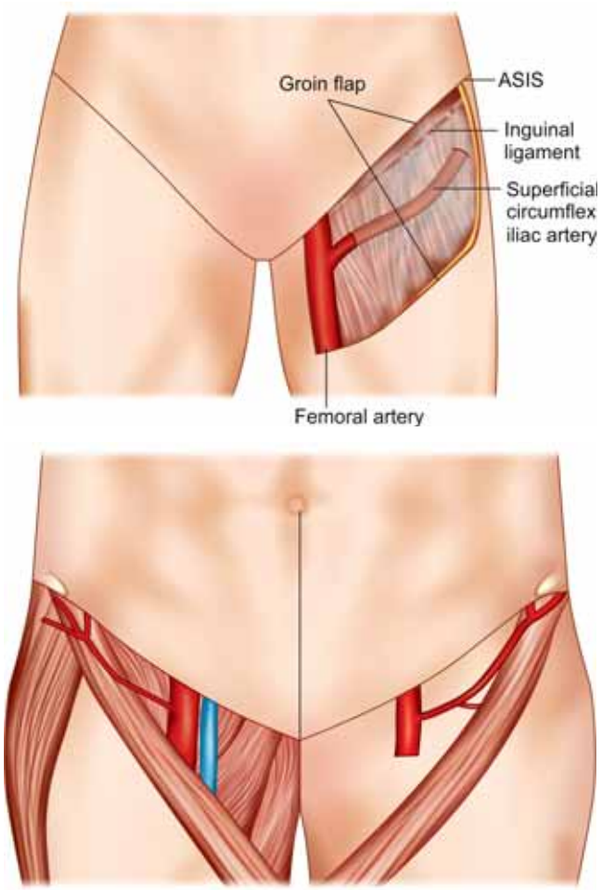


Fig. 7-100: Groin flap is based on superficial circumflex artery. It can be used for defects in hand and forearm. It is a cutaneous flap.

Fig. 7-101: Groin flap used for burns defect in the hand.

and not to injure the radial nerve. In free flap artery is sutured to the recipient artery like facial artery using microscope. Other similar flaps are—ulnar forearm flap, scapular flaps, and vascularised fibular transfer.

Limberg flap is a type of rhomboid flap used in—pilonidal sinus with base at gluteal skin; defects in face after surgical wide excision **(Fig. 7-108)**.

Cross leg flap: It is commonly used to cover the defect in the opposite foot/leg. It is random pattern flap. Limb should be immobilised for 3 weeks by plaster of Paris or external fixation. Raw donor flap area needs split skin graft cover. It is direct flap with 1:1 length breadth ratio **(Fig. 7-109)**. It is commonly used in post-trauma defects in younger individuals. Joint stiffness due to immobilisation may be a problem.

Free Flaps

Flap with a single lengthy wide calibered arteriovenous system is transferred with its vascular pedicle. Here vascular pedicle is transected with flap; both artery and vein of the flap is anastomosed to

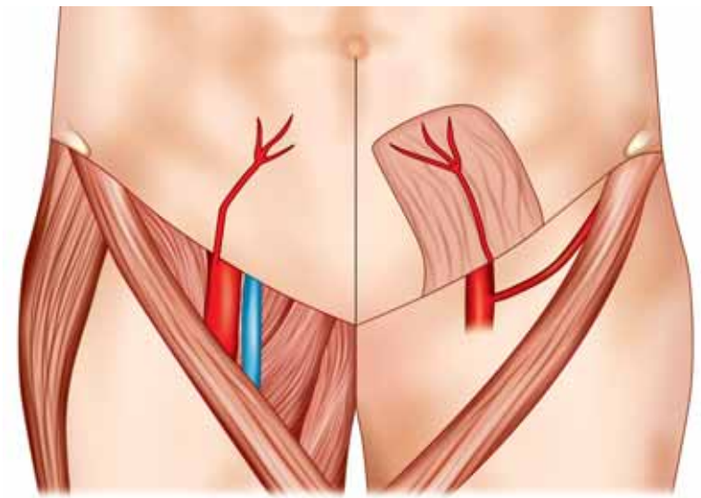


Fig. 7-102: Diagram showing hypogastric flap based on superficial epigastric artery.

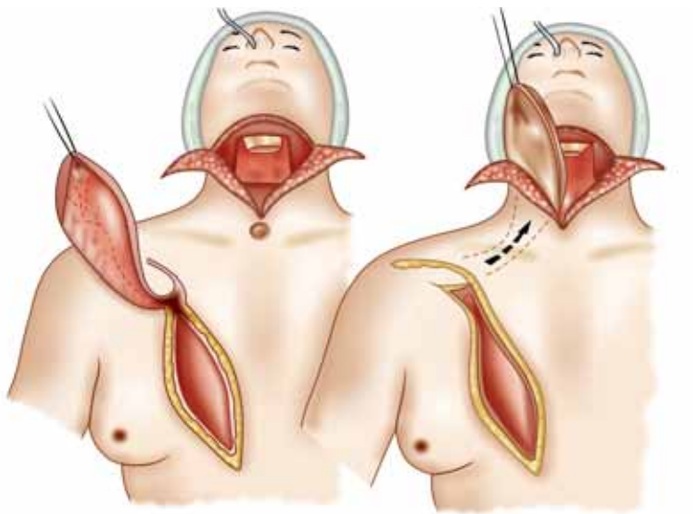
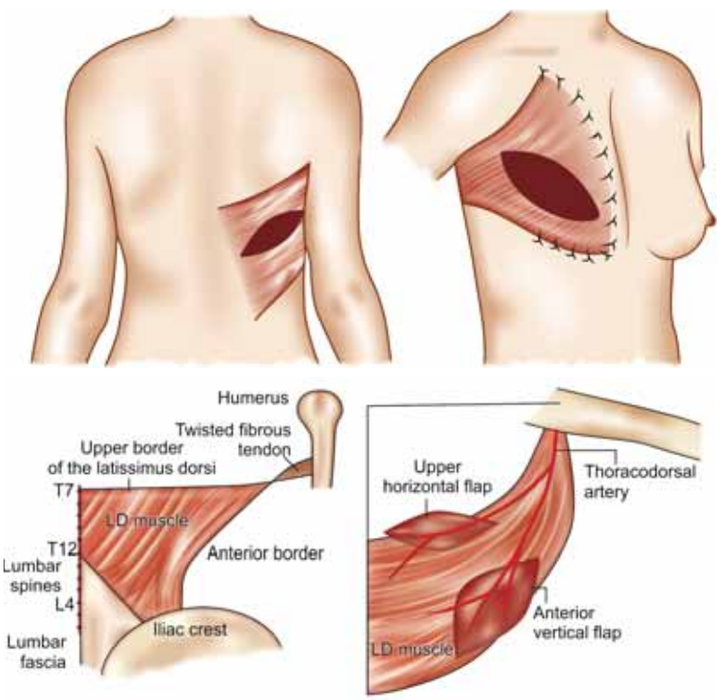


Fig. 7-104: Diagrammatic look of pectoralis major myocutaneous flap.



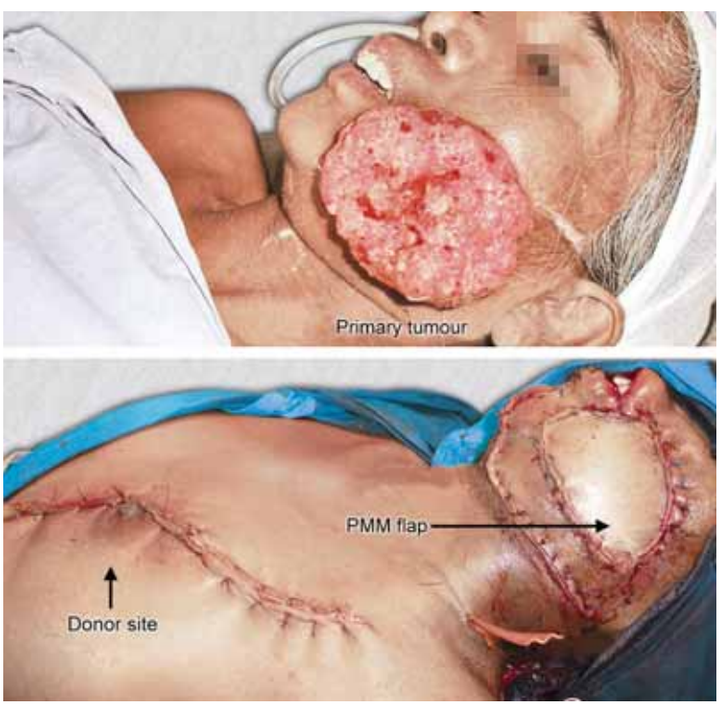
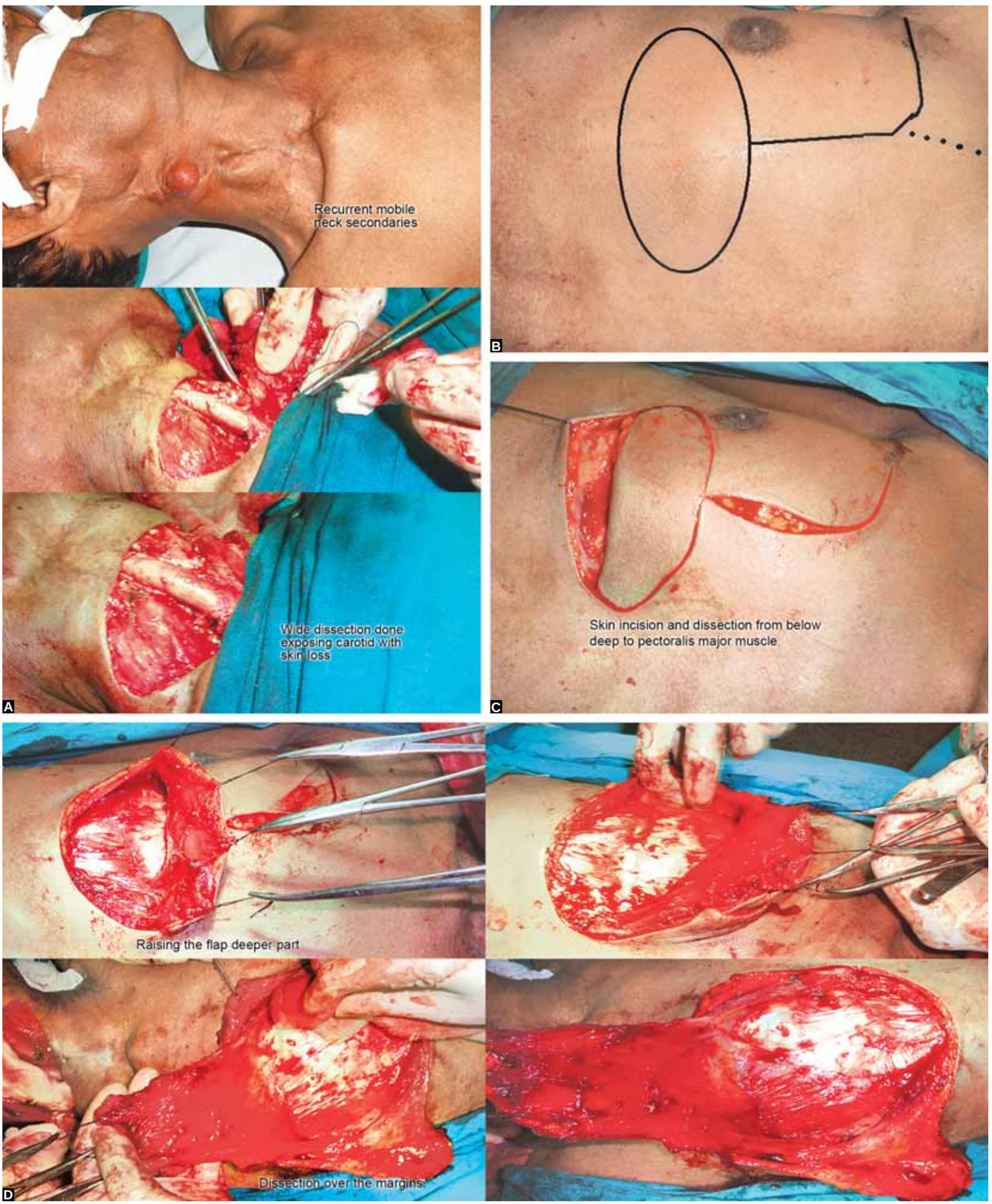


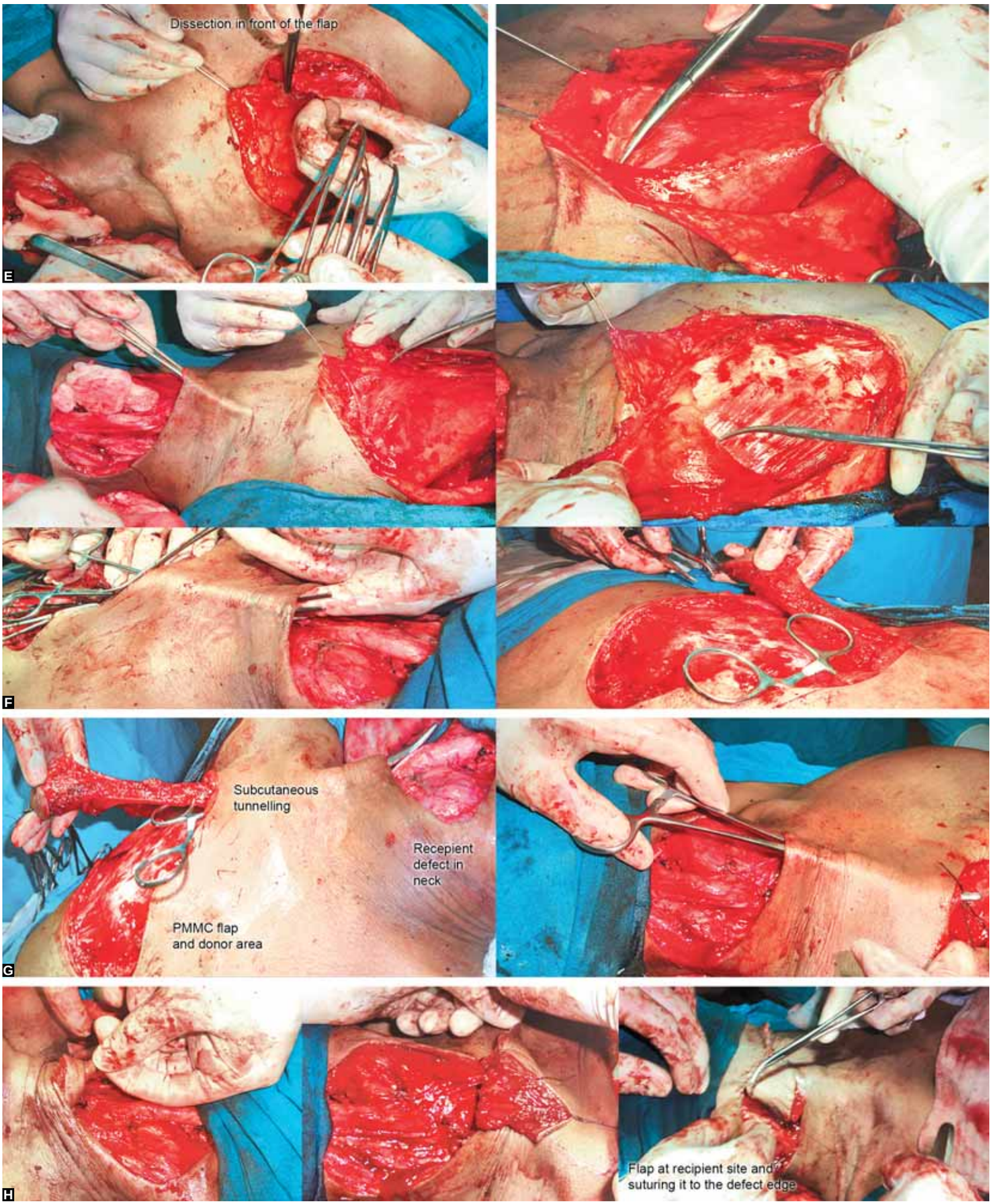
Fig. 7-105: Pectoralis major myocutaneous flap used for carcinoma cheek.

Fig. 7-103: Latissimus dorsi myocutaneous flap.

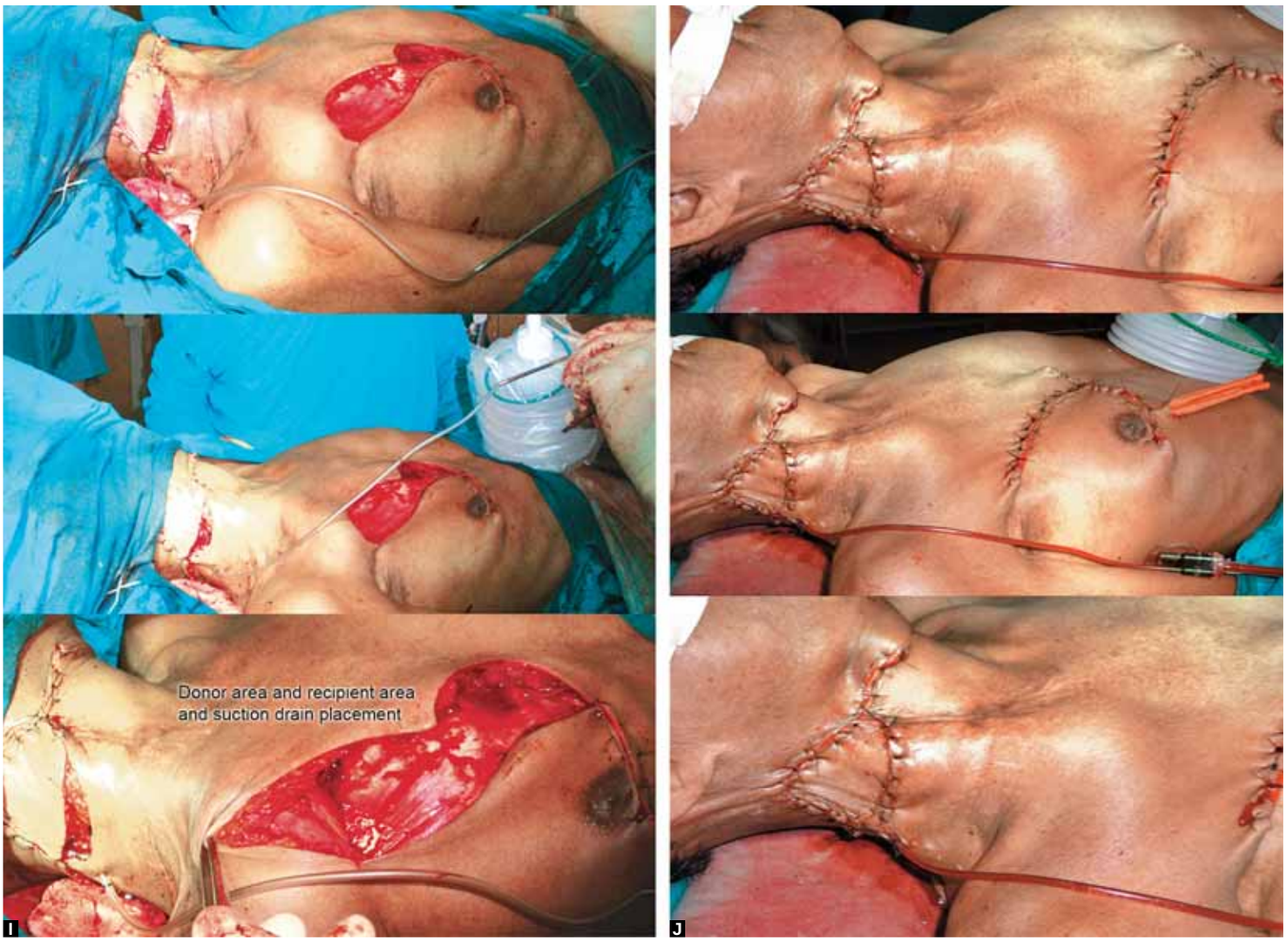
the specific artery and vein at recipient area to re-attain its perfusion through newer blood vessel. *Length and calibre of the vessels* are deciding factors here. Often associated nerves either motor or sensory are also anastomosed. *Healthy vessel wall and adequate pulse volume* are essential in recipient vessel. Presence of *infection* in recipient area is *absolute contraindication*. It can cause thrombosis of the vessel and flap necrosis. Vein ideally should be as large as artery. Often if possible a second vein is also anastomosed. Calibre of the vessels of both recipient and donor parts should be reasonably corresponding. Recipient bed and vessel preparation and donor flap raising should be done simultaneously. *The ischaemic time* (time between division of the donor vessel and restoration of perfusion at recipient) should be kept minimum as much as possible.


Recurrent mobile neck secondaries
Wide dissection done exposing carotid with skin loss
A
B
Skin incision and dissection from below deep to pectoralis major muscle
C
Raising the flap deeper part
Dissection over the margins
D

Figs 7-106A to D



Figs 7-106E to H



Figs 7-106I and J

Figs 7-106A to J: Incision marking, flap raise and steps in pectoralis major myocutaneous flap.

Factors deciding the adequacy of a flap

- Blood supply of the flap.
- Avoiding mechanical tension and kinking.
- Flap geometry with limited angulation at pivot point of the flap.
- Marking the flap and using cut gauze equal to the size of the flap mock transfer and placing of the flap.
- Postsurgery positioning, prevention of infection.
- Compression of flap should be avoided while passing through a tunnel-like pectoralis major myocutaneous flap.
- Avoiding injury to feeding vessel while raising the flap.
- Thinning of flap if needed should be done with utmost care.
- Prevention of haematoma formation.
- Proper placement of suction drain under the flap.
- Dressings should not be too tight to compromise the blood vessel.
- Delaying the flap especially in random pattern flap.
- Careful tubing of the flap, proper selection of carrier site when needed.
- Positioning of the part and immobilisation.

Anastomosis is done *end to end or side to end* to the flap vessel from recipient vessel (side of the recipient vessel to end of flap vessel). When diameters of the both vessels are equal end to end anastomosis is done. When diameter is unequal, then side to end anastomosis is done. End to end in such situation may cause turbulence blood flow due to unequal diameter and leads to thrombosis of the vessel. Instruments used for anastomosis are—spring handled needle holder; spring handled scissors; fine dissecting and cutting scissors; blunt tipped forceps as vessel dilator; microclamps.

Vessel wall should be healthy, atheroma free, without any branches near to the suturing site, without any valves in veins near the site. Any factor which is likely to cause turbulence should be avoided. Vessel should be held using fine forceps on the periadventitia. *Only bipolar cautery* should be used. Main vessel should not be handled directly. Unnecessary handling of the vessel may cause *vasospasm* which should be avoided. During dissection of the vessel, to prevent spasm area is irrigated with local anaesthetic agents (lignocaine) or using papaverine. Tension, kinking, torsion of the both recipient and flap vessels should be carefully avoided. Only once recipient vessel is ready, flap vessel is divided after applying a *microclamp*. Once vessels are ready then only microscopy should be used for anastomosis. Now periadventitia is removed for 3 mm from the cut margin in end to

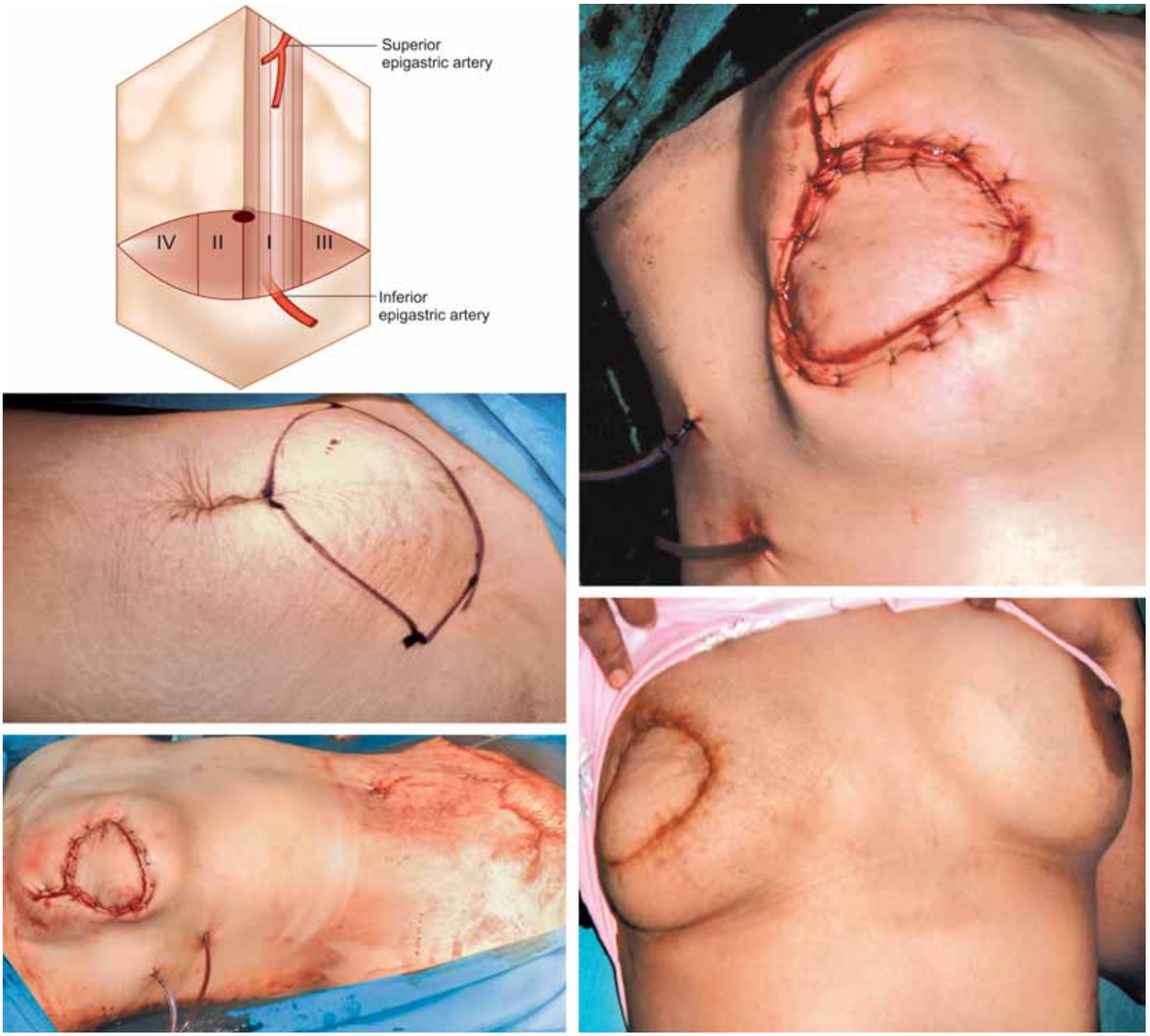


Fig. 7-107: Transverse abdominis myocutaneous flap to cover post-mastectomy area.

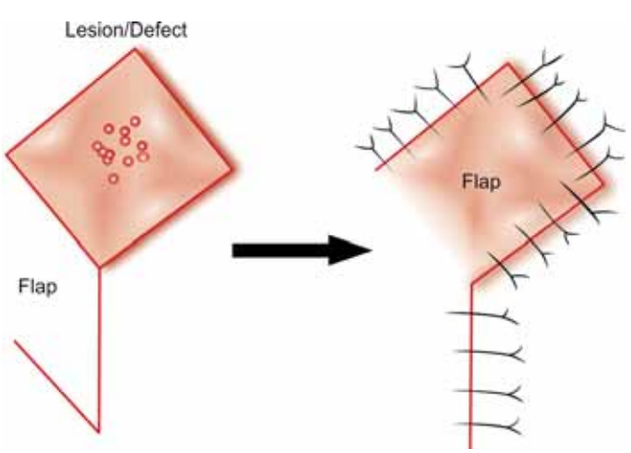


Fig. 7-108: Rhomboid flap.

Fig. 7-109: Cross-leg flap.

end anastomosis and 1 cm in end to side anastomosis. Entrapment of periadventitia into the suture line will induce thrombosis. Final trimming of the cut ends is done. *Flushing of the lumen* with heparinised Ringer lactate or Hartmann's solution is done to remove small thrombi and to maintain wet operating field. Vessel ends are *dilated using forceps* to prevent spasm.

Suturing is done using 8 zero/9 zero *monofilament polypropylene* suture material. *Interrupted sutures* are used. Distance of the needle bite from the cut margin should *be twice* the thickness of the vessel wall. Bite is taken from adventitia outside into the lumen on one side then from lumen towards outside through adventitia on opposite side. Knot should *be always outside*. Carrel's triangulation technique with placement of three key stitches at equidistance in the circumference of the cut edges of the vessels. First two key stitches are placed at 120° gap; additional sutures are placed in this gap; vessels are turned over to visualize the remaining gap; in the middle 3rd key stitch is placed; further stitches are placed in the gap. Vessels should be completely apposed to prevent blood leak. Knots should be *on one side* of the suture line in end to end anastomosis; and should be on the *flap vessel side in end to side* anastomosis. In end to side suturing first posterior row is sutured; then anterior row is sutured. Deeper vessel in the area should be sutured first; then superficial one. Only after suturing of the both artery and vein is completed, then microclamps are released. Always microclamp distal to the suture line should be released. Again first venous clamps should be released then arterial. Last clamp to be released is arterial microclamp proximal to anastomosis. After release small leak at suture site will subside **(Fig. 7-110)**. Significant blood leak when observed is controlled by few additional sutures. *Bounding arterial pulse, pink flap, filled vein* suggests good perfusion. Local anaesthetic or papaverine instillation over the area may relieve or prevent spasm. If still features are not obvious refashioning of the anastomosis is needed. Two fine forceps are placed over the emptied vein with a gap in between; and releasing the proximal one if causes filling of vein distally, it means anastomosis is patent. Kinking, compression over the site should be avoided.

Complications are flap oedema, cyanosis, venous block, arterial spasm/block, flap failure. Flap temperature, oxygen tension assessment percutaneously, Doppler study are the methods used to assess the flap. When doubt exists *re-explore the flap immediately*; do not waste time by watch and wait policy.

Uses and advantages—free flap is used in reconstruction of cheek, mandible, neck, etc. Once flap takes it is cosmetically better. Perfusion is well maintained. Osteomyocutaneous flap like radial forearm flap, myocutaneous flap, fasciocutaneous flaps can be used as free flaps.

EAR LOBE REPAIR

It is commonly used cosmetic simple surgical procedure. Ear stud pierced point gets widened and will not hold the earring any more and lobule sags downwards. Problem is common in those who use overweight earrings/studs; in old people.

Technique: Xylocaine 1% plain (without adrenaline) is injected into the root of lower part of the ear lobule (lobule is supplied great auricular nerve) and directly over the margin of the defect (upper 2/3rd of lateral surface of external ear is supplied by auriculotemporal nerve and lower 1/3rd by great auricular nerve; upper 2/3rd of medial surface is supplied by lesser occipital nerve; lower 1/3rd by great auricular nerve). Elliptical circumferential defect area in the ear lobule is excised using no 11 sharp pointed blade. Tip of the ear lobule is held using a stay suture. Skin parts of the cut wound both in front and behind are approximated using 4 zero polypropylene sutures (interrupted mattress). Bites should not be taken

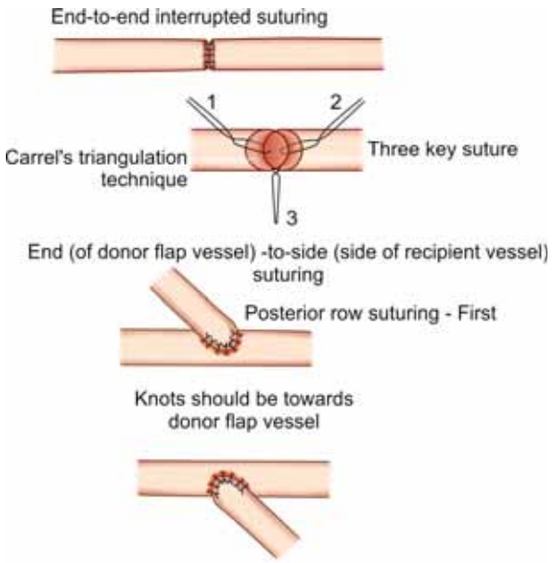


Fig. 7-110: Technique in end-to-end and end-to-side vascular anastomosis in free flap.

from the cartilage. Dressing is placed. Sutures are removed after 5-7 days. Re-piercing of the ear lobule is done only after 3 months **(Figs 7-111 to 7-113)**.

TOE NAIL EXCISION

It is done for trauma, infection and in ingrowing toe nail. *Ingrowing toe nail* is a real problem as it is often recurring, distressing due to pain, infection and tenderness. Hypertrophy of soft tissue with formation of protruded unhealthy granulation tissue is common. Often foul smelling pus exudes out. Medial or lateral or both margin/margins are ingrown on the edge causing soft tissue injury and irritation. It is common in great toe often bilateral.

Zadik's excision (Frank Raphael Zadik) of the toe nail is done. Procedure is done using finger tourniquet under digital local anaesthesia block using injection xylocaine 2% plain without adrenaline. Nail from the margin is carefully lifted using haemostat or Allis forceps and is avulsed off the nail bed. Here after avulsion of the nail, germinal matrix is also removed. Germinal matrix is located on the proximal third of the nail bed. It extends proximally under the skin fold and extending much more over the proximal corners. Entire germinal matrix should be removed carefully. Incision should extend more proximally near the edge. Flap is raised from the skin fold. Glistening whitish germinal matrix is identified and it is excised. Flap is placed back. Suturing is not done. Careful phenolisation of the specified area without any spillage into the surrounding tissues prevents the recurrence. Phenol applied is allowed to settle for 5 minutes and is neutralised using alcohol. Application of phenol is useful in presence of infection. Often only medial or lateral margin of the nail is removed. Here nail is retained in the centre. But problem here, even though cosmetically better is, recurrence of ingrowing toe nail **(Figs 7-114 to 7-116)**.

DERMABRASION

Dermabrasion is a cosmetic medical procedure in which the surface of the epidermis of the skin (the stratum corneum) is removed by abrasion (sanding). The instrument used to perform the procedure is called a dermabrader. It is used to remove sun-damaged skin, to remove or lessen scars and dark spots on the skin. The procedure is very painful and usually requires a general anaesthesia or twilight anaesthesia, in which the patient is still partly conscious. Afterward, the skin is very red and raw-looking, and takes several months for the skin to regrow and heal. Dermabrasion is useful for scar removal especially when the scar is raised above the surrounding skin, but is less effective in sunken scars. In the past, dermabrasion was done using a small, sterilised, electric sander. In the past decade, it has

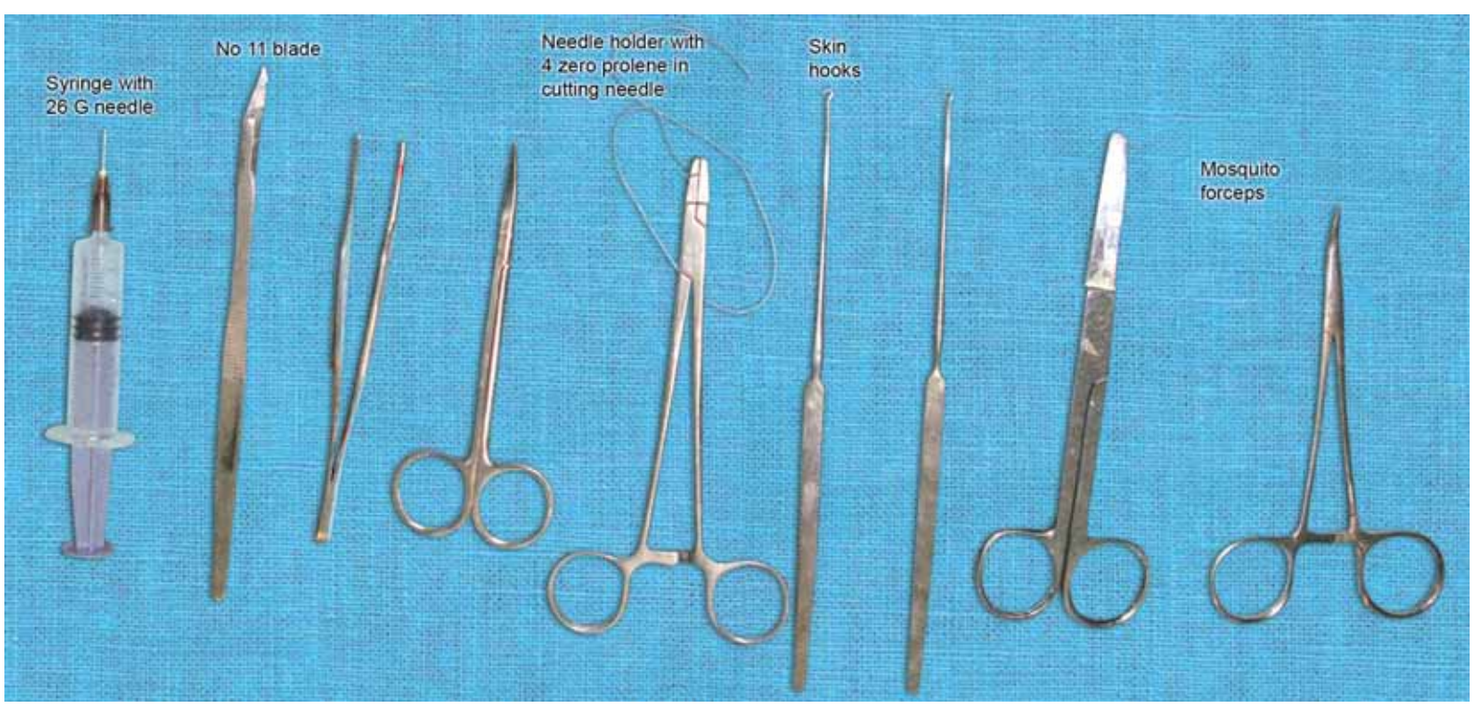


Fig. 7-111: Instruments used in ear lobe repair.

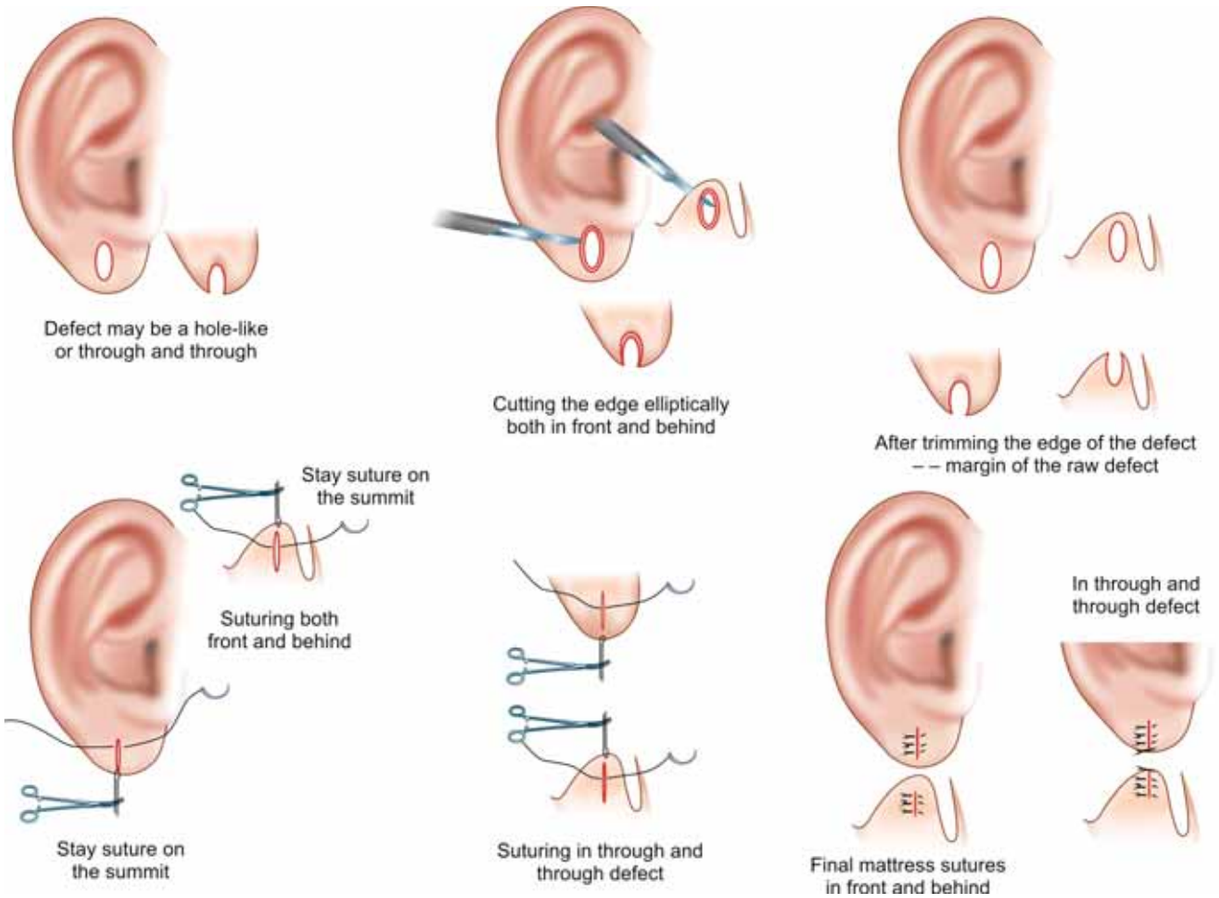


Fig. 7-112: Diagram showing steps in ear lobe repair.

become more common to use a CO_2 or Erbium:YAG laser. Laser dermabrasion is much easier to control, much easier to gauge, and is practically bloodless compared to classic dermabrasion. Microdermabrasion, crystal dermabrasion, diamond dermabrasion are different types. Even though healing is slow, eventual result is cosmetically better **(Fig. 7-117)**.

VENEPUNCTURE

Forearm veins are commonly used. Venepuncture is needed for fluid therapy, parenteral drug therapy, transfusions, etc. Clothing of the arm and forearm is removed. Hairs are shaved from the site. Area is cleaned with spirit. Tourniquet is applied above in the arm. Patient is asked to fist the fingers. Needle is passed obliquely into the skin with its bevel facing front and to the prominent vein. Skin puncture is 5 mm distal to the site of entry of the vein. Blood will enter the syringe. Intravenous cannula when used needle is removed once it is inside the vein which is confirmed by the blood flow; cannula is pushed into the vein entirely; needle is removed; cannula is connected to IV set and fluid. Cannula is fixed using plasters. Small dose of heparin should be flushed into the cannula daily to prevent thrombophlebitis.

Problems with venepuncture: Veins may not be visible. Flow may not be sufficient. Circulatory overload, thrombophlebitis, local haematoma, infection are common problems. Infection may be often hospital acquired and severe enough to cause septicaemia. Abscess at local site, oedema are also common. Air embolism if IV set is not closed once drip fluid gets over is a real danger.

VENESECTION

It means accessing the vein by *open surgical* approach. It is done in a patient inshock where peripheral vein or central vein cannot be cannulated. It aids in rapid fluid therapy in shock, monitoring of central venous pressure, administration of different drugs.

Incision: Usually upper arm on lateral aspect or in the leg on medial, posterior lower aspect is used. In the upper arm cephalic vein is used (if CVP monitoring is needed cephalic vein is selected); in the leg long saphenous vein is used. Cephalic vein is used in upper/mid-arm aspect, laterally between triceps and biceps muscles. Long saphenous vein is cannulated 1-2 cm above and posterior to the medial malleoli. *Saphenous vein* is superficial in the subcutaneous plane. But *cephalic vein* is deep and needs deeper dissection. Inadvertent dissection may cause injury to brachial vessels and so one should be careful.

Procedure: Area is cleaned and draped with aseptic precautions. *Transverse incision* is made. Skin, subcutaneous tissue is incised. Vein is identified by its bluish nature. It is dissected using mosquito forceps and freed of from adjacent tissues for 2 cm. Two thread or silk sutures are passed under the vein, each with 1 cm gap. Distal thread is ligated. Aneurysm needle may be helpful for proper dissection and passing ligatures around the vein. Front aspect of the vein is opened using a scalpel blade no 11. Venous cannula or venous catheter or polythene tube or infant feeding tube with cut tip is passed adequately. Its tip is empirically adjusted to place at subclavian vein or at superior vena cava. C-arm monitoring may confirm it if needed (usually not used). Patency of the vein is

Widened ear lobule stud opening
A
Elliptical skin of the margins of the defect is removed through and through
B
Xylocaine plain and fine needle used to give local anaesthesia
C
Injecting local anaesthesia
D
Removal of elliptical skin from the defect edge
E

Figs 7-113A to E

4 zero prolene is used for suturing
Initially stay suture over the summit-
later interrupted mattress sutures infront and behind separately are placed
F
Front
Suturing front and behind separately-interrupted mattress sutures
Placing dressing
Behind
G

Figs 7-113F and G

Figs 7-113A to G: Operative steps in ear lobe repair.

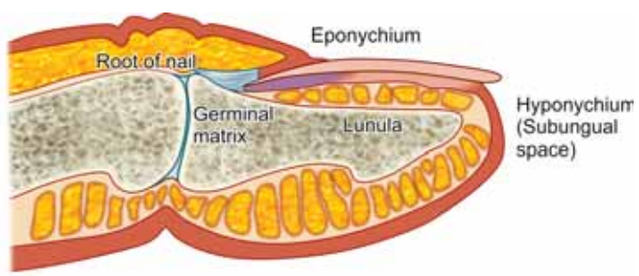
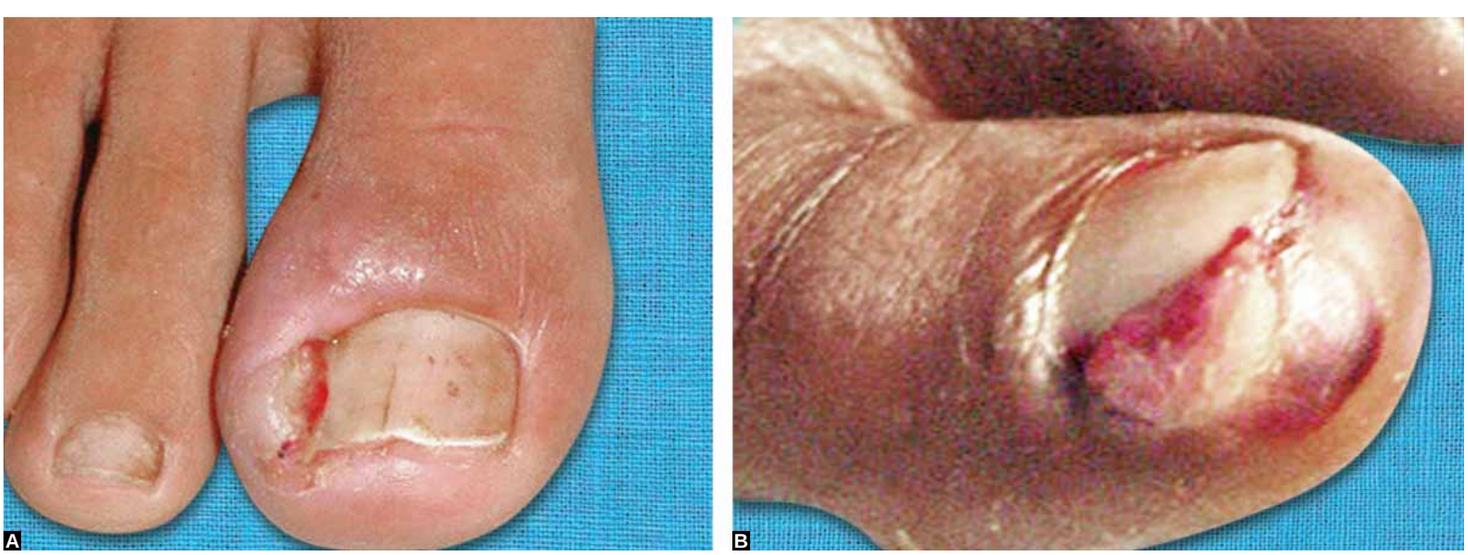


Fig. 7-114: Anatomy of the nail.

confirmed by pushing the saline and rapid flow of fluid through the drip. Proximal thread is tied around the cannula. Skin is closed and cannula is secured firmly **(Figs 7-118 and 7-119)**.

Complications-Problems—Often difficult to get vein as vein may be collapsed due to shock or vein may be thrombosed due to repeated earlier venepuncture. Thrombosis of vein, blockage, bleeding, sepsis, failure, displacement of cannula are other complications.



Figs 7-115A and B: Ingrown toe nail with hypertrophied soft tissue.

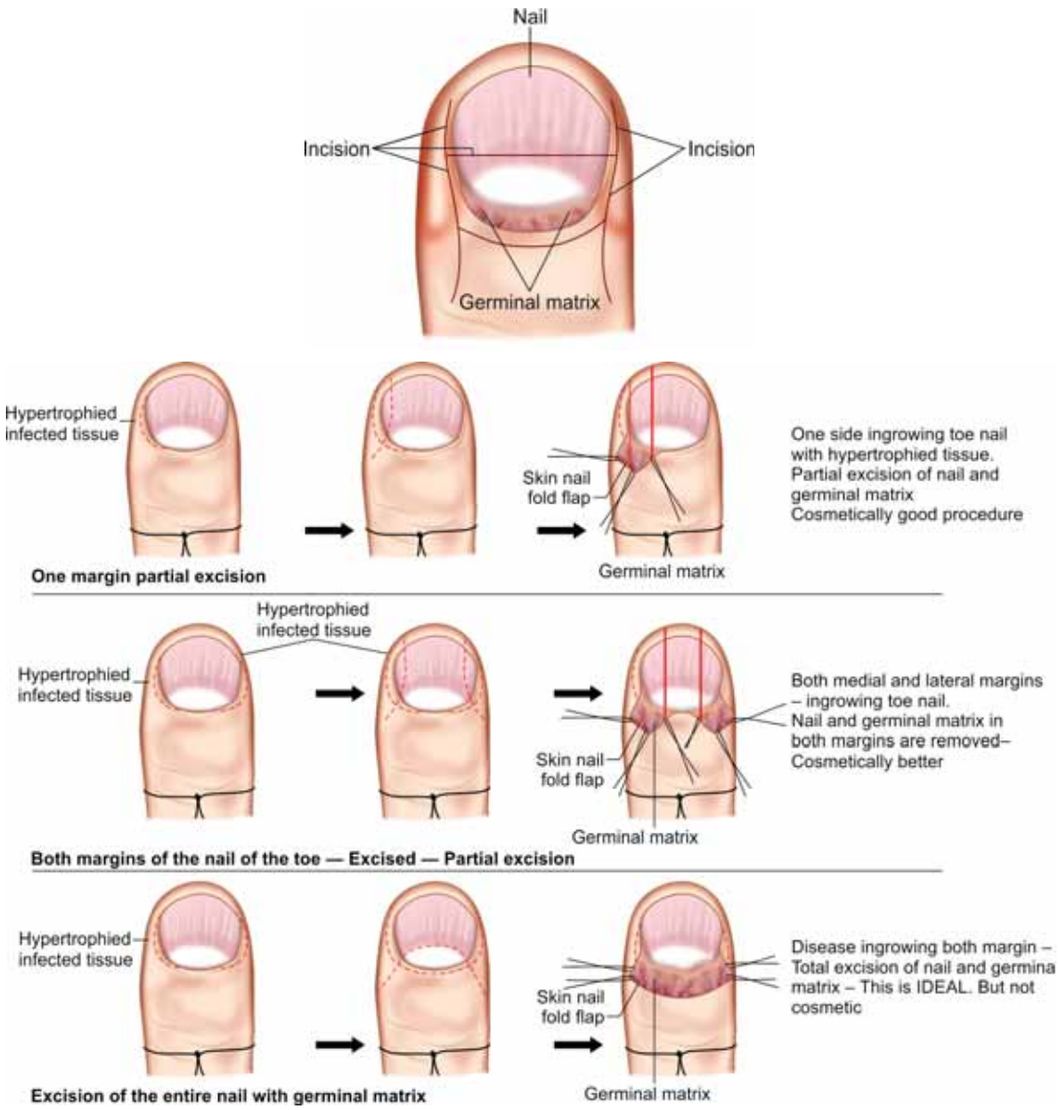

Nail
Incision
Incision
Germinal matrix
Hypertrophied infected tissue
Skin nail fold flap
Germinal matrix
One side ingrowing toe nail with hypertrophied tissue. Partial excision of nail and germinal matrix Cosmetically good procedure
One margin partial excision
Hypertrophied infected tissue
Hypertrophied infected tissue
Skin nail fold flap
Germinal matrix
Both medial and lateral margins – ingrowing toe nail. Nail and germinal matrix in both margins are removed– Cosmetically better
Both margins of the nail of the toe — Excised — Partial excision
Hypertrophied infected tissue
Skin nail fold flap
Germinal matrix
Disease ingrowing both margin – Total excision of nail and germina matrix – This is IDEAL. But not cosmetic
Excision of the entire nail with germinal matrix

Fig. 7-116: Technique of excision of nail, partial and complete with removal of adjacent or entire germinal matrix. Note the incision used for removal of the germinal matrix.

Figs 7-117A and B: Rhinophyma—typical look. Also observe after scraping/dermabrasion.

INTRAOSSEOUS FLUID THERAPY

Intraosseous fluid therapy is useful in children whenever intravenous access has failed completely. Through vascular bone marrow fluid is infused which reaches main circulation in 10 seconds. Specific needles *(Sussmane-Raszynski needle)* are available for this purpose. 18 G spinal or bone marrow aspiration needle is also can be used. Local anaesthesia is injected under the skin. Tibia is ideal site. Children *below* 5 years, *upper end of tibia* is used—anteromedial aspect just below the tibial tuberosity with direction of the needle will be *caudal*. In *children above 5 years* and in adult, *lower end of tibia* 5 cm above the medial malleolus is used. Here direction of needle will be *cephalad*. This part of the bone is thin and flat and so it is easier to puncture. Lower end is not used in children below 5 years. Intraosseous fluid flow is usually at the rate of 10-15 ml/minute **(Fig. 7-120)**.

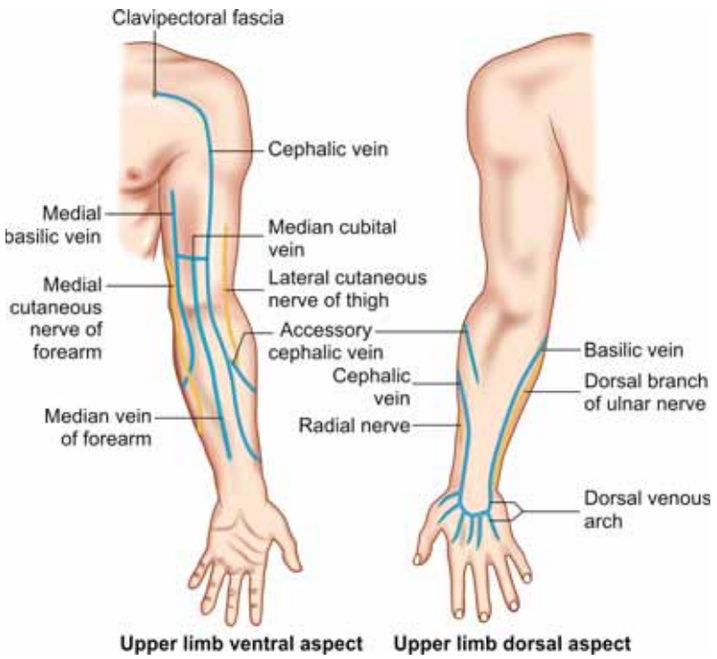


Fig. 7-118: Venous anatomy of the upper limb. *Cephalic vein* (preaxial vein of upper limb) is formed at lateral part of the dorsal venous arch runs upwards along the anatomical snuff box, lateral part of the forearm, lateral margin of the biceps brachii, lateral aspect of the arm. At lower margin of the pectoralis major, after piercing the deep fascia, it passes through deltopectoral groove, clavipectoral fascia to enter the cephalic vein. *Median cubital vein* is a large communicating vein begins from cephalic vein 2.5 cm below the elbow crossing obliquely from lateral to medial side to reach the basilic vein 2.5 cm above medial epicondyle. Median cubital vein is located in front of the bicipital aponeurosis, through which a constant perforator vein from deep veins pierces. This perforator vein fixes the median cubital vein making this vein ideal for intravenous injections, drawing blood. Median cubital vein is absent in 30% of individuals; in such occasions basilic vein is used in drawing blood than cephalic vein as it is more efficient. Cephalic vein is mainly used for venesection. *Basilic vein* is post-axial upper limb vein; begins at lateral aspect of the dorsal venous arch; runs medially along forearm, elbow, medial border of the biceps brachii, medial part of the arm. In middle of the arm it pierces the deep fascia running along the medial aspect of the brachial artery; continues as axillary vein at the lower margin of the teres major.

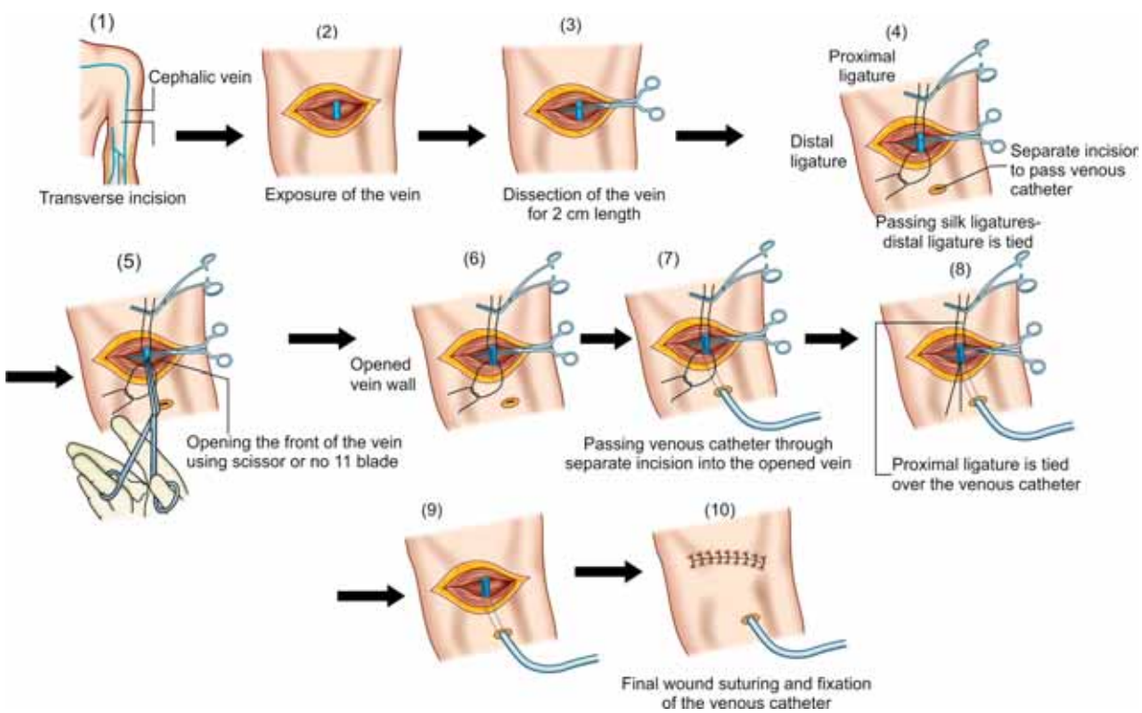


Fig. 7-119: Venesection—steps (Venous cutdown)—shown here is in cephalic vein.

SUBCUTANEOUS INFUSIONS AS FLUID THERAPY

It is rarely used but in dire time can be used only for fluid therapy. Sites used are—outer aspect of the thigh, abdominal wall, and lateral chest wall. After cleaning the wide skin area, needle is inserted (20 G needle) into the subcutaneous tissue and is connected to drip. Usual infusion rate possible is 80 ml/minute. *Problems are*—pain, swelling, infection and slow absorption of the fluid.

LOCAL/REGIONAL ANAESTHESIA

Carl Koller, an *ophthalmologist* introduced cocaine as local anaesthetic in ophthalmic practice. Mode of action: It causes temporary conduction block of the nerve, thus preventing the propagation of nerve impulse. *Advantages* of local anaesthetic agents are—It is technically simpler; general anaesthesia is avoided; patient's consciousness is retained; Patient can have food earlier after surgery.

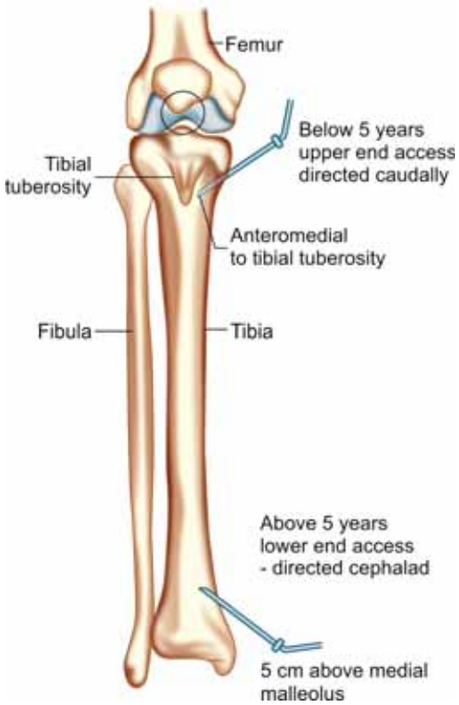


Fig. 7-120: Intraosseous fluid therapy sites.

Drugs used:

Cocaine, procaine, cinchocaine— amino esters.
Lignocaine, prilocaine, bupivacaine, ropivacaine–amino amides.

Lignocaine/lidocaine/xylocaine: It is the commonest local anaesthetic agent used. It is available as 0.25-5% concentrations. It is metabolised in the liver and excreted in the kidney as xylidines. It is also an antiarrhythmic drug and so commonly used in cardiology and cardiac surgery.

Side effects: Giddiness, headache, postural hypotension, tinnitus, circumoral anaesthesia, rarely anaphylaxis, convulsions and cardiac arrest if it becomes inadvertently intravenous.

Local anaesthesia infiltration is painful; intradermal injection of the drug is effective but much more painful. Using fine gauge needle (24 G/26 G) will reduce the pain. Adding bicarbonate into the drug increases the efficacy and reduces the pain. A combination of lignocaine and prilocaine (EMLA) topical agent prior to injecting the drug (one hour prior) prevents such pain.

Dose: 4 mg/Kg. Its effect lasts for 90 minutes.

Uses:

- Topical: 4%.
- Infiltration block: 0.5-2%.
- Field block: 0.5-2%.
- Nerve block: 1.0%.
- Epidural: 1.5, 2.0%.
- Spinal: 5%.

It can be used with or without adrenaline. Xylocaine with adrenaline (1 in 200000) has got longer duration of action. It creates relatively bloodless field. Higher dose can be injected as absorption is slow (7 mg/Kg). But it should not be used in places where end arteries are present like glans penis, ear lobule, tip of the nose, lip, fingers and toes.

Bupivacaine (Marcaine): It has got prolonged action. It is a vasodilator also. It is used as 0.25-0.5%. It takes more time to begin its action but has got prolonged action of 8 hours. Dose: 3 mg/Kg. For epidural block: 0.5%; spinal 0.5% of 3 ml solution.

Topical Anaesthesia

It is used for minor surgeries of eye, laryngoscopy, bronchoscopy, cystoscopy, gastroscopy, submucus injection. It is available as instillation, spray, viscous, ointment, gel, *EMLA* (Eutectic mixture of local anaesthetic).

Infiltration Block

Direct injection of local anaesthetic under the skin for small procedures.

Field Block

It is achieved by blocking the entire field of excision where lesion is located.

Nerve Block

- Block of inferior dental nerve and lingual nerves in the region of the mental foramen for extraction of teeth.
- Finger block of digital nerves. Here plain xylocaine is used (without adrenaline)—*digital nerve block*. It is injected just distal to web space near base of the finger on either side into palmar and dorsal digital nerves.
- Intercostal block.
- Ankle block.
- Median and ulnar nerve block.
- Brachial plexus block (Winnie's block)—It can be given through Interscalene, axillary, supraclavicular approaches. Supraclavicular approach is commonly used. 1 cm above the mid-point of the clavicle, needle is passed downwards, backwards and medially towards first rib. Once needle hits the first rib, 15-20 ml of 1.5% xylocaine is injected (with walking or stepping over the first rib). Complications are pneumothorax and injury to the great vessels.

Other Blocks

Cervical plexus block; sciatic nerve block; femoral nerve block.

Intravenous Regional Anaesthesia (Bier's Block)

Limb is exsanguinated and occluded with tourniquet. Pressure in the tourniquet must be 30 mm Hg more than the systolic pressure of the patient. Needle is placed in the selected vein. 40 ml of 0.5% xylocaine for upper limb and 80 ml of 0.25% of xylocaine for lower limb is injected into the vein. *Xylocaine with adrenaline should not be used.* It gives very good analgesia for 2 hours. Side effects: Sudden release of drug into the circulation can cause hypotension, convulsions and often death. Bupivacaine should not be used.

Indications: For upper and lower limb surgeries it can be used without general or spinal anaesthesia.

Spinal Anaesthesia

Xylocaine or bupivacaine is injected into subarachnoid space using long (disposable needles are available now) needle (***Quincke spinal needle***). It is 10 cm long with stillete inside it. Transparent hub needle is available now. 25 G/27 G needles are finer and better with lesser complications especially headache and backache. *Refer lumbar puncture* for details.

Saddle block: It is used for surgeries in perineal and anorectal region. It is spinal anaesthesia using xylocaine or bupivacaine given in sitting position. It is low spinal block.

Epidural Anaesthesia

It is a potential space between dura anteriorly and ligamentum flavum posteriorly which has got negative pressure inside. It extends from foramen magnum to sacral haitus. ***Touhy needle*** is used for epidural anaesthesia. Once the needle is in the space there will be sudden indrawing of air or saline drop. An epidural catheter is placed in the space and fixed. 2% xylocaine with adrenaline or 0.5% bupivacaine is injected into the space to achieve anaesthesia up to the desired level **(Fig. 7-121)**.

Advantages: It can be used for continuous repeated prolonged anaesthesia. It can be used for post-operative analgesia. It can be kept for several days.

Fig. 7-121: Epidural anaesthesia is being given.

Caudal Anaesthesia

Caudal space is the sacral component of *epidural space* and access is through the sacral hiatus. *Indications:* Haemorrhoidal surgery; circumcision; small procedures in the perineum like cystoscopy. *Procedure:* It is given in lateral position. Needle is inserted through the sacral hiatus to enter the caudal epidural space. Drug is then injected into the space. It takes 20 minutes to act and so surgeon has to wait for this to act. *Complications:* Trauma to anal canal, intravascular injection, failure of caudal block is common.

Chapter

8

Principles of Surgical Management in Trauma

Trauma is the major cause of death worldwide. It can be road traffic accidents, stab injuries, thermal injuries, and gun shot related injuries.

Inexperienced motor skills, alcohol consumption; aggressive driving, influence of drugs are the common factors for RTA. Gun shot injuries becoming more common due to usage of guns for fights. Gun shot can cause local injury, compression injury, cavitational injury (10 times the diameter of the bullet), burn injury. Fall from height is also a major cause as it leads into spinal injury, internal organ injury. Fall from 10 meters height has got impact velocity of 50 kph. Fall from more than 15 meters height carries more than 50% mortality. Nature of landing surface, part of the body coming into contact with the surface first, deceleration force, body's position during landing.

Trauma is categorised as group trauma like in earth quake, train accidents, fire injury, etc. or individual trauma **(Fig. 8-1)**.

War injuries are of special type could be missile wounds, low velocity missile wounds or high velocity missile wounds or blast injuries.

Dictum in trauma is '*first save life; then think of limbs; later worry about sufferings*'.

ASSESSMENT OF SEVERITY OF THE INJURY

AIS (Abbreviated Injury Scale) scoring system is used once all injuries of the patient is identified. Each injury is scored from 1 to 6. An AIS score of 6 anywhere in the body is not compatible with life. So maximum score assessed in a live patient is 5. Square of three highest AIS scores within six areas in the body – head and neck; abdomen and pelvic contents; bony pelvis and limbs; face; chest and body surface is called as *Injury Severity Score* (ISS). Maximum ISS score is $5 \times 5 + 5 \times 5 + 5 \times 5 = 75$. Glasgow coma scale and revised trauma scale [RTS = respiratory weight × 0.2908 + systolic blood pressure weight × 0.7326 + GCS (Glasgow Coma Scale) weight × 0.9368] are commonly used in head injury patients.

Trauma and Injury Severity Score (TRISS) system is used by combining anatomical and physiological injuries **(Figs 8-2 and 8-3)**.

Severe trauma may be entrapment, high speed impact, collision, fall from height of more than 3 meters, ejection from a moving vehicle and penetrating injuries.

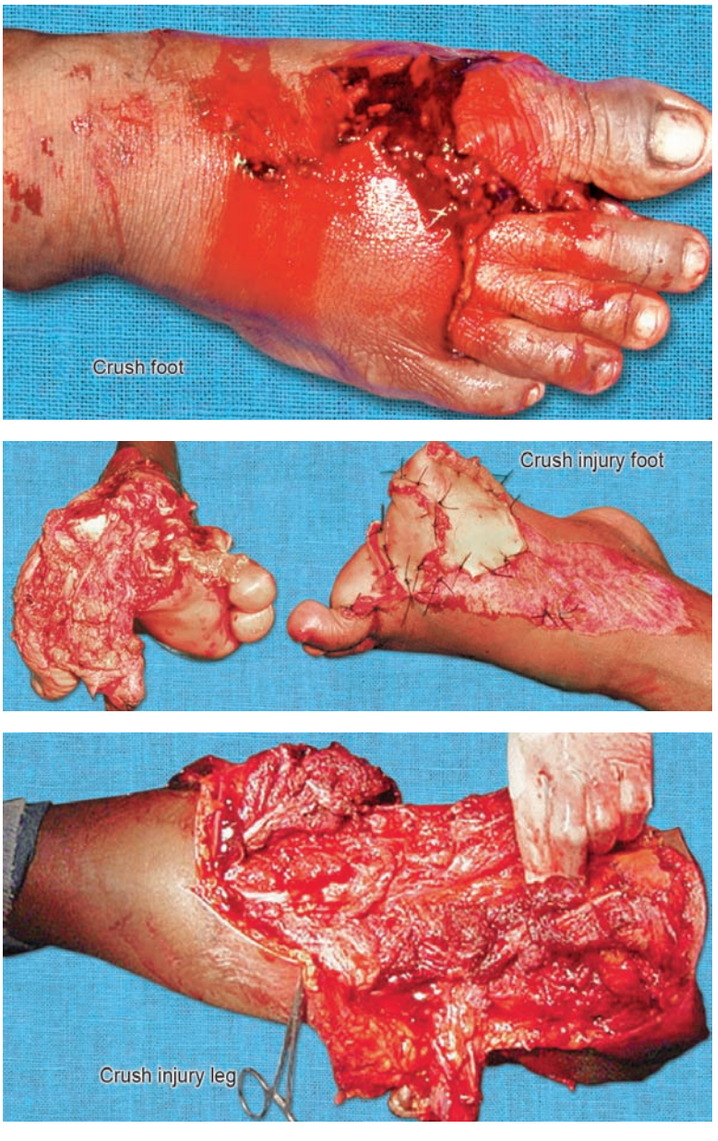


Fig. 8-1: Thorough warm saline wash is a must to all open wound. Wound excision is done by removing all devitalized tissue. Viable skin part should be retained for future reconstruction. Often such flap can be rotated as quilting into the defect area.

Fig. 8-2: Scalp trauma exposing outer table partly.

Fig. 8-3: Black eye. It may be a sign of intracranial bleed.

Baton round injury occurs during police firing in mob dispersion. It is rubber bullet/plastic compound injury occurring during police firing. It can cause bruising, lacerations or life threatening blunt injuries/penetrating injuries also. So *baton round injury* cannot be ignored.

Table 8-1: Glasgow coma scale (GSS)

Eye opening		*Verbal response*		*Motor response*	
Spontaneous	4	Oriented	5	Obeys commands	6
To Speech	3	Confused	4	Localises pain	5
To Pain	2	Inappropriate words	3	Flexion to pain	4
None	1	Incomprehensible words	2	Abnormal flexion	3
		None	1	Extension to pain	2
				None	1

Total score—15.
Mild head injury: 13—15.
Moderate head injury: 9—12.
Severe head injury: less than 8 [3—8].

Score 1—dead or dying.
Score 2—vegetative state.
Score 3—severe disability.
Score 4—moderate disability.
Score 5—good recovery.

PREHOSPITAL TRAUMA CARE

It is the initial safe resuscitation and proper arrangement and planning for transport as early as possible. It is done by police and fire service people. They should be trained for initial resuscitation. Transportation and ambulance service is essential. Well equipped ambulance should be available. Transport is done by vehicles, ambulances and helicopters. Careful transport is essential depending on the type of trauma. It is essential in spine injury, chest/abdominal/head injuries. A dedicated resuscitation team is ideal. 3 doctors, 2 nurses, 2 technicians are essential in the team with all essential facilities like central line, fluid therapy, emergency drugs, etc.

TERTIARY HOSPITAL CARE

Airway – Suctioning, clearing throat, clearing foreign bodies/dentures, oxygen, endotracheal intubation, percutaneous cricothyrotomy, tracheostomy are done, depending on need.

Breathing – Breathing is assessed and if needed intercostal tube drainage in case of pneumo or haemothorax should be inserted.

Circulation – It is assessed by pulse, blood pressure, capillary filing and monitoring. Proper perfusion and blood transfusion is needed. Two 12 or 14 G cannulas should be passed to have proper intravenous access. In difficult situations when patient is in shock with collapsed peripheral veins, long saphenous vein, cephalic vein, basilic vein, external jugular vein or femoral vein cannulation should be tried. Definitive venous cut down of long saphenous vein or cephalic vein should be done. Percutaneous puncture of internal jugular vein is also possible. Blood samples should be collected for electrolyte estimation, haematocrit, blood urea and creatinine, blood group and cross matching. Central venous catheter should be passed after that in all patients. It is passed through subclavian vein or through internal jugular vein. In children *intraosseous* route is possible to perfuse in emergency **(Fig. 8-4)**.

Initially isotonic crystalloid such as normal saline / Ringer's lactate is used. Once around 1500 ml of crystalloids are infused to bring up the volume, then colloids and blood are given. Dextrans, other

volume expanders are also used in emergency but not more than 1500 ml. It is better to give warmed fluid of any of these forms to prevent hypothermia. Intravenous warmer devices are available. If patient is responding for initial 2 liters of fluid therapy means blood loss is more than 40% suggesting severe circulatory failure. *Blood transfusions* are given to maintain haematocrit at 30%.

Fig. 8-4: Intensive care is needed in critical trauma patient.

Nasogastric tube and urinary catheter placement is a must.

Monitoring is done by pulse, oxygen saturation, urine output with a indwelling catheter in situ (should be > 1 ml / kg / hour), platelet count, coagulation factors, serum electrolytes estimation, ECG monitoring, CVP and PCWP assessment, arterial blood gas analysis.

Further assessment is done by assessing neurological status, specific injuries in head, skull base, thorax, abdomen, pelvis and fractures. CT of part is ideal investigation. Usually plain CT without contrast is done. Hypoxia, hypercapnia, hypotension are the important critical factors. Spine injury may be missed very often in initial assessment. It should be carefully assessed and if needed/suspected should be evaluated by CT imaging. MRI is not possible in initial phase of resuscitation which should be done at later period.

Often endotracheal intubation, ventilator or tracheostomy may be needed and should be utilized without any hesitation to save the life.

Adequate analgesia is important. Morphine/dimorphine/NSAIDs intramuscularly can be given. *Temporary immobilization* using proper splintage for long bone fractures reduces the pain severity. Fixation in pelvic fractures with external fixator reduces the pain. Medical anti shock trouser (MAST) is used for shock.

Three primary X-rays are done even though they have got limitations. Chest X-ray to see pneumothorax/haemothorax/fracture ribs. But 30-40% of fracture ribs will be missed in X-ray. Cervical spine lateral X-ray and pelvis anteroposterior X-rays are taken.

Ultrasound abdomen, CT of chest, pelvis and abdomen is ideal. Diagnostic peritoneal lavage (DPL) is useful in blunt injury abdomen.

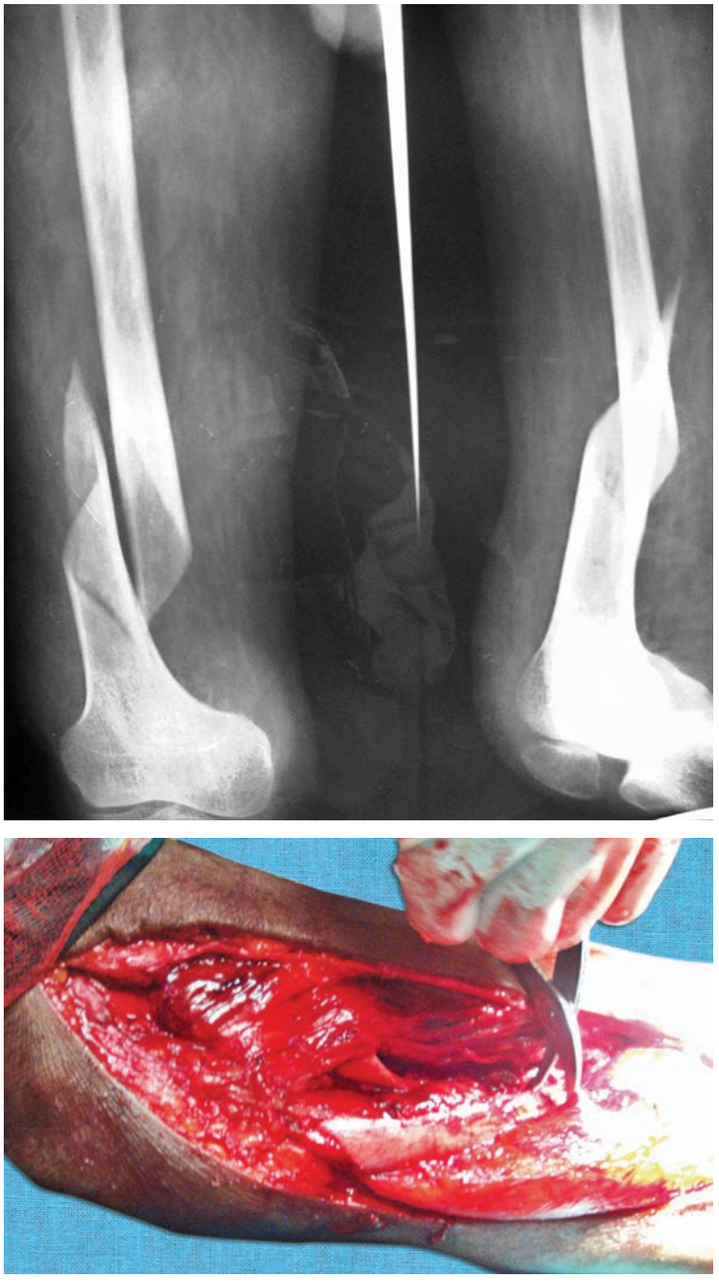


Fig. 8-5: X-ray should be taken to see the fracture. Soft tissue injury should be assessed properly.

ASSESSMENT OF THE WOUND

Size of the injury; extent of the damage – nerve, vessels, viscera, peripheral ischaemia especially in the limbs, presence of haematoma, extent of deeper injury including bones, entry wound and exit wound in missile injury are carefully assessed **(Fig. 8-5)**.

First Aid Management of the Wound

Large occlusive firm pressure dressing of the wound, compression bandage, control of haemorrhage, occasionally tourniquet application, positioning of the patient are the first aid measures often required.

Wound will be minimally contaminated in 0-6 hours; significantly contaminated in 6-12 hours; grossly contaminated in more than 12 hours **(Fig. 8-6)**.

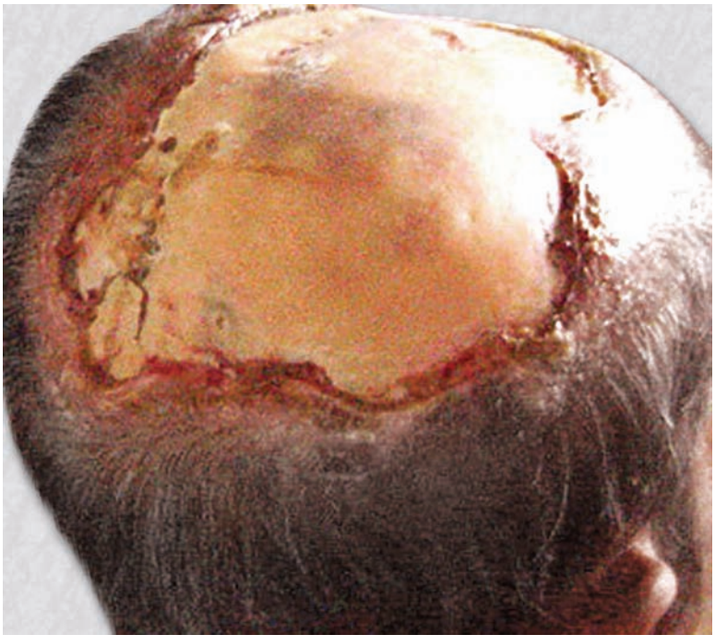


Fig. 8-6: Skull bone is exposed without any retained periosteum. Such bone will not show any granulation tissue. Burr holes in many places on the outer table allow marrow to proliferate as granulation tissue; later area is covered with flap. Care should be taken while doing burr drills to avoid injury to the venous sinuses.

WOUND EXCISION AND MANAGEMENT

Wound excision should be done under *general* anaesthesia. Local anaesthesia should be avoided. Here dead/damaged or contaminated tissues are excised. All foreign bodies should be removed. Exception for this is probably bullet injuries/pellet injuries. It is often difficult to remove a bullet or multiple pellets. They may be in close proximity to the major vessel or often difficult to identify and remove. During entry they are in high temperature and so are absolutely sterile; will not precipitate any contamination. Control of bleeding is also an essential part in wound excision.

Tourniquet during surgery (wound radical excision) is used only if it is inevitable; otherwise should be avoided as it is difficult to differentiate dead and living tissue under tourniquet. Hairs should be removed 1 cm beyond the margin of the wound. Skin and wound should be thoroughly scrubbed with soap, water and saline for 5–10 minutes until it appears clean and then area is widely cleaned with povidone iodine before draping. Proper initial irrigation of the contaminated wound often using pressure devices is important to remove dirty particles from the surface. Incision placed in the wound should be enlarged/extended liberally without any hesitation especially in penetrating wounds, war wounds, bullet wounds, crush wounds, entry wound of bullet, multiple deep wounds. Exploring the entire wound is very important. Excision is done until healthy bleeding live tissue is reached. Excision should be done by sharp dissection using knife or scissor. Underlying nerves and major feeding vessels should be protected. Skin is excised for 2 mm from the contaminated edge. There is no use in retaining the dead tissue and no point in cutting healthy skin which is again essential for future closure or reconstruction. Wound can be re-inspected for further wound excision if needed especially skin after 48 hours.

Often *flap-like injury* when found with a wide base it can be retained provided it is relatively healthy. Crushed skin may not be vital for placing. Flap should be washed, irrigated and placed over the raw area. When such flap sustenance is not sure, the flap can be cut fully, fat underneath should be cleared and sutured like a free full thickness graft. It is also possible take split thickness graft taken from the surface of such flap using a Humby's knife, can be very well placed on the defect area which often takes properly. Fat in the entire area should be excised otherwise it is a sure way of causing necrosis and contamination of the area in later period. Fascial layers should be split. Ragged devitalised part should be excised. Oedema underneath the fascial layer causes initial impairment of venous and lymphatic drainage later blocking arterial function leading into distal ischaemia, necrosis and gangrene. Lengthy liberal fasciotomy is a must in these patients. All *devitalised, dying and dead muscles* should be excised without fail. There is no reason to retain the dead muscle at all. Dead muscle is a sure way for infection like Clostridium bacteria. All haematomas should be evacuated liberally. After radical wound excision if there spurting bleeders, it should be ligated securely using fine absorbable sutures **(Figs 8-7 to 8-10)**.

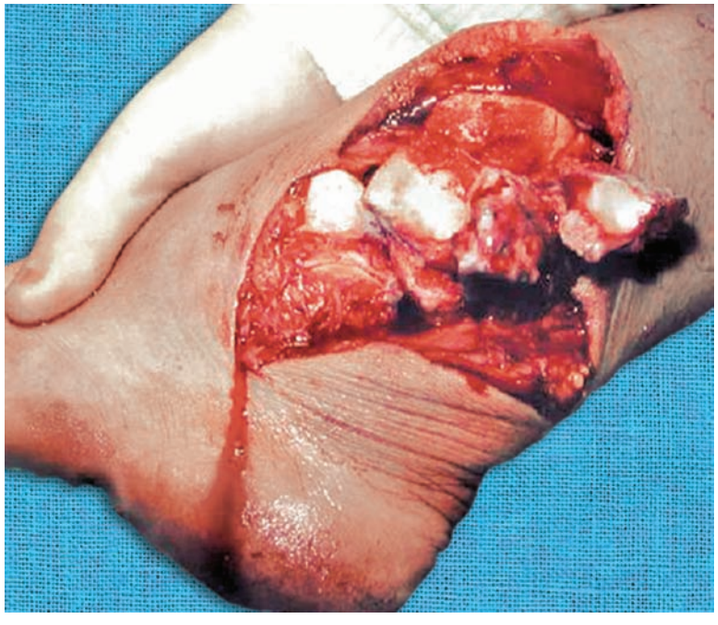


Fig. 8-7: Crush injury of ankle.

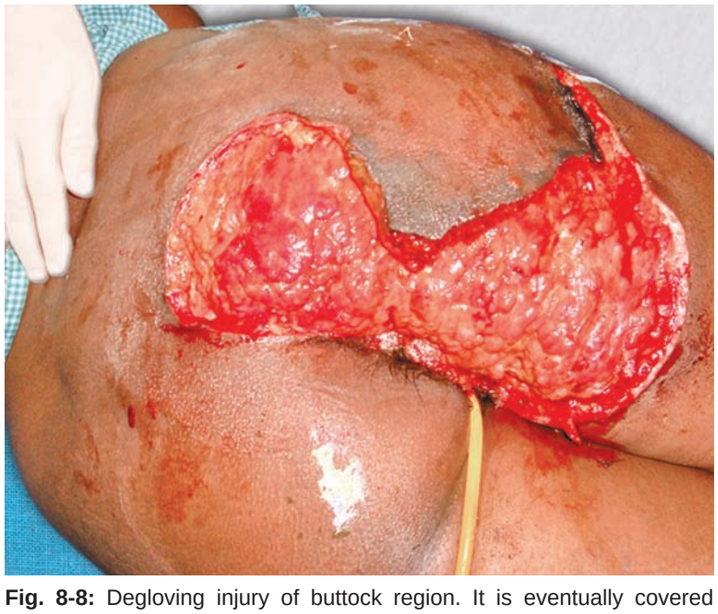


Fig. 8-8: Degloving injury of buttock region. It is eventually covered using a flap.

Fig. 8-9: Extensive injury in a child due to dog bite. Wound debridement should be done under general anaesthesia.

Fig. 8-10: Injury to the lower lip causing defect in its central part which is primarily repaired.

Nerve injury is dealt in different ways. If wound is clean and healthy it is sutured primarily with non-absorbable sutures; otherwise it is trimmed and tethered to the adjacent soft tissues loosely using non-absorbable sutures to prevent recoiling. Later once wound clean it is taken up for repair. Many nerves are injured it should be tagged in different coloured sutures for eventual identification purpose.

Exposed tendons can be left alone; but if with denuded paratenon as tendon will necrose it should be excised. Repair of tendon may be done at later period in such occasion. If it is a clean incised tendon injury then only primary repair of tendon is done.

Bone even though injured until periosteum is intact, it heals well. Skin can be covered over periosteum. If periosteum is denuded then flap is needed to cover it. Bone fixation, prevention of sepsis and flap cover is needed plan in these patients.

Joint injury needs early immediate cover to prevent from anticipated infection. Synovium should be sutured with interrupted sutures. Proper wound cleaning with adequate ideal antibiotics are mandatory.

Major vessel injury should be sutured as per vascular anastomosis rule.

Body cavities when opened by trauma should be closed. Dura should be closed by temporalis fascia graft.

Primary closure means closure done immediately after wound excision. Delayed primary closure in 5 days after wound excision. Secondary late closure is closure done after 5 days. When in doubt do not close the wound immediately—is the principle.

PRINCIPLES IN USAGE OF ANTIBIOTICS

It is a debate whether use to it or not. In minor wounds it is not necessary to take antibiotics or single intravenous dose is sufficient. In major wounds it is essential to give antibiotics intravenously; an oral antibiotic in initial phase of therapy is less preferred one than intravenous one. Intravenous penicillin or cephalosporins are given conventionally. Higher generation antibiotics are used depending on the need and contamination.

One should remember that antibiotics are not a substitute for adequate wound care. There is no short coming in proper wound care to have a good final outcome.

Gas gangrene is more common in deep ragged wounds, crush injuries, war wounds, blast injuries. Radical wound excision and closure of wound only at later period are the important preventive measures. In suspected cases anti-gas gangrene serum should be injected.

Immobilisation is often very important in major wounds even if there is no bony injury. Immobilisation improves healing; reduces the pain; possibly decreases the infection rate.

MANAGEMENT OF FOREIGN BODY

Unlike many think it is usually not an emergency procedure unless it is causing life threatening problems. Image intensifier (C-arm) should be used to remove foreign body. It should be done under general anesthesia. Tourniquet is used when it is in the limbs. Adequate incision with wide exposure is a must. Gentle finger exploration is better than of instruments as feel of the foreign body is more appreciable than through the instrument. Every foreign body need not be removed (like bullets/pellets). Even if in 45 minutes foreign body is not retrieved, procedure should be abandoned.

TRIAGE

Triage: Triage means *`To sort' in `French'*.
Triage was formulated by a committee of Trauma of the American College of Surgeons.

Advanced Trauma Life Support (ATLS) *is essential for first hour care of an inujred patient.*

Pre-hospital Trauma Life Support (PHTLS) *is to prevent deaths while injured patients are transported to the hospital.*

Types of Triage System

Multiple casualties – Staff and facilities are sufficient, net priority is given to life threatening injuries.

Mass casualties – Staff and facilities are not sufficient to manage. Here those who are likely to have highest chance of survival are given priority.

CONCEPTS IN TRAUMA MANAGEMENT

Concept of 'golden hour' to treat the trauma patient is important. Multidisciplinary approach; planning, setting up, organizing, team work; assessing respiratory system; circulation; bleeding areas – as priority; assessing also whether patient is haemodynamically stable or unstable; arranging fluids, blood, catheters, ventilator, etc. Further definitive therapy is undertaken depending on severity and site of injury.

DAMAGE CONTROL SURGERY

It includes - Resuscitation and early therapy in operation theatre itself; minimum but essential surgery to control bleeding and prevent contamination; Secondary definitive surgery at a later period to have final control.

Assessing four components

i. Physiologic response.
ii. Anatomical injury.
iii. Biomechanical injury.
iv. Comorbid factors.

Triage algorithm

STEP ONE (Assess physiological impact)
- Measure vital signs and level of consciousness.
  - By Glasgow coma scale.
  - Systolic blood pressure.
  - Respiratory rate.
  - Revised trauma score. It is based on airway, laryngeal injury, spine injury, maxillofacial injury.

STEP TWO (Assess anatomical impact)
- All penetrating injuries to head, neck, thorax, major burns, fracture bones, pelvic fractures, paralysis.

STEP THREE (Assess mechanism)
- Automobile accidents, crash or blast injuries, high energy injuries, fall from more than 20 feet.
- Bullet injury.

Contd...

Contd...

STEP FOUR (Assess history)
- Patient`s age below 5 years or age more than 55 years.
- Cardiac diseases, respiratory and metabolic diseases.
- Pregnancy.
- Patients with bleeding disorders.
- Immunosuppressed individuals.

BASED ON THE STEP CONSIDER TO SHIFT THE PATIENT TO TRAUMA CENTER & TRAUMA TEAM SHOULD BE KEPT ALERT.
It is important in multiple and mass casualities (fire, blasts, automobile accidents, train accidents).

Management includes – Goals; Primary management; Investigations; Secondary survey; Definitive care.

Tag the patient accordingly

Red colour: Immediate treatment is required.
Yellow colour: Urgent treatment is required.
Green colour: Delayed treatment is required.
Blue colour: Expectant treatment is required.
Black colour: Deceased.

Primary management - ABCDEF

AIRWAY
Chin lift.
Jaw thrust.
Nasal airway.
Oral airway.
Endotracheal intubation.
Tracheostomy.
[Assess airway patency].

BREATHING
100% oxygen.
Assess bilateral chest raise.
Assess breath sounds.
Use pulse oximetry.
Treat flail chest, pneumothorax.
Intercostal tube drainage.

CIRCULATION
Monitor vitals.
Heart sounds.
ECG.
IV fluids Blood transfusion.
Treatment of shock.
Control of external bleed.
Use two IV lines-14G/16G.]

DISABILITY EVALUATION
Neurological examination.
Glasgow coma scale.
Pupillary reaction.

EXPOSE THE PATIENT FULLY
Undress the patient.
Hypothermia assessment.

Assess injuries.
Examine joints, bones, abdomen, other systems.
Look for identification marks.

FINGERS and TUBES
Examine all orifices like P/R,P/V, etc.
Use required tubes like catheter, Ryle`s tube.

GOALS	INVESTIGATIONS
Identify life threatening conditions.	X-ray spine, chest, pelvis, extremities.
Decide and implement appropriate treatment to the area of trauma.	CT scan.
First think of salvage of life, then think of salvage of limb.	Blood group and cross matching.
Rapid assessment, rapid resuscitation, rapid stabilisation.	Arterial blood gas analysis.
Optimum, complete care.	Serum electrolytes.
Transport efficiently to higher trauma center.	U/S abdomen.

Contd...

Contd...

Categorise the patient.	
i. Deceased.	
ii. Walking wounded.	
iii. Immobile wounded.	
iv. Trapped wounded.	
SECONDARY SURVEY	DEFINITIVE CARE
Re-evaluate the patient completely again.	

NECK INJURIES

Neck is divided into zones for managing neck injuries. *Zone I* is from clavicle to cricoid cartilage. Injury here may extend into the mediastinum/thorax. *Zone II* is from cricoid cartilage to angle of the mandible. *Zone III* is above the angle of the mandible. Injury here may extend into cranial cavity or skull base; extended vascular injuries here are quite difficult to manage **(Fig. 8-11)**.

Indications for neck exploration in injuries are - Expanding haematoma; uncontrolled external haemorrhage; decreased carotid pulse; stridor, hoarseness, dysphonia, haemoptysis; severe dysphagia, odynophagia; blood in oropharynx. Vital structures in compact area make neck injury an area of priority. Penetrating injuries of major vessels (20%), trachea, oesophagus, thyroid, and nerve plexus can cause severe problems. Exact anatomical extent of the injury should be assessed. Extension into pharynx, larynx, chest or mediastinum should be thought of. Anterior triangle injuries pose a high threat than posterior triangle injury. CT neck is the ideal investigation for neck injuries. One must also think of possible injuries like Le Fort facial injuries; cervical spine injuries; skull base injuries which should be assessed clinically and radiologically properly before jumping into hurried intervention.

Treatment

Patient with aerodigestive and vascular injury needs neck exploration. It is the exploration of the neck rather the wound as such is important. Oblique incision along the anterior border of the sternomastoid is done in unilateral injury. Bilateral connecting collar incision along the anterior borders of the both sternomastoid muscles is used for bilateral injuries of the neck **(Fig. 8-12)**.

Intraoperative endoscopy to identify injuries of trachea and oesophagus is beneficial. Methylene blue instillation into the oesophagus will identify the oesophageal tear. Neck is explored with adequate incision under general anaesthesia. Suturing of the injured structure like carotid, oesophagus, trachea, muscles, etc. is done. External carotid artery can be safely ligated. Internal carotid or common carotid requires repair often using vein or PTFE graft. Tracheal injury up to two rings can be repaired primarily using interrupted non-absorbable sutures like polypropylene. Loss of more than two rings needs tracheostomy. In laryngeal injuries cartilage fractures should be reduced; mucosal lacerations should be sutured. Oesophageal injury if identified within 12 hours of injury is repaired primarily in two layers of interrupted PDS/vicryl with nasogastric tube in situ. Drain to the wound is a must. Injury identified after 12 hours of trauma or extensive injury of cervical oesophagus needs; initial cervical oesophagostomy and later reconstruction. Often total oesophagectomy with gastric/jejunal colonic interposition may be needed. Antibiotics, blood transfusion, nasogastric tube passing—as required.

THORACIC TRAUMA

Thoracic trauma is the cause of 25% of all trauma deaths. Cardiac injury is the cause for early deaths. Airway obstruction, tension pneumothorax, massive haemothorax, cardiac tamponade are other causes of death which are actually preventable in *golden hours*. Chest trauma causes *hypoxia, hypercapnia and acidosis*. Chest X-ray,

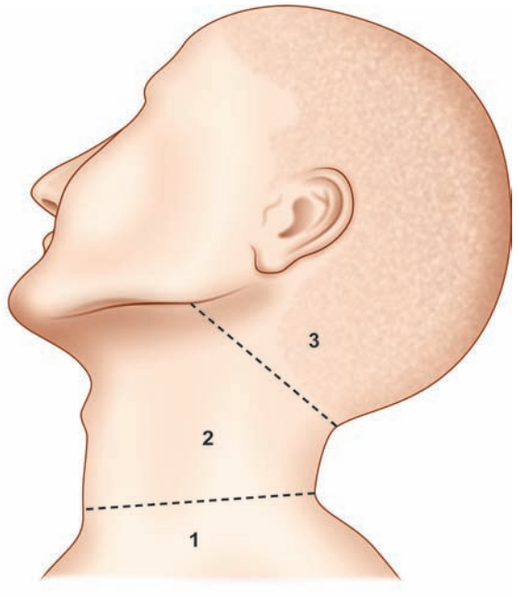


Fig. 8-11: Neck zones used in neck trauma.

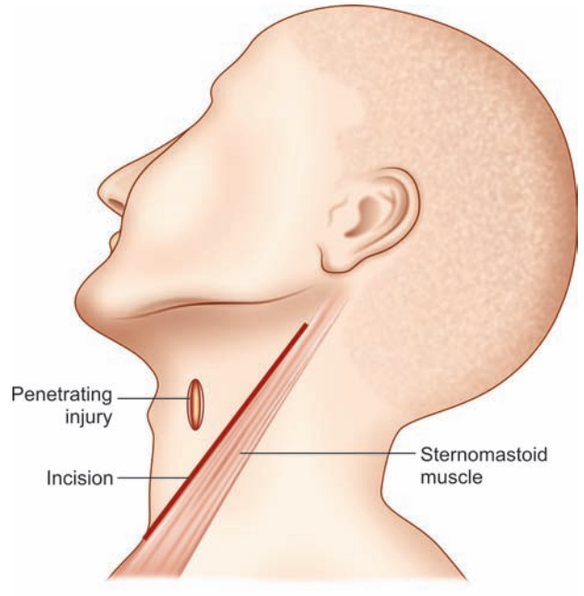


Fig. 8-12: Incision in neck trauma is oblique one along the anterior border of sternomastoid muscle.

CT chest and ultrasound chest are diagnostic methods in chest trauma. But in severe critical cases one should not wait for these investigations. Instead it is better to take up straight a way the therapeutic parts like *intercostal tube drainage* (tube thoracostomy), aspiration of tension pneumothorax and cardiac tamponade.

The thoracostomy (ICT drainage) is done in midaxillary line in 6th intercostal space. In slight head up position, after injecting xylocaine 1% local anaesthesia, 1 cm incision is made in the space in lower part of the space to avoid injury to the intercostal vessels. External and internal intercostal muscles are split; pleura is opened; finger is inserted and blunt finger dissection is done; mattress stay suture is loosely placed using polyethylene suture; 40 French IC tube with end and side holes is introduced. Tube is directed above and posteriorly. Tube is secured to the skin by tying the tube. Tube is connected to under water seal apparatus. If pre-insertion suture is not placed, suture is placed later after inserting the tube. Postoperative air column movement is observed. *Absence of air leak; fluid drain less than 100 ml/day; chest X-ray* if shows adequate expansion then tube can be removed safely.

Twenty percent of chest trauma patients *need thoracotomy* and definitive repair of injured intrathoracic structures. *Indications are* – massive haemothorax with more than 1500 ml of blood in ICT when passed or hourly drainage if more than 300 ml/hour; pericardial/cardiac injuries; thoracic cage open wounds; thoracic vascular injury; tracheobronchial tree injury; oesophageal injuries. All these indications are critical and life threatening situations. But still if proper cardiothoracic set up is available and timely intervention is done, life can be saved **(Fig. 8-13)**.

Fig. 8-13: Open communicating wound in thorax/chest wall.

Rib fractures are the commonest type of chest trauma. But commonly it does not cause problem unless there is haemothorax or pneumothorax. 4th to 10th ribs are commonly fractured. Rib fracture causes severe *pain, reduces the ability to cough, and reduces vital capacity causing atelectasis and pneumonia*. Pain on *inspiration* is the main feature in rib fracture along with *crepitus.* Proper pain control is essential using intravenous analgesics, epidural analgesia. *Flail chest* (15%) with fractures in two or more ribs, with each rib having two or more fracture sites causes chest wall instability → paradoxical movement of the chest wall (during inspiration flail segment is drawn in) → pendular movement of the air → mediastinal flutter → sudden kinking of great vessel → respiratory failure and cardiac arrest. It can be anterior, lateral or posterior. Pain and pulmonary contusion is common. Endotracheal intubation, ICT placement, tracheostomy, prevention of movements of flail segment is needed.

Pulmonary contusion is a different typical recognised entity. It can be commonly due to blunt trauma or often due to penetrating injury. It commonly causes respiratory failure. So along with management of mechanical problem, respiratory problems also should be dealt with carefully. Arterial blood gas analysis is a must. *Measures are*—Crystalloid infusion, oxygen support, avoiding fluid overload, maintaining the tissue perfusion, blood transfusion, ventilator support, transfusion of packed cells and blood products.

Pneumothorax – It can be *small* pneumothorax with volume loss is 1/3rd of normal lung volume*; large* pneumothorax with complete collapse of the lung on one side but without any tracheal/mediastinal shift; *tension* pneumothorax which is a critical emergency situation with tracheal mediastinal shift towards opposite side causing *hypotension* decreased cardiac venous return and cardiac arrest and acute respiratory distress or *open pneumothorax* with a large chest wall *sucking open wound*. Pneumothorax needs ICT placement in 4th space in midaxillary line. Tension pneumothorax needs emergency placement of *wide bore needle in midclavicular line in 2nd intercostal space* with a glove finger placed over the hub of the needle to prevent air getting sucked inside during expiration; later ICT should be placed. Open pneumothorax needs open *surgical closure* of the chest wall defect with an ICT in place **(Fig. 8-14)**.

Haemothorax – 80% of haemothorax is treated by ICT placement. Remaining 20% needs thoracotomy and control of bleeding like resection of lung.

Pulmonary injury - Small lacerations of the lung are common but are treated with ICT. 10% of patients will have large significant lacerations with massive air leak through ICT. It needs thoracotomy, lung sparing resections like nonanatomic resection or tractomy using stapling device. Extensive lung injury occasionally needs lobectomy or pneumonectomy as life saving measure. Persistent air leak in ICT may be due to broncho-pleural fistula.

Tracheobronchial tree injury is difficult to mange. It needs initial bronchoscopy to identify the site and extent. Later thoracotomy is done to explore entire tracheobronchial tree, depends on the side of injury. Small injury heals spontaneously. Injury more than 1/3rd of

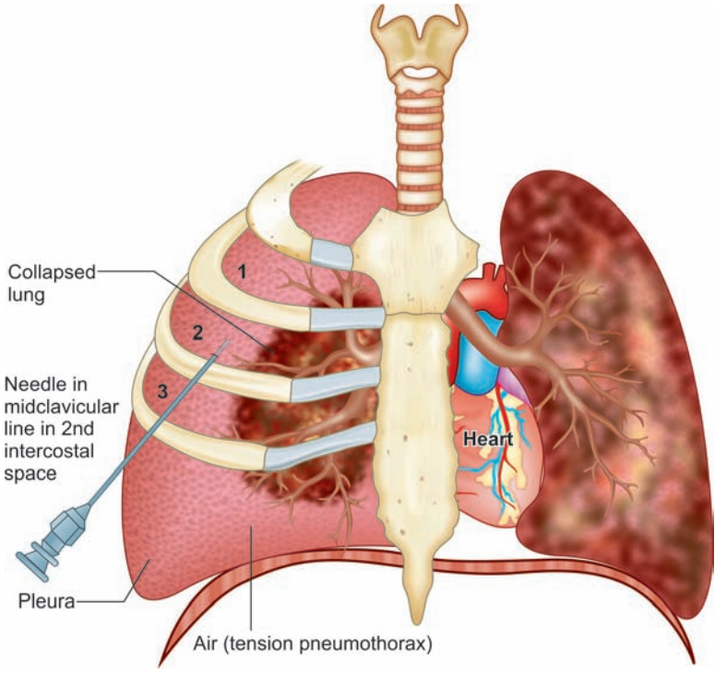


Fig. 8-14: Emergency aspiration through 2nd intercostal space in midclavicular line is life saving measure in tension pneumothorax.

the circumference of the tracheobronchial tree needs primary repair using polypropylene interrupted sutures with selective intubation of the opposite bronchus. Collapse of lung, stricture of tracheobronchial tree, pneumonia and septicaemia are distressing complications.

Cardiac injury – Blunt injury to anterior chest wall causes cardiac trauma. It may be minor contusion of the wall, major contusion, cardiac chamber rupture, haemopericardium and death. Right ventricle is commonly affected as it lies near to the anterior chest wall. If patient reaches the hospital it is diagnosed by US chest, echocardiography, CT chest and ECG. ECG and raised serum troponin I level suggests early or late myocardial damage. *Treatment* in small contusions continuous ECG monitoring and observation. Major injuries need *urgent thoracotomy* and surgical repair by cardiac surgeons. *Pericardial tap* may be helpful in haemopericardium. Mortality rate is more than 80% in major cardiac injuries. During admission if pulse is felt survival rate increases to 70% with proper intervention and care. Even cardiac tamponade due to haemopericardium needs early open surgical intervention as tamponade itself is a temporary natural haemodynamic compensatory mechanism.

Oesophageal injuries – Thoracic oesophageal injuries are rare as it is located in posterior mediastinum. It occurs due to deep penetrating injuries. It is often difficult to diagnose. It is always associated with other thoracic injuries. Oesophagoscopy and oesophagography, increased oesophageal pressure, CT chest may reveal oesophageal injury. Problems with oesophageal injury are – empyema, mediastinitis and septicaemia. If identified within 24 hours of trauma, early debridement, primary repair, and drainage with nasogastric placement is the treatment. If identified after 24 hours, mediastinal sepsis is likely and so needs diversion with cervical oesophagostomy, feeding jejunostomy, oesophageal resection, later colonic/gastric transposition.

Diaphragmatic injury can occur in thoracic or abdominal injuries. It can be diagnosed by CT scan. But more often it is identified during laparotomy or thoracotomy. It is sutured using interrupted horizontal mattress sutures with polypropylene sutures.

ABDOMINAL TRAUMA

Abdominal trauma is a major emergency surgical problem which surgeons face. It is often associated with head, chest, pelvic and bone injuries. Often patient may be unconscious causing difficulty in diagnosing the condition. Often while giving more importance to other systems like head, thorax and bones and abdominal injury is not addressed properly causing life threatening consequences. When patient is conscious, history related to abdominal trauma is useful. Abrasion over the abdominal skin suggests possibility of internal injury *(London's sign)*. Distension, tenderness, rebound tenderness, fullness and dullness in the flank, when present one should presume internal injury. Tachycardia, hypotension, shock may be evident when there is significant haemoperitoneum. Injuries may be organ injuries like of liver, spleen, kidney, pancreas. etc; or bowel injury or retroperitoneal injury which is often under diagnosed or missed. Major vessel injury like inferior vena cava, mesenteric vessels can cause real threat to life unless it is identified and managed early. 25% of entire trauma patients need surgical exploration of the abdomen.

Abdominal trauma can be *blunt or stab/penetrating or abdominal wall injuries*. Spleen is the commonest organ involved in *blunt trauma*. Often in blunt trauma first part of the jejunum or ileocaecal junction gives way (blow out effect) due to traction causing often complete transection of bowel horizontally close to the junction. It is due to force of the mobile part of the bowel over fixed part of the bowel. Liver is the commonest organ involved in *penetrating injuries* **(Fig. 8-15)**.

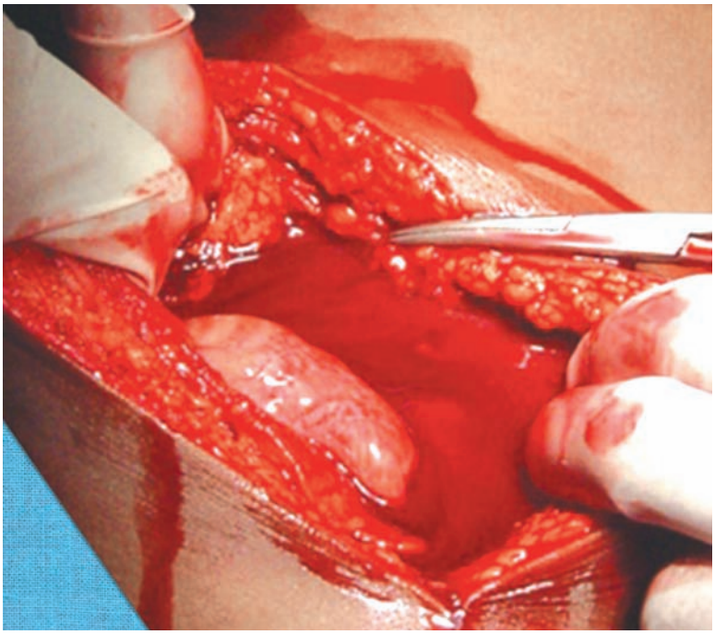


Fig. 8-15: Haemoperitoneum on table.

Injuries of the abdomen may be *closed injuries, compression injuries and penetrating injuries*. Penetrating injury may be low velocity injury like stab or high velocity injury like gunshot injury. Blunt weapon penetration causes lesser deep trauma than sharp weapon trauma (sickle, knife). In sickle injury tip and sharp edge moves in curved pattern and so it is often difficult to predict the depth, track and organs injured **(Figs 8-16 and 18-17)**.

Fig. 8-16: Penetrating injury of the abdomen and chest right sided. Patient fell over a tree which had its top end cut. Tree has penetrated into her abdomen and chest wall. Patient was brought after cutting the tree from its root. Patient survived after surgery.

Fig. 8-17: Stab wound in the abdomen with omentum protruding through the wound.

Blunt trauma is common in accidents. It is often missed or lately diagnosed. Ultrasound / CT abdomen or diagnostic peritoneal lavage (DPL) is useful. In many cases on clinical grounds direct exploratory laparotomy is done. Plain X-ray abdomen may show gas under diaphragm.

Difficulty arises in *deciding about the need for laparotomy* in abdominal trauma in *unconscious* patients. If external injury is not severe in proportionate to the existing severe shock then exploratory laparotomy is indicated in an unconscious patient. It is also often difficult to diagnose bowel injury in such patients. If it is suspected laparotomy should be undertaken in such patients.

Routinely followed indications in abdominal trauma are – hypotension without any other cause; bleeding through wound; continuous bleeding from nasogastric tube; evisceration of abdominal content through the open wound except in case of protruded omentum without any hypotension and features of peritoneal irritation; air under diaphragm in blunt abdominal injury (not in penetrating injury as external air gets sucked into the peritoneal cavity through the wound).

Ultrasound abdomen is very useful, simpler, non-invasive method of evaluating the abdomen. Negative ultrasound means no immediate further work is needed and also can be treated conservatively. *Advantages of ultrasound are* - there is no danger of radiation; it can be done at bedside; it can be repeated many times; it is cost effective. It is less useful in obesity, with gas interposition, intraperitoneal fluid less than 500 ml; retroperitoneal injuries and bowel injuries. Its sensitivity is 90%; specificity is 98%. Focused Abdominal Sonar (ultrasound) for Trauma *(FAST)* is very useful method. FAST is rapid, noninvasive, portable bedside method of investigation focusing on pericardium, splenic, hepatic and pelvic areas. Blood more than 100 ml in cavities can be identified. It is not reliable for bowel or penetrating injuries. It often needs to be repeated.

Diagnostic peritoneal lavage (DPL) (by Perry) is useful in *blunt injury* abdomen. It is not very useful in penetrating injury, bowel injury, retroperitoneal and pelvic injuries. It is the *procedure of choice in physiologically unstable patient* with blunt abdominal injury (like with spinal injury, unconscious patient, in situations where clinical signs cannot be interpreted, where injuries of more priority are in other areas like head or chest). 10 French polyvinyl catheter is used. Urinary bladder is emptied by passing a catheter. After injecting xylocaine local anaesthesia in subumbilical region, 2-3 cm vertical subumbilical midline incision is made. Skin, linea alba is incised. Local anaesthesia is infiltrated into the peritoneum again. Peritoneum is held with two haemostats and a purse string suture is placed using polylactic acid absorbable suture material. Peritoneum is incised for 3 mm length. Catheter (standard peritoneal dialysis catheter) is introduced into the peritoneal cavity. If blood enters the catheter immediately, it means early laparotomy is needed and carried out without continuing the peritoneal lavage. If otherwise, one liter of normal saline is infused into the peritoneal cavity rapidly in few minutes through the catheter using a drip set with elevation of the fluid bottle/bag. Patient is moved well to mix the fluid in all four quadrants. Now bag is lowered below so that fluid from the peritoneal cavity reenters/siphoned into the bag. Collected fluid is analysed for red cells, leukocytes, etc. (see box). DPL may not be useful in bowel injury, retroperitoneal injury, diaphragmatic injury, organ haematoma (subcapsular splenic haematoma). If patient is decided for observation catheter can be left in situ for repeat DPL after 6 hours. One has to remember that DPL is not a substitute for clinical assessment and monitoring. In *Lazarus–Nelson approach* Teflon catheter with a guidewire is used **(Fig. 8-18)**.

Diagnostic Peritoneal Lavage (DPL)

Significant positive lavage –
- 10 ml of gross blood.
- Red cells more than 1, 00,000/cu mm.
- WBC count more than 500/cu mm.
- Amylase more than 175 ml/dl.
- Presence of bacteria, bile, food particles, foreign body.

Indeterminate lavage –
- Red cells between 50,000 to 1, 00,000/cu mm.
- WBC between 100 to 500/cu mm.

Lavage not significant –
- Red cells less than 50,000/cu mm.
- WBC less than 100/cu mm.

Strongly positive means –
- Red return solution in the bag.
- Always needs laparotomy.
- Features mentioned above.

Weakly positive means –
- Pink or just red tinged fluid.
- Laparotomy chances are 10%.
- Observation / repeat investigations/repeat DPL later.
- Retroperitoneal haematoma may be present.

Lavage negative –
- Return fluid is crystal clear.
- No need of laparotomy here. Patient is observed.

False positive
Occurs when bleeding from retroperitoneum into peritoneal cavity occurs. It may lead into negative laparotomy.
Abdominal wall bleeding into the peritoneal cavity can cause false positive result.

Contraindications for DPL –
- When laparotomy is indicated definitely.
- Previous laparotomy history.
- Pregnancy and obesity.

CT scan of abdomen is most commonly used and better investigation for abdominal trauma. It is useful in blunt/penetrating trauma, suspected pancreas, spleen, liver, duodenal, retroperitoneal injuries. Smaller injuries, early haemoperitoneum are better detected. It is non- invasive, highly specific, highly accurate (96%), with low false positive/low false negative, non-invasive. It is very essential investigation when solid organ injuries are treated nonoperatively. Three dimensional helical CT is needed to identify mesenteric or bowel injury and to find out site of injury. It is obviously not necessary to do CT when there is clear indication for immediate laparotomy. In such occasions ultrasound is more than sufficient.

Other investigations are - (1) *Abdominal diagnostic paracentesis* (Drapanas and McDonald): Here 18 G short bevel spinal needle is inserted into the peritoneal cavity after injecting local anesthetic agent into the abdominal wall. With continuous suctioning through syringe needle is passed at various sites. Positive tap means return of minimum of 0.1 ml of nonclotted blood. False positive result occasionally can occur due to needle puncture of abdominal wall vessels. Needle should not be inserted close to previous abdominal scar as bowel may be adherent underneath the scar. Change of direction of needle is done by withdrawing the needle tip outer to peritoneum and again puncturing the peritoneum. Puncture of non-distended bowel will seal without

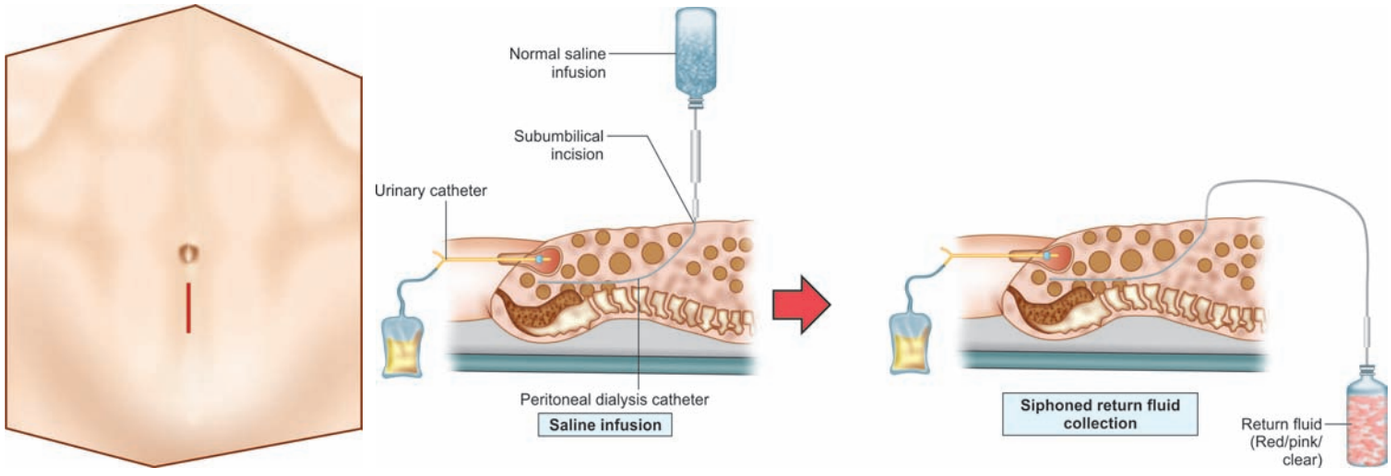


Fig. 8-18: Diagnostic peritoneal lavage - incision and technique.

any leakage in 18 G needle. If there is distended bowel peritoneal tap should be avoided **(Fig. 8-19)**. *Bilateral flanks tap/four quadrant tap* is also done with similar result. Rectus sheath haematoma and false negative results are problems **(Fig. 8-20)**. (2) *Diagnostic laparoscopy* is very useful. It can be done under local anaesthesia. Haemoperitoneum and solid organ and diaphragmatic injuries are well assessed. But bowel and retroperitoneal injuries are more likely to be missed. (3) *Arteriography* through Seldinger technique is useful in suspected cases of renal arterial injury (thrombosis/spasm); intimal tears, traumatic aneurysm and aortic occlusion (after seat belt injury) are well diagnosed with arteriography. Often it can be therapeutic also. Pelvic bleed extending into retroperitoneum is not uncommon which can be assessed by arteriography to identify the bleeding vessel. But venous bleed cannot be assessed by this. (4) *Doppler assessment of major vessels* may be beneficial especially for IVC, aorta, iliac vessels, portal system; but with haemoperitoneum visualisation window may be poor and vessels can be better identified by contrast CT scan.

Management Concepts in Abdominal Trauma

Evaluation of extent of the injury; number of organs injured and severity; haematocrit assessment (haemoglobin drop up to 6 gm% is tolerated well with adequate tissue oxygenation. Rapid drop of haemoglobin needs adequate number of blood to be kept ready like 5/10/more); central line with volume replacement; urinary catheterisation; systemic antibiotics administration.

Autotransfusion of blood is very useful in such situation as a life saving procedure. Blood from the cavity is sucked out into a sterile bottle which contains 150 ml of 3.8% sodium citrate dextrose solution. This blood is strained/filtered through gauze and retransfused. If there is colonic and small bowel injuries autotransfusion is not possible in fear of sepsis due to contamination.

Upper midline incision extending down across the left of the umbilicus is the preferred incision. But surgeon should not be hesitant to extend into the thorax or make horizontal T or as needed depending on the internal organ injury **(Fig. 8-21)**.

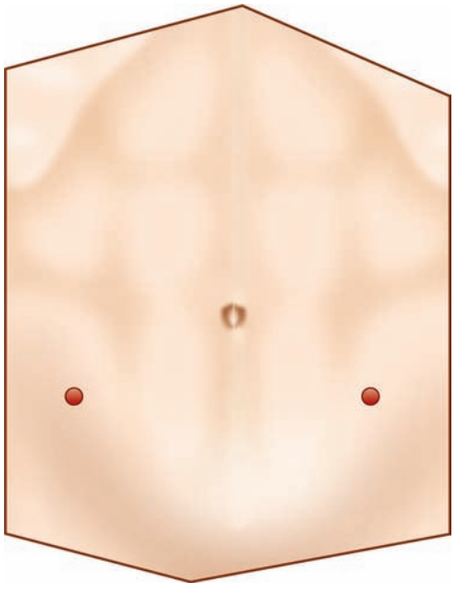


Fig. 8-19: Abdominal paracentesis.

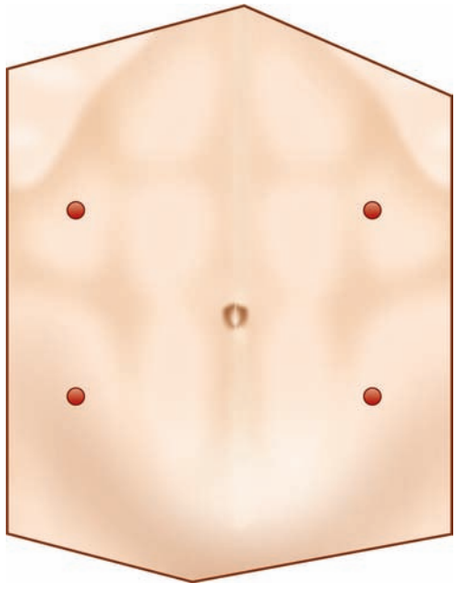


Fig. 8-20: Four quadrant aspiration of the abdomen.

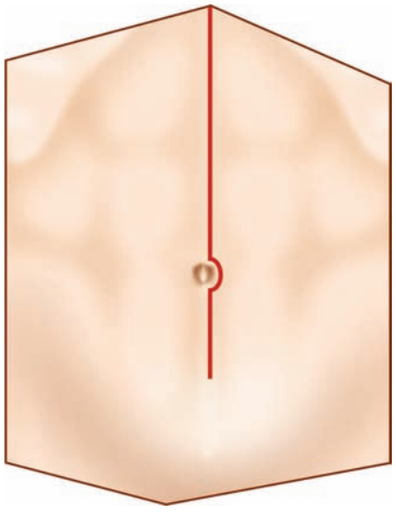


Fig. 8-21: Lengthy midline incision with extension on the left side of the umbilicus is used.

First priority after opening the abdomen *is immediate control of profuse bleeding using finger or mop* or pressure. Later once field is clean; area is assessed for the extent of the injury without releasing the compressed finger on the bleeding site. A vascular clamp or bulldog clamp is helpful in such situation. Once it is applied over the site of bleeding, compressing finger can be removed. Vascular suturing using 4 zero or 6 zero polypropylene/resection of the tissue; reconstruction of the area; persistent pressure mop in situ with closure of the abdominal wall with an option for second look surgery in 48 hours are different options. Individual organs are assessed and graded for injuries and managed accordingly.

During laparotomy entire abdomen should be inspected/palpated carefully for any additional missing injuries. Lesser sac, retroperitoneum, duodenum, pancreas and diaphragm should be checked for. Often peritoneum on the margin of the duodenum and right side colon is incised to and duodenum and colon are reflected medially to visualise the retroperitoneum. Pelvic structures need special attention. Rectum and urinary bladder injuries may be missed. If on catheterisation, urine is clear it means usually urinary system is normal. Portal venous system should be assessed.

Resection or repair should be decided afterwards once haemostasis is maintained. Whether injury to bowel or organs (liver/spleen/kidney, etc.) resection or repair approach is decided depends on the individual organ injury (based on scale or grade) severity.

Mesenteric tear may be the cause for haemoperitoneum. Tear may be perpendicular or parallel to the bowel. If it is perpendicular, haemostasis and approximation of the mesentery is sufficient; if it is parallel tear, then blood supply to corresponding bowel may be compromised and resection of that part is indicated. When mesenteric haematoma is small and non-progressive, it is left alone. Colour changes if any in the adjacent bowel should be observed. If haematoma is large and is progressive causing compromised blood supply of the adjacent bowel, then it should be gently evacuated. Mesenteric leaf is opened using curved scissor; using gentle finger dissection clot is evacuated; bleeder is identified and ligated. If there is compromised bowel function, it should be resected. Bleeding from the major vein like superior mesenteric vein is disastrous as tear may not be localised but may be extensive; even during gentle dissection and may cause more tear. It is carefully mobilised; vascular clamps are applied and repaired using 5 zero polypropylene sutures **(Figs 8-22 to 8-24)**.

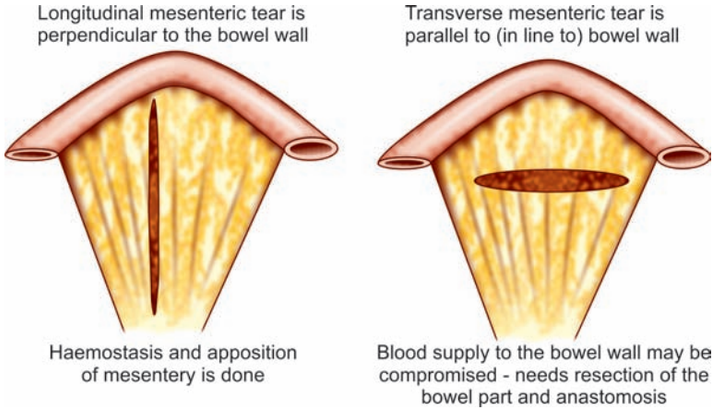

Longitudinal mesenteric tear is perpendicular to the bowel wall
Transverse mesenteric tear is parallel to (in line to) bowel wall
Haemostasis and apposition of mesentery is done
Blood supply to the bowel wall may be compromised - needs resection of the bowel part and anastomosis

Fig. 8-22: Transverse mesenteric tear is risky as it may compromise the blood supply of adjacent bowel. In such tear adjacent bowel should be resected.

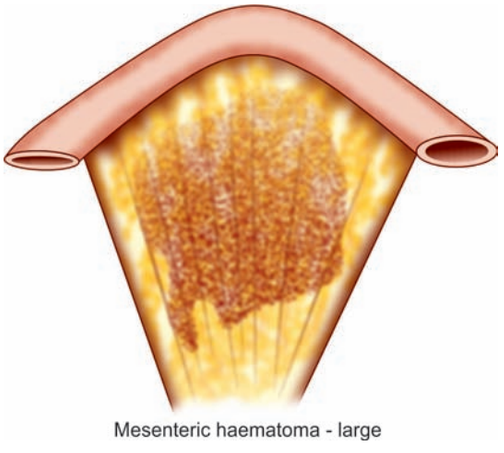


Fig 8-23: Large mesenteric haematoma which is progressive needs to be intervened. Gentle evacuation by finger dissection and ligation of bleeding vessel is the option.

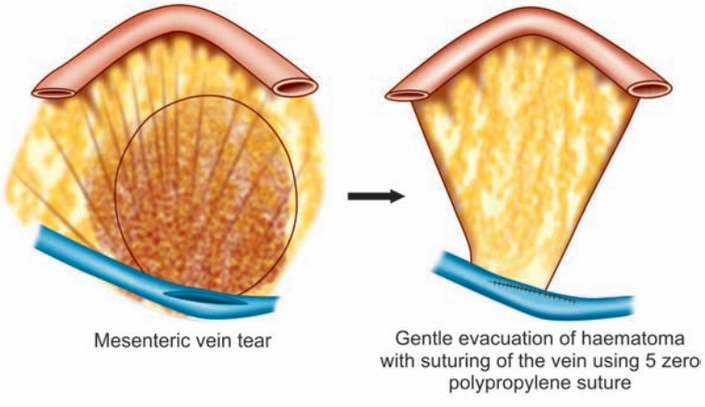


Fig. 8-24: Major mesenteric vein tear should be sutured using 5 zero polypropylene. Vascular clamps should be used to control bleeding. Gentle approach is needed as tear may extend and get worsened.

Aortic Clamping

Catastrophic bleeding found after opening the abdomen which cannot be controlled and bleeding with profound hypotension are the indications for aortic clamping. Profuse intraperitoneal bleed comes

under control temporarily by tamponade effect of tense abdominal wall and it itself temporarily helps to the patient. The moment abdomen is opened tamponade is released causing further rapid bleed leading into critical catastrophe. If such event is expected prior to opening the abdomen a very quick rapid thoracotomy (*prelaparotomy thoracotomy*) through left 5th intercostal space is done; left lung is deflated and displaced; pleura over the thoracic aorta is incised; aorta is dissected using finger; vascular clamp or soft intestinal occlusion clamp is applied to occlude the thoracic aorta. Later laparotomy is performed to go ahead with management of the bleeding. If profound bleeding is observed after laparotomy necessitating the aortic clamping, it is done by applying the clamp in infradiaphragmatic part of the aorta. Peritoneum is incised on the right of the abdominal oesophagus in infradiaphragmatic area; aorta is dissected using finger high up close to diaphragm to avoid injury to celiac plexus; clamp is applied across (infradiaphragmatic aortic occlusion) **(Figs 8-25A and B)**.

Usually drainage using tube drains on either side of the abdomen is used even though it is controversial. ICT should be placed if thoracotomy is also undertaken.

Jejunostomy for enteral nutrition is ideal in all major abdominal injuries. Often gastrostomy is also done along with jejunostomy in case of duodenal and pancreatic injuries.

LIVER INJURY

Liver is the commonest organ injured in penetrating abdominal trauma. Mortality is 10%. It is less in isolated liver injury but increases up to 25% when it is associated with other injuries.

Grade and type	*Injury*
I – Haematoma – Laceration	Subcapsular haematoma less than 10% surface area. Capsular laceration less than 1 cm in depth.
II – Haematoma – Laceration	Subcapsular haematoma 10-50%; intraparenchymal less than 10 cm diameter. Capsular laceration 1-3 cm in depth; less than 10 cm length.

Contd...

Contd...

III – Haematoma – Laceration	Subcapsular haematoma more than 50%; intraparenchymal more than 10 cm diameter - expanding. Capsular laceration 3 cm in depth.
IV – Laceration	Parenchymal disruption 25-75% hepatic lobe; 1-3 Couinaud segments.
V – Laceration – Vascular	Parenchymal disruption more than 75% or more than 3 Couinaud segments. Major hepatic veins or retrohepatic venacaval injuries.
VI – Vascular	Hepatic avulsion.

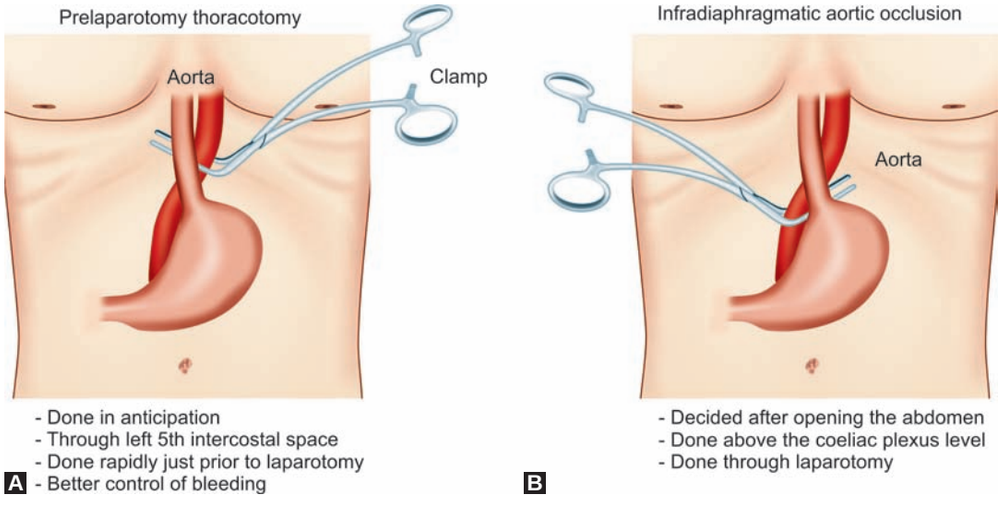
Management

Initial Conservative Nonoperative Management

It is done in non-progressive liver injuries who are haemodynamically stable, low grade liver injury, need for transfusion less than 2 units. However, CT abdomen (absence of contrast extravasation during arterial phase can be treated nonoperatively) and repeat CT or regular ultrasound follow up is a must. Replacement of lost blood; prevention of sepsis; regular monitoring by haematocrit, liver function tests, prothrombin time are needed. *Angiographic embolisation* increases the success rate of nonoperative therapy. Initial critical care (ICU) management for 2-5 days; repeat CT scan after 5 days; bed rest to be continued; patient can have normal activity only after 3 months. When any time patient's condition worsens, he should be taken up for laparotomy.

Surgical Management

If bleeding continues, if patient deteriorates, if major hepatic injury with vascular lacerations, surgical intervention is done. Lengthy midline incision is better if other parts of the abdomen like bowel are



Figs 8-25A and B: Aortic clamping is done when there is dangerous bleeding. Prelaparotomy thoracotomy is done just before laparotomy in anticipation through left sided 5th intercostal space. Aorta is clamped in the thorax. Abdomen is opened later. Infradiaphragmatic aortic clamping is done just above the celiac plexus level; it is decided after laparotomy because of the torrential uncontrollable bleeding. Vascular clamp is placed behind the abdominal oesophagus from right side.

also need intervention. Bilateral subcostal/bucket handle or often thoracoabdominal incision is also needed **(Fig. 8-26)**.

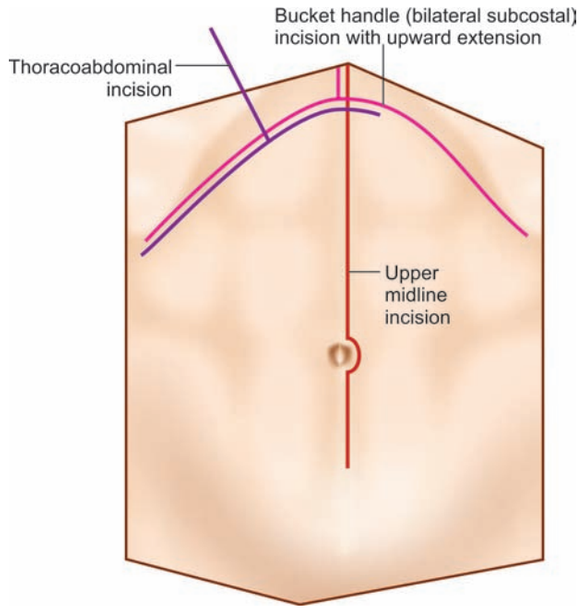

Bucket handle (bilateral subcostal) incision with upward extension
Thoracoabdominal incision
Upper midline incision

Fig. 8-26: Incisions used for different liver injuries. Wide exposure is the basic need in these patients.

Small lacerations are apposed using simple sutures with haemostatic agents. Polyglactic or PDS is used with a gel foam or surgicel support. *Kous Netzof aluminium needle* is used for these *co-opting sutures*. Initially mattress sutures parallel to the tear is placed. Row of perpendicular sutures to the tear to co-opt these mattress sutures are placed. Large lacerations need deep suturing. It is not necessary or often risky to try to bring the margins together **(Fig. 8-27)**.

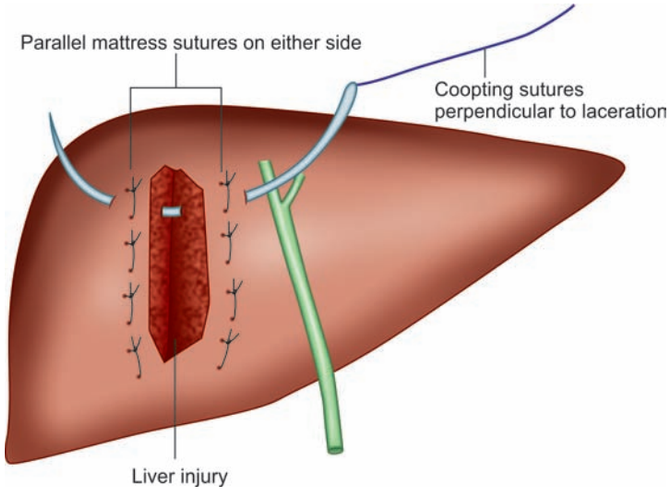


Fig. 8-27: Coopting sutures are placed perpendicular to already placed parallel mattress sutures.

Packing is a good old method of controlling bleeding in critical patients. It can be done quickly, controls bleeding well by *tamponade*. Reexploration is done in 48-72 hours. Pack is removed. Necrotic tissue is removed. Proper saline irrigation is done. Haemostasis is achieved using bipolar cautery, argon beam ligaseal, harmonic, etc. Risk of abscess formation in packing is 15%.

In *deeper lacerations*, ligation of bleeding vessel individually on the cut surface is needed and is called as *tractotomy*. Biliary ductules are also ligated. As vessels are supported by *fibrous adventitia* suture ligation holds well in these vessels even though liver parenchyma is soft and friable.

Pringle manoeuvre is occluding the porta at foramen Winslow to control bleeding temporarily. It is done using fingers and thumb or vascular clamps or vascular loops. During Pringle, if bleeding gets controlled means it is bleeding from portal vein or hepatic artery branches, and if bleeding continues it is due to hepatic vein or retrohepatic IVC injury. It needs bypass (venovenous bypass between femoral vein and superior vena cava) and vascular repair. As access is technically difficult in these patients with retrohepatic caval injury, a wide tube placed across from atrial appendages to IVC just above the renal vein level may be appropriate (*intracaval catheter placement*). Pringle manoeuvre can be used continuously maximum only for one hour beyond that hepatic ischaemia may occur. But usually it is wiser to release the occlusion once in 10 minutes to reperfuse the liver and clamping the porta again. Pringle manoeuvre also helps to control bleeding while suturing the liver surface. In surface injury, liver can be wrapped with absorbable mesh (*mesh hepatorrhaphy*) to achieve haemostasis. Segmental resection is done often when needed. Hepatectomy and hepatic artery ligation is *rarely used* nowadays. Such an extensive injury can be treated initially by packing and further therapy is planned at later dates. *Push* (direct compression), *plug* (plugging the deep track injuries using silicone tube or SB tube), *Pringles'* manoeuvre, *pack* (liver wound is directly packed with mop) are basic principles in initial management **(Figs 8-28 to 8-30)**.

Management of liver trauma

- Control of haemorrhage – packing; tractotomy; mesh hepatorrhaphy; debridement of devitalized tissue; segmentectomy, vein repair with venovenous bypass; transfusions.
- Management of metabolic disturbances – prevention of acidosis, DIC, FFP; platelets.
- Monitoring – repeat US; repeat CT; urine output; LFT; Prothrombin time; platelet count; haematocrit.
- Prevention of sepsis – proper debridement; irrigation of liver wound with warm normal saline; antibiotics.
- Identification and management of complications of liver injury

Porta Hepatic Injury

It is life threatening even though rare. Penetrating injuries commonly cause this injury. It is commonly associated with organ injuries. Isolated porta injury is rare. It is difficult to manage with mortality 50-80%. Portal vein is sutured after venovenous bypass. Common bile duct injury involving less than half the circumference can be sutured over a T tube. Injury more than 50% or transection needs choledochojejunostomy.

Complications of Liver Injury

Shock, blood loss, DIC, sepsis, intraabdominal abscess or liver abscess formation, bile leak, biliary peritonitis, biliary fistula, hepatic artery aneurysm, haemobilia, hypoalbuminaemia, electrolyte imbalance, respiratory problems, liver failure, stricture of common bile duct are common complications.

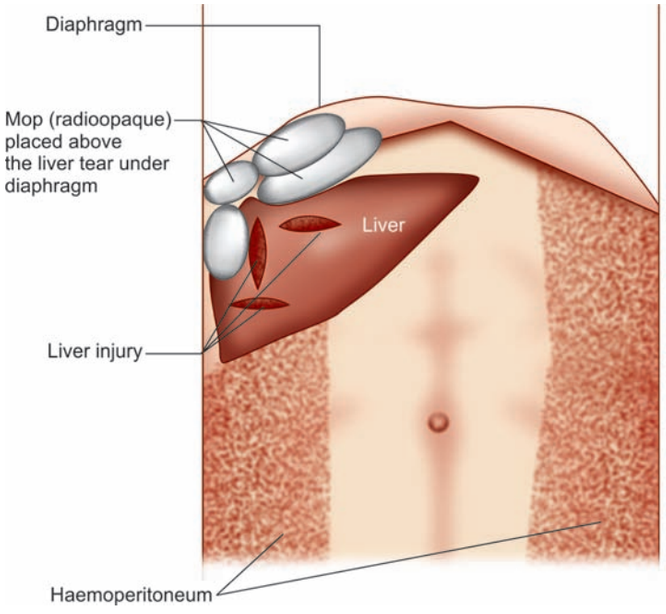


Fig. 8-28: By placing 3-5 mops between injured liver and diaphragm tamponade effect can be achieved to control bleeding from the liver. After 48-72 hours electively abdomen is reexplored for further intervention. Often bleeding will be controlled by then and further management becomes easier. Sepsis should be taken care of by higher generation antibiotics.

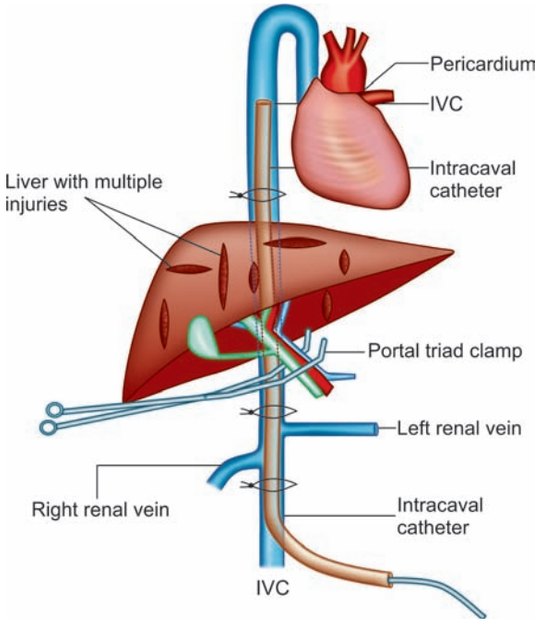


Fig. 8-29: Intracaval catheter placement is the only life saving option in case of hepatic vein or retrohepatic IVC injuries.

SPLENIC INJURY

It is the most commonly affected intraabdominal organ in blunt injury. Any injury towards left side of the chest or abdomen should suspect splenic trauma. Stab injuries also can cause splenic injury. Splenic injury is often associated with fracture lower ribs (30%), haemothorax, liver injury (left lobe), jejunal, pancreatic and left kidney injuries.

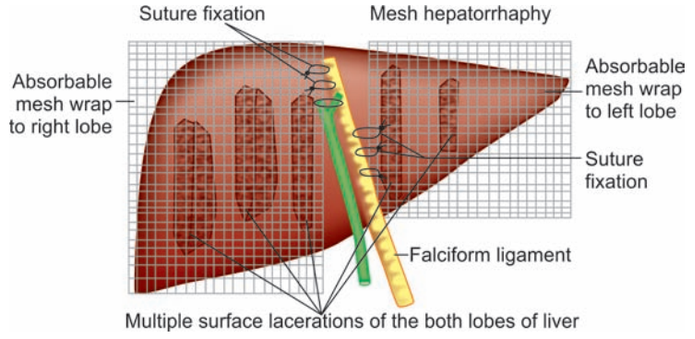

Suture fixation
Mesh hepatorrhaphy
Absorbable mesh wrap to right lobe
Absorbable mesh wrap to left lobe
Suture fixation
Falciform ligament
Multiple surface lacerations of the both lobes of liver

Fig. 8-30: Mesh hepatorrhaphy using absorbable mesh wrap around the liver surface. Right and left lobes are separately wrapped with mesh and fixed to falciform ligament.

Left side diaphragmatic injury is also known to occur. Injury is more common and severe in already enlarged spleen like of malaria, tropical splenomegaly, etc. Spontaneous rupture of spleen can occur in malaria. *Larang* was used for killing by the murderers in Far East where malaria is endemic leading to splenomegaly, ruptured spleen more easily **(Fig. 8-31)**.

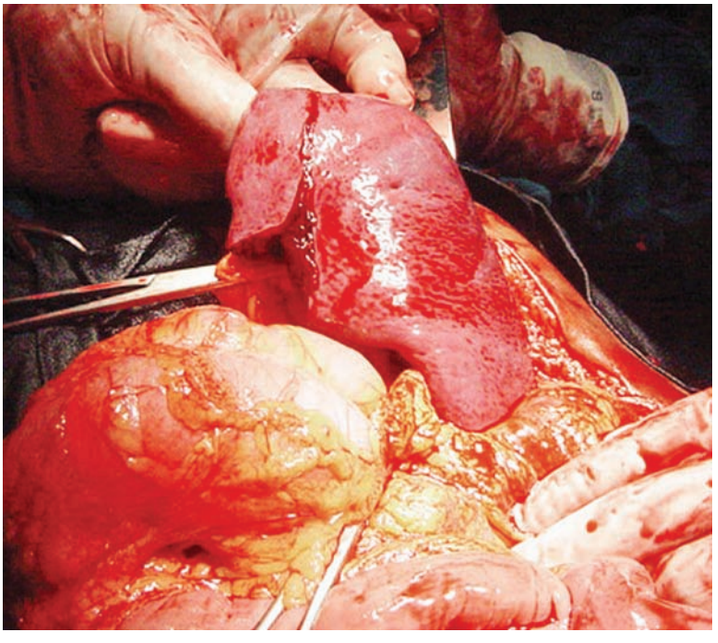


Fig. 8-31: Splenic laceration on one side. Splenorrhaphy/partial splenectomy is possible here.

Types of Splenic Injury

Splenic subcapsular haematoma – After initial injury patient remains asymptomatic for a short period. But this haematoma may rupture often later after few days- causing torrential haemorrhage. *Clean incised wound on the splenic surface* may be treated by nonoperative methods or by splenorrhaphy. *Splenic lacerations* when occur its extent of involvement and depth is important. If it is less than 50% part of the spleen can be salvaged by partial splenectomy. *Splenic hilar injury* often needs emergency splenectomy **(Figs 8-32 and 8-33)**.

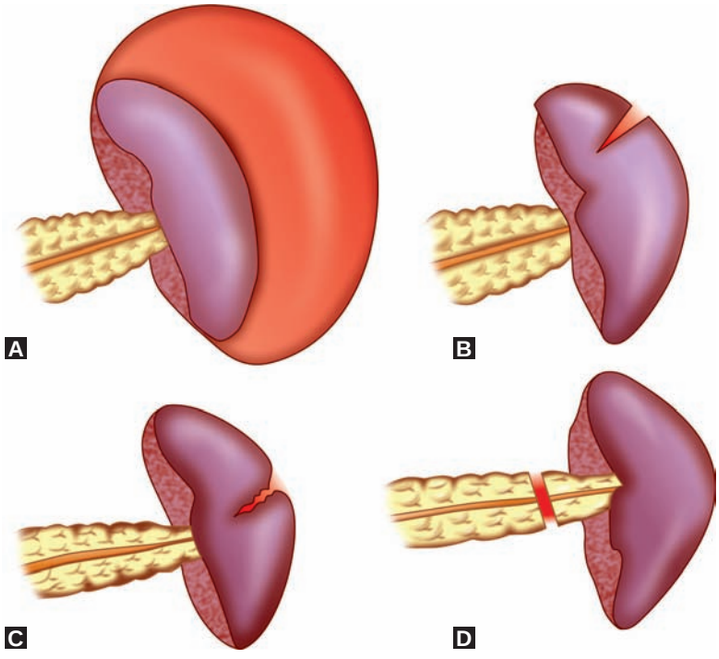
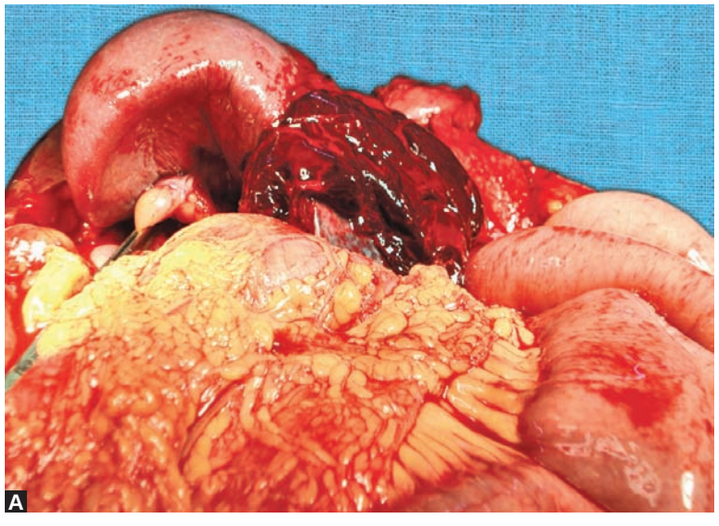
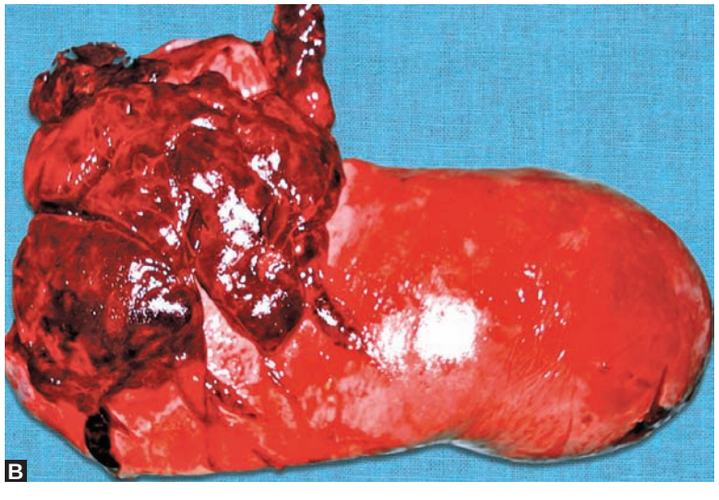


Fig. 8-32: Types of splenic injury – (A) Subcapsular haematoma. (B) Incised tear / wound on the surface. (C) Lacerated wound. (D) Hilar injury.





Figs 8-33A and B

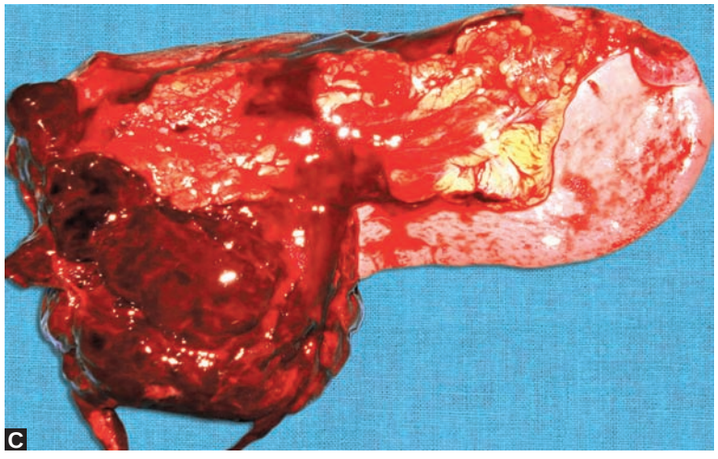


Fig. 8-33C

Figs 8-33A to C: Extensive splenic laceration which needed splenectomy.

Presentations

Common presentations in severe splenic injury are features of shock; left upper abdominal pain and tenderness; referred pain over left shoulder due to irritation of left side diaphragm and left phrenic nerve (Kehr's sign); dullnes over left side abdomen which is not shifting due to presence of clot formation (Ballance's sign); tenderness between left sternomastoid and scalenus medius (Saegesser's tender point); formed haematoma in perisplenic area is initially localised by omentum and bowel and so patient shows delayed presentation of severe haemorrhage once clot dislodges off the omentum (latent period of Bandet).

Splenic organ injury scale		
Grade I	Haematoma	Non-expanding subcapsular haematoma <10% surface area.
	Laceration	Non-bleeding capsular laceration with <1 cm depth.
Grade II	Haematoma	Non-expanding subcapsular haematoma 10-50% surface area. Nonexpanding intraparenchymal haematoma < 5 cm.
	Laceration	Capsular tear; 1-3 cm depth parenchymal injury not involving trabecular vessel.
Grade III	Haematoma -	Expanding subcapsular or intraparenchymal haematoma. Bleeding subcapsular haematoma or subcapsular haematoma > 50% area or intraparenchymal haematoma > 5 cm.
	Laceration -	Parenchymal laceration >3 cm depth.
Grade IV	Laceration -	Ruptured intraparenchymal haematoma with active bleed; laceration involving segmental or hilar vessels with > 25% devascularisation.
Grade V		Shattered or avulsed spleen; hilar devascularisation with separation of entire spleen.

Complications

Complications of splenic injury are – haemorrhage and its consequences; disseminated intravascular coagulation; sepsis like subphrenic abscess, pancreatitis; splenic artery pseudoaneurysm; splenic arteriovenous fistula.

Investigations

Ultrasound is the basic investigation to initially identify splenic trauma.

CT scan should be done in all patients to confirm the type of injury. CT with contrast to see blush in arterial phase of the contrast is very significant.

Haematocrit, blood grouping and cross matching samples and often to keep ready needed quantity of blood are basic requisites. Angiogram with possible need for angiographic embolisation is commonly used in some centers as diagnostic as well as a nonoperative method of treatment. Diagnostic peritoneal lavage as discussed earlier is also helpful.

Chest X-ray with plain X-ray abdomen is older method of evaluation with higher chances of missing the splenic injury. However, features in X-ray looked for are – obliteration of splenic outline and left sided psoas shadow; indentation of fundic gas shadow; fracture ribs; elevation of left sided diaphragm; dilated intestinal coils in the left side.

Treatment

Initial Management

Central venous line for perfusion and monitoring; transfusion of blood as needed; antibiotics coverage; urinary catheterisation; nasogastric tube aspiration.

Nonoperative Management

When facilities are available, splenic injury can be managed conservatively by nonoperative method. Clinically close observation, serial haematocrit evaluation, serial CT abdomen/US abdomen at regular intervals to assess the progress or regress of the bleeding spleen has to be done. Initial abdominal CT with intravenous contrast is essential to see contrast extravasation and contrast blush in arterial phase. If in later period bleeding persists it is again repeated. Presence of blush is whether an indication for surgical intervention or not is a controversy. In a set up where all facilities are available for intervention, patient still be managed with nonoperative method. Absolute bed rest, sedation, antibiotic coverage and proper monitoring are needed. It is often supported by angiographic embolisation to improve the splenic salvage rate. But it may cause pain, splenic abscess or infarction. Routine angiographic embolisation is also advocated but whether it is needed is a doubtful entity. 70% of stable splenic injury patients can be treated by nonoperative method. Decreasing haematocrit, hypotension, and persistent paralytic ileus may be an indication for surgical intervention. *Indications for nonoperative treatment* - Only splenic injury - no other associated injuries; Grade I, II and selected grade III injuries. Absolute bed rest for 10 days and avoiding over physical activity for 3 months is mandatory.

Surgical Management

Splenorrhaphy

Especially in a clean incised wound spleen can be salvaged by suturing the wound carefully with placement of gel foam, topical thrombin, absorbable mesh wrap over the wound. PDS or vicryl is used as interrupted horizontal mattress sutures. Fibrin glue and use of argon beam coagulator on the surface is also beneficial. But in class/grade III, IV or V injuries splenorrhaphy is not possible **(Fig. 8-34)**.

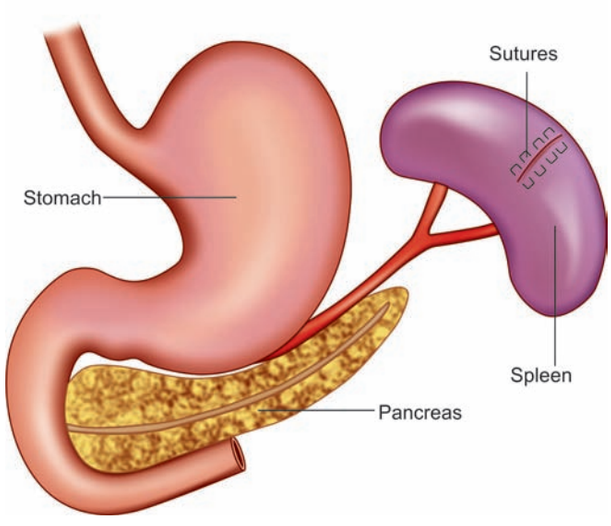


Fig. 8-34: Splenorrhaphy is ideal in surface injury and simple injuries.

Advantages of splenorrhaphy

- It avoids OPSI.
- It avoids dead space and so prevents potential space for subphrenic abscess.
- Cellular components of blood are better maintained.

Partial splenectomy (upper/lower)

It can be done by retaining either of the upper or lower polar branches of the splenic artery depending on the location of the injury whether in lower or upper part of the spleen. Hilum is carefully dissected to identify the division of the splenic artery into polar vessels. Isolated artery is individually ligated. Accompanying veins are also ligated. Injury extending across both poles is difficult to manage by partial splenectomy. Surface of the spleen is sutured with PDS or vicryl and cut surface is cauterised or small bleeders are controlled using Ligaseal. Gelfoam/spongistan which are placed over the raw area **(Fig. 8-35)**.

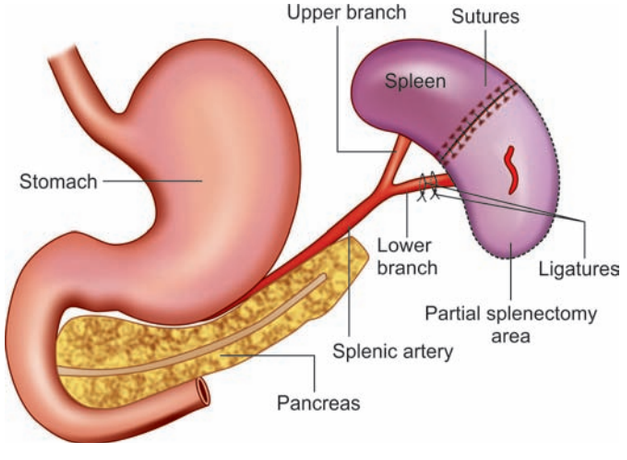


Fig. 8-35: Partial splenectomy can be done if injury is on one pole of the spleen.

Emergency splenectomy

It is done through midline / left subcostal incision. Thoracoabdominal extension of incision may be needed for rapid control of bleeding for injury to a large tropical spleen with

severe bleeding. Other associated injuries should be looked for and dealt with (injury to left lobe liver/pancreas/intestine/colon). Abdomen is opened rapidly; splenic hilum is held between thumb and fingers to control bleeding immediately; blood/clots in the peritoneal cavity is sucked out and washed to clear the field; often a soft vascular clamp can be placed across hilum including the tail of the pancreas to free the surgeon's hand. With this splenic hilum will be clearly seen and bloodless hilum is dissected carefully and artery and vein and branches are individually ligated using silk or vicryl (2 zero). Spleen is dissected from the short gastric vessels by ligating it and also from splenorenal and phrenicocolic ligaments. Few surgeons also prefer to use polypropylene but knot holding may be difficult **(Fig. 8-36)**.

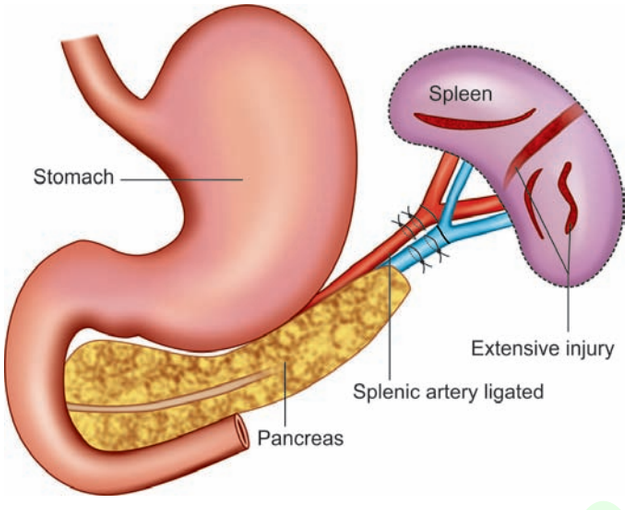


Fig. 8-36: Technique of splenectomy.

Mass ligature of the entire splenic hilum, even though is commonly used by many surgeons, is a controversial and not universally accepted; however, if patient is haemodynamically *unstable* due to exsanguination and adequate quantity of blood is not available, quick mass ligature can be done using silk. In such situation abdomen is also closed as single mass closure instead of layer by layer **(Fig. 8.37)**.

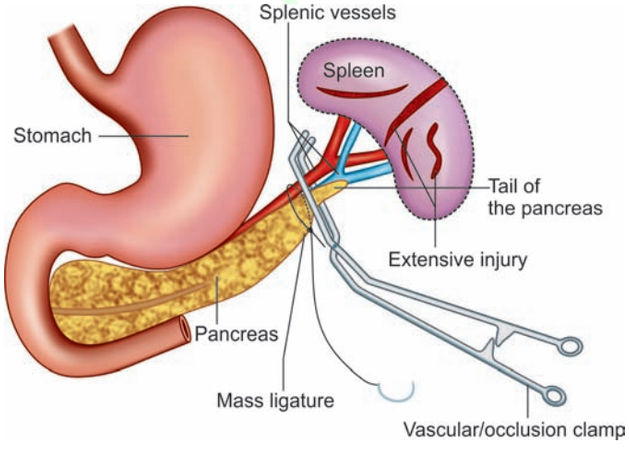


Fig. 8-37: Mass ligature of the splenic pedicle is often used in emergency splenectomy in splenic trauma.

Salutary effect

In traumatic rupture of spleen, spleen is cut into pieces of 0.5 cm and placed in omental pockets. This autotransplantation is still experimental and controversial.

Complications of Splenic Injury

Metabolic imbalance, acidosis, shock, renal failure, sepsis, DIC, splenic artery pseudoaneurysm, splenic arteriovenous fistula.

Splenectomy can cause DVT, OPSI, haematemesis, left sided pleural effusion, pancreatitis, pancreatic fistula, subphrenic abscess left sided, left lung atelectasis (commonest), left colonic and rarely gastric injury, severe sepsis.

PANCREATIC INJURY

It is rare entity as pancreas is retroperitoneal and well protected. However, penetrating injury and blunt seat belt injury (due to close proximity to vertebral column) can cause pancreatic trauma. It is commonly associated with other abdominal injuries and so commonly missed also. It is often difficult to diagnose the pancreatic trauma clinically, sonologically or CT scan wise. DPL is also not much beneficial. High degree of suspicion is needed. Isolated pancreatic injuries are rare. It is usually associated with duodenal injury. Superior mesenteric vessel injury is common association. Repeat CT, persistent elevation of serum amylase (repetitive assessment of serum amylase) is helpful. MRI/MRCP may be beneficial. *Pancreatic duct injury* is the main deciding factor in managing and predicting the outcome. If injury is right of the superior mesenteric vein, it is called as *proximal pancreatic injury*. If it is towards left it is called as *distal pancreatic injury*.

Proximal injury is treated by surgical debridement; suture ligation of bleeding area; drainage of the pancreatic bed. If there is associated duodenal injury, then pancreaticoduodenectomy is also done. Debridement, closure of duodenal wound and pylorus exclusion is also done. Pancreatic fistula (40%), pancreatic abscess, pancreatitis (15%) septicaemia, pancreatic ascites, pancreatic pleural effusion are common complications which can occur in survived patient.

Distal injury is managed by distal pancreatectomy. Role of pancreaticojejunostomy, ERCP stenting is controversial.

Pancreatic injury	
Grade I – Haematoma – Laceration	Minor contusion without duct injury. Superficial laceration without duct injury.
Grade II – Haematoma – Laceration	Major contusion without duct injury or tissue loss.
Grade III Laceration	Distal transection or parenchymal injury with duct injury.
Grade IV Laceration	Proximal transection or parenchymal injury involving the ampulla.
Grade V Laceration	Massive disruption of the parenchymal head.

DUODENAL INJURIES

Duodenal injuries are 5% common; commonly penetrating; commonly associated with other abdominal injuries like liver, pancreas, major vessels, etc. Isolated injury of the duodenum even though is rare, causes difficulty in diagnosing as it does not cause early peritonitis or haemodynamic instability. But late life threatening

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intraabdominal abscess or peritonitis develops. Raised serum amylase; plain X-ray abdomen showing mild scoliosis, obliteration of psoas shadow, *presence of air in retroperitoneum around kidney*, absence of air in duodenal bulb; gastrografin study; CT abdomen with oral intravenous contrast; or dilute barium (microbar solution) study are the investigations needed. CT may show extravasation which is an absolute indication for laparotomy. *Extraluminal air in the CT is diagnostic* **(Fig. 8-38)**.

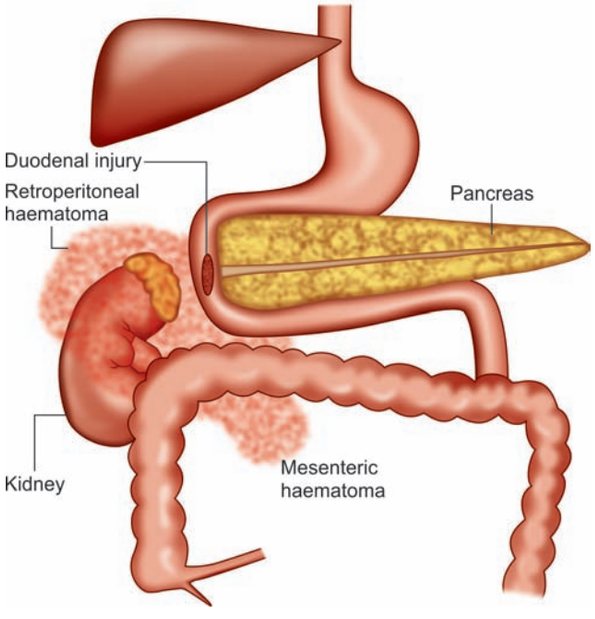


Fig. 8-38: Duodenal injury often associated with pancreatic injury; haematoma in duodenum, and retroperitoneum, around right kidney, mesentery.

Duodenal haematoma causes radiologically coiled spring or stacked coin sign; but is not a sign to do surgery; only haematoma causing obstruction is operated. It occurs on the convex surface of the duodenum extending into the retroperitoneum. If it is causing obstruction, it can be carefully evacuated without opening the mucosa; gastrostomy and jejunostomy is a must **(Fig. 8-39)**.

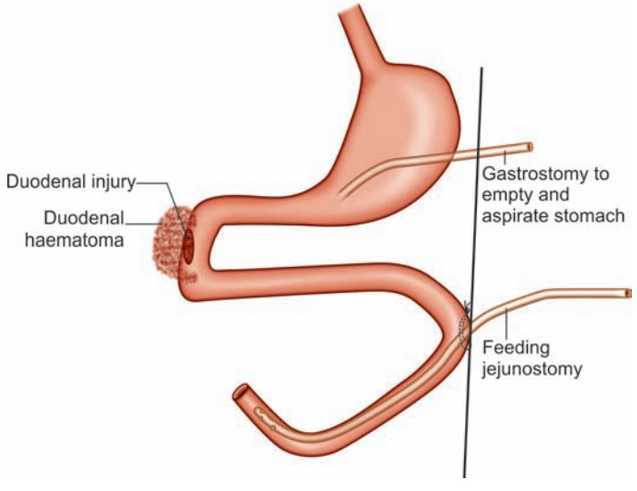


Fig. 8-39: Duodenal haematoma. It is treated by gastrostomy; feeding jejunostomy. It is intervened when it causes duodenal obstruction.

Duodenal injury grading	
Grade I – Haematoma – Laceration	Involving single portion of the duodenum. Partial thickness injury without perforation.
Grade II – Haematoma – Laceration	Involving more than one portion. Disruption less than 50% circumference.
Grade III – Laceration	Disruption 50-75% of the circumference of 2nd part of the duodenum; disruption 50-100% of the 1st, 3rd or 4th part of the duodenum.
Grade IV – Laceration	Disruption more than 75% of 2nd part of the duodenum and involving the ampulla or distal common bile duct.
Grade V – Laceration – Vascular	Severe disruption of duodenopancreatic complex. Duodenal devascularisation.

Procedure

When decided for surgery; after laparotomy with a lengthy midline incision, extended Kocherisation is done (peritoneum on the right of the 2nd part is cut and duodenum is mobilised in front and medially in front of the IVC and up to left margin of the aorta completely); hepatic flexure and right part of the transverse colon is mobilized fully; 3rd and 4th parts of the duodenum are visualised properly. Any haematoma or injury or presence of associated pancreatic injuries is looked for. Duodenojejunal junction is mobilised more proximally by dissecting the peritoneal fold to get the proximal length.

Eighty percent of duodenal injuries are *sutured primarily* using polyglactic acid or PDS interrupted sutures horizontally **(Fig. 8-40)**.

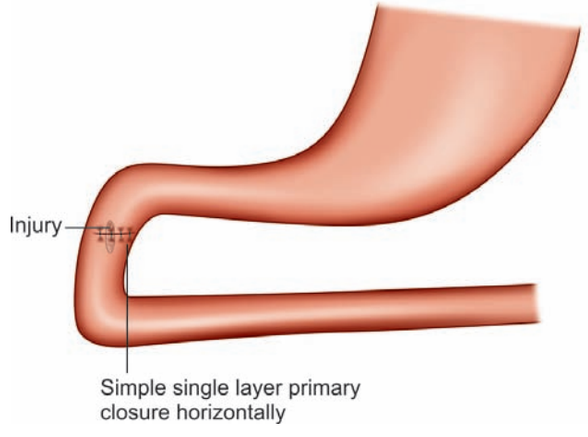


Fig. 8-40: Simple duodenal injury is closed using interrupted single/double layer sutures horizontally. Jejunostomy is usually needed.

Single layer suturing is proved to be sufficient. But many advocates two layer suturing. Often many use silk; silk holds the bowel wall well with low rate of leak; but being a nonabsorbable multifilament braided suture it has got tendency to form small granulomas in the anastomotic line even though said to be safer.

Injury on the medial/inner aspect of the duodenum especially in 3rd and 4th parts is sutured transduodenally using continuous single layer PDS sutures. Incision made in the anterior wall is closed horizontally **(Fig. 8-41)**.

In grade I and II injuries - just suturing if opened within 6 hours or if opened after 6 hours suturing with jejunostomy is done. Often tube duodenostomy is preferred by many **(Fig. 8-42)**.

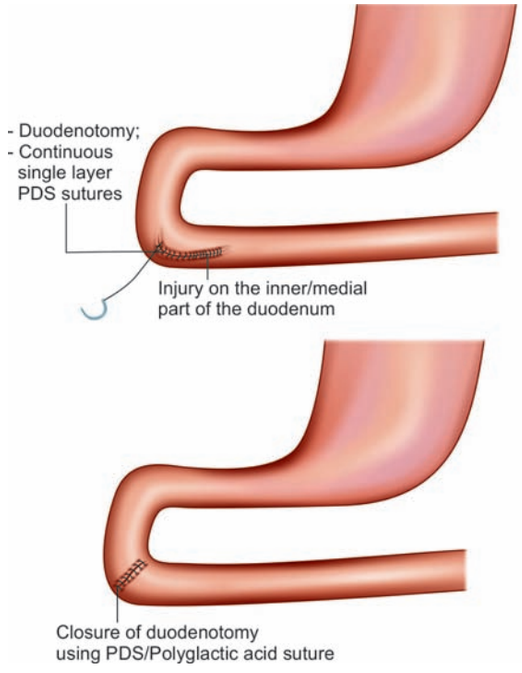

- Duodenotomy;
- Continuous single layer PDS sutures
Injury on the inner/medial part of the duodenum
Closure of duodenotomy using PDS/Polyglactic acid suture

Fig. 8-41: Injury on the medial wall of the duodenum is closed with continuous PDS sutures after doing duodenotomy. Duodenotomy is closed with interrupted vicryl sutures.

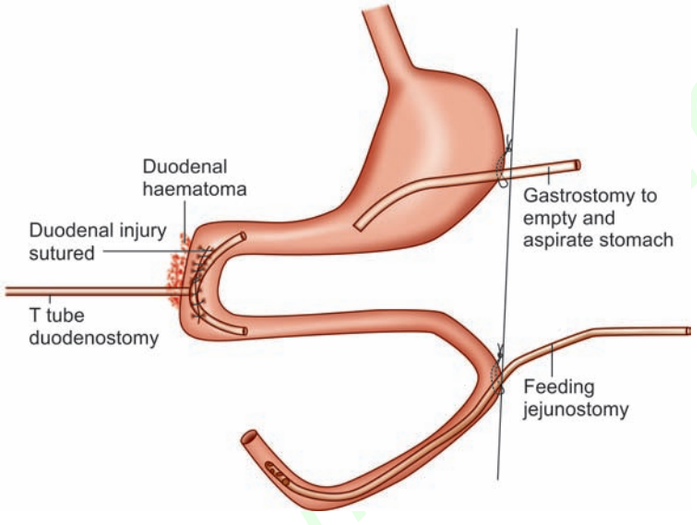


Fig. 8-42: Duodenal injury with T tube duodenostomy; closure of the injury; gastrostomy and feeding jejunostomy.

In grade III injury - Duodenojejunostomy or pyloric exclusion with gastrojejunostomy drainage procedure is done. Serosal patch of the jejunum is useful. Roux en Y duodenojejunostomy with feeding jejunostomy is also beneficial **(Figs 8-43 to 8-45)**.

In grade IV injuries – Duodenal repair; repair of CBD with T tube having lower part of the horizontal limb of T tube into the duodenum across the injury is done. Other option is duodenal repair with or without pyloric exclusion with ligation of the CBD; later during second stage dilated proximal CBD is used for choledochoenteric anastomosis.

Grade V injury needs pancreaticoduodenectomy. It carries high mortality. But one has to remember that if overall duodenal injuries are considered, pancreaticoduodenectomy is rarely needed **(Fig. 8-46)**.

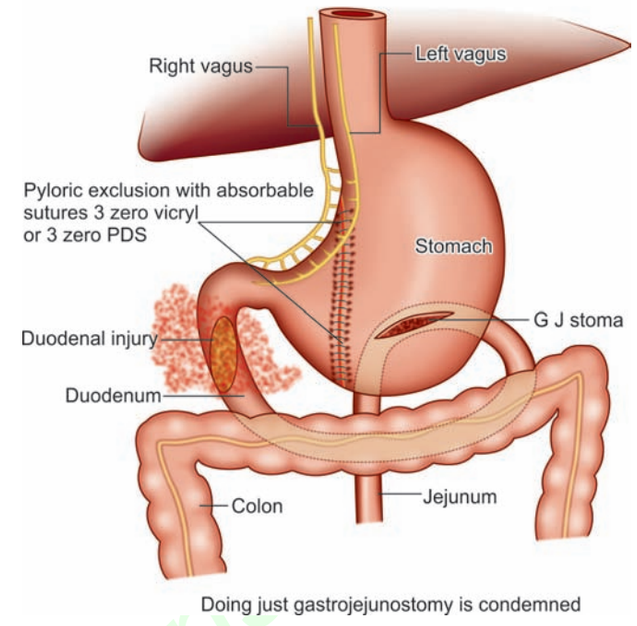


Fig. 8-43: Pyloric exclusion with gastrojejunostomy with feeding jejunostomy is one of the options can be used in duodenal injury. Just doing gastrojejunostomy is not advised.

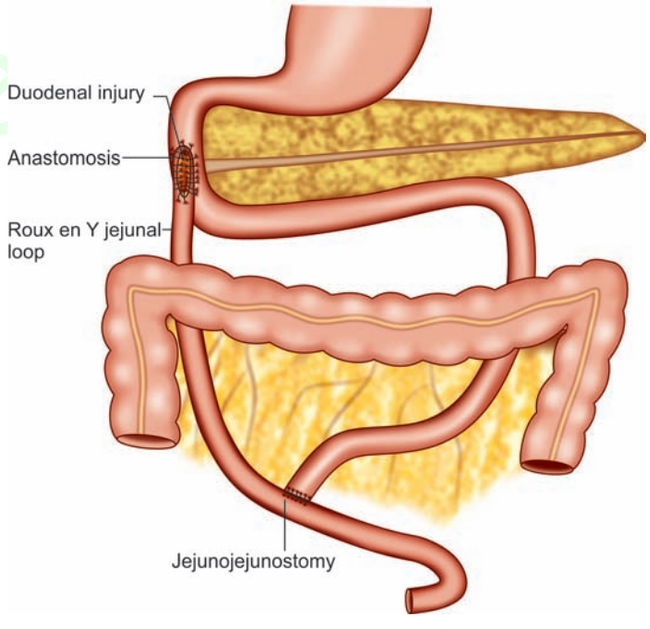


Fig. 8-44: Roux n Y loop duodenojejunostomy on to the site of the injury with a feeding jejunostomy is another alternative.

Small Bowel Injury

Blunt injury abdomen causing small bowel trauma is often difficult to identify at initial phases when patient arrived to the hospital. London's sign (abrasion over the abdominal wall; Monk's localizing zones in the abdomen may be useful features but not clear cut evidence of small bowel injury). Once peritonitis develops patient presents with typical features. Junction of fixed proximal jejunum or terminal ileum is commonly injured due to shearing force. Often it is like a blow out injury causing complete transection of the bowel at the junction **(Fig. 8-47)**.

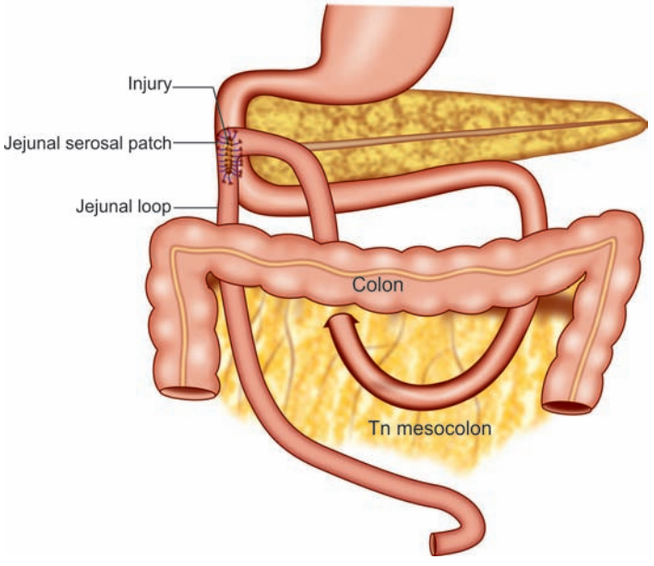
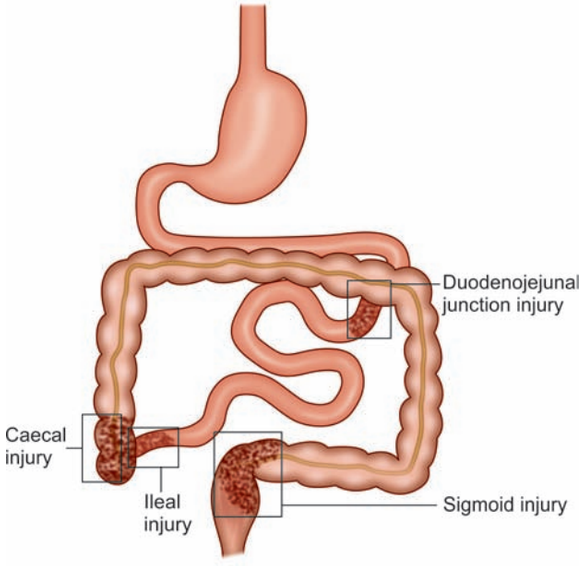
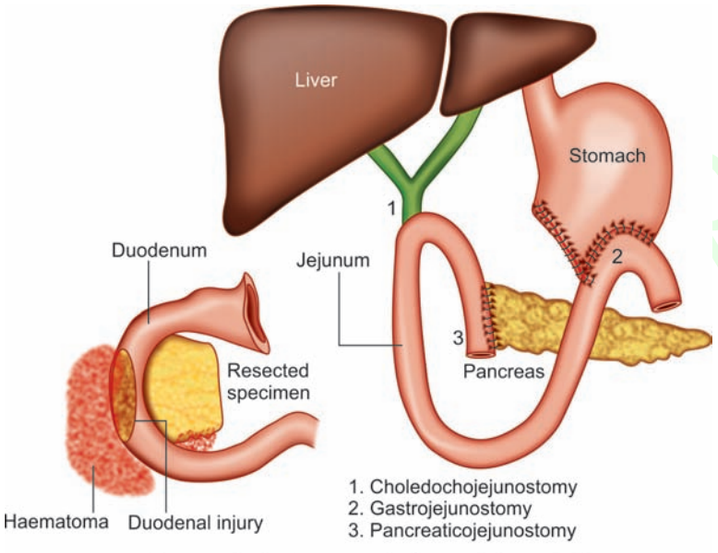


Fig. 8-45: Jejunal serosal patch over the injury site reduces the risk of duodenal leak. Feeding jejunostomy is also added.



Sites of blunt injury in small and large bowel. Penetrating injury can occur anywhere

Fig. 8-47: Sites of bowel injury in blunt trauma abdomen. Proximal jejunum, terminal ileum, caecum, sigmoid are the common sites.



Pancreaticoduodenectomy is done only in grade V duodenal disruption and/or severe devascularisation

Fig. 8-46: In extensive injury only pancreaticoduodenectomy is done.

Fig. 8-48: Transection of the jejunum in blunt injury abdomen due to shearing force/blow out effect.

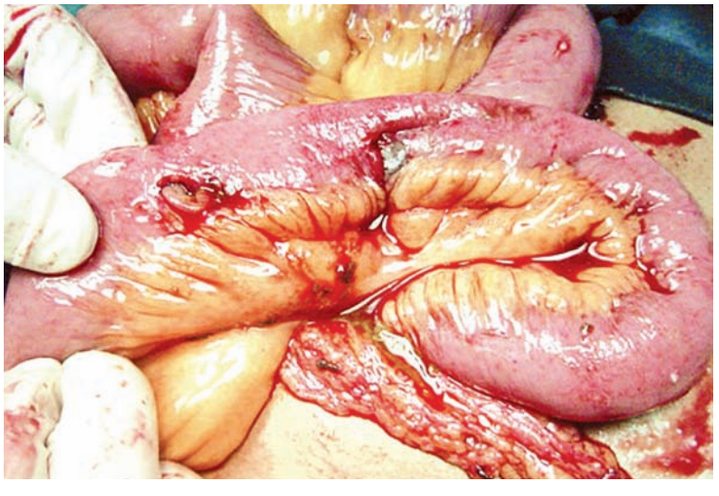


Fig. 8-49: Small bowel injury causing multiple perforations due to penetrating trauma.

Penetrating injury can often cause not just single perforation **(Fig. 8-48)** but multiple perforations with mesenteric injury **(Fig. 8-49)**.

Plain X-ray abdomen shows gas under diaphragm in blunt injury abdomen. DPL may not be diagnostic. CT may be useful. Best way is to explore if there are features of peritonitis.

Formal laparotomy using midline incision is done. Entire small and large bowel and mesentery and other organs are examined for any injury.

Small single tear in the small bowel is sutured horizontally using polyglactic acid (vicryl) interrupted *single layer* sutures (preferred). In *two layer method* – inner continuous absorbable sutures with outer interrupted seromuscular interrupted mattress sutures can be placed. One should not miss additional tears in other part of the bowel **(Fig. 8-50)**.

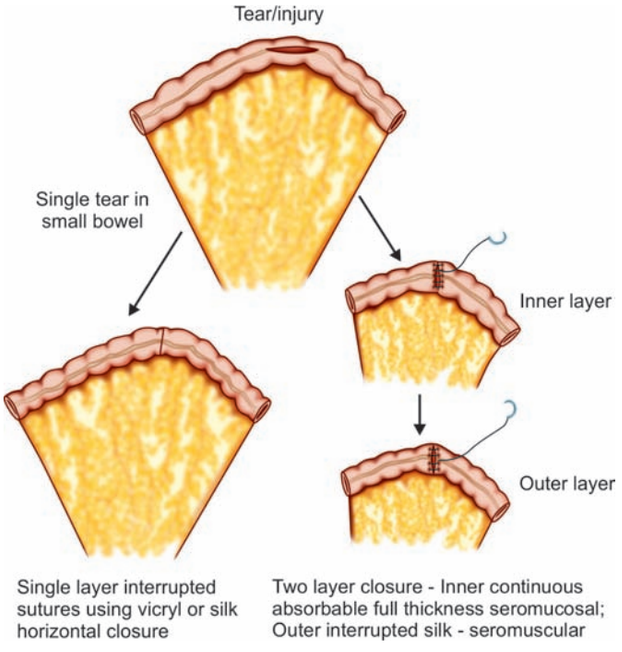

Tear/injury
Single tear in small bowel
Inner layer
Outer layer
Single layer interrupted sutures using vicryl or silk horizontal closure
Two layer closure - Inner continuous absorbable full thickness seromucosal; Outer interrupted silk - seromuscular

Fig. 8-50: Single small tear in the small intestine is closed horizontally using silk/vicryl either as single layer interrupted sutures or two layer closure with inner continuous suture and outer interrupted sutures.

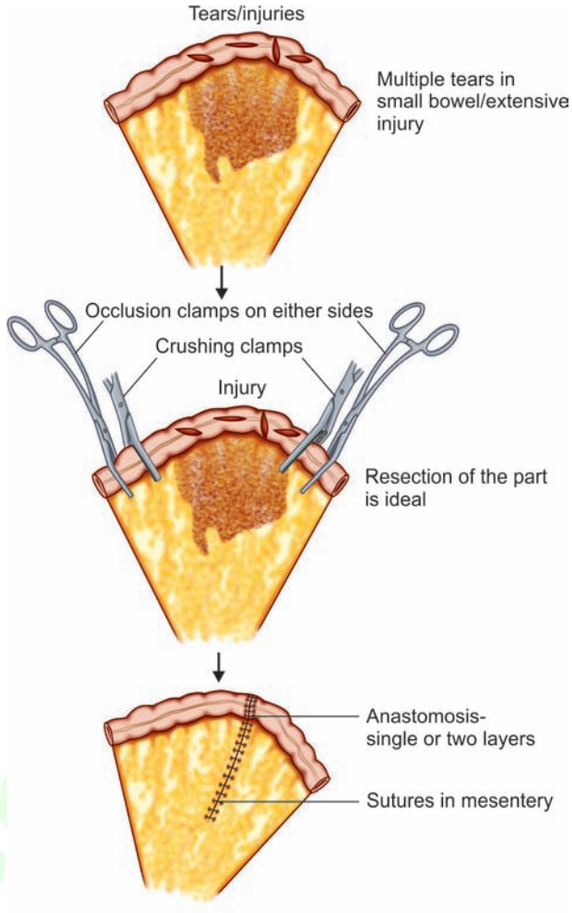


Fig. 8-51: When extensive/multiple tears at close proximity, resection of the involved bowel segment and anastomosis is done. But one should remember that massive small bowel resection may cause short gut syndrome due to less than required (120 cm) length of the small bowel is retained.

When there are *multiple perforations (10%)* located very closely in the bowel loop; shattered injury in one segment; adjacent mesenteric injury which may probably compromise the blood supply of the bowel are the indications for *resection* and anastomosis. Drainage is used only if there is contamination. It is a controversial topic. Literature opines that drainage is not needed in routine cases; but most surgeons prefer to place a tube/corrugated drain **(Fig. 8-51)**.

LARGE BOWEL INJURY

Penetrating injury of colon is common. It causes faecal peritonitis. It needs essentially colostomy/ileostomy depending on the site of injury. Small tear can be closed primarily using silk/vicryl horizontal interrupted mattress sutures. Primary repair is done only if early diagnosis is done in 6 hours of injury; without any hypotension; without gross contamination of the peritoneal cavity; without colonic vascular injury.

Low risk colonic injuries are one without much contamination of peritoneal cavity and without vascular injury. It is treated by primary closure or resection and primary anastomosis. Stapled or hand anastomosis has equal results in colonic trauma.

Plain X-ray abdomen, presence of blood during digital examination is typical and one can suspect colonic injury.

Blunt trauma of colon is rare. Caecum and sigmoid colon are commonly affected. Pericaecal haematoma can cause late bowel wall ischaemia → necrosis → perforation → peritonitis. In critically ill patient due to trauma, initially there is only serosal injury without mucosa, but due to persistent hypotension and hypoperfusion late ischaemic necrosis and perforation can occur. It is common in sigmoid colon.

Exteriorization either ileostomy or colostomy should be always kept in mind by the surgeon whenever needed. If extensive injury is found right or left hemicolectomy is the need. Splenic or hepatic flexure is commonly used for colostomy as a loop. Ileostomy is done usually as end type **(Figs 8-52 to 8.54)**.

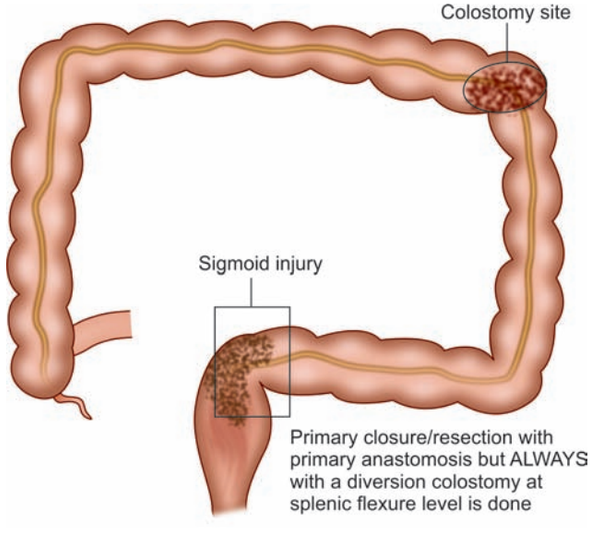

Colostomy site
Sigmoid injury
Primary closure/resection with primary anastomosis but ALWAYS with a diversion colostomy at splenic flexure level is done

Fig. 8-52: Injury to sigmoid colon needs diversion colostomy at splenic flexure or proximal level. Tear in the sigmoid colon is sutured using interrupted silk/vicryl. Often sigmoid resection and anastomosis is done if injury is extensive.

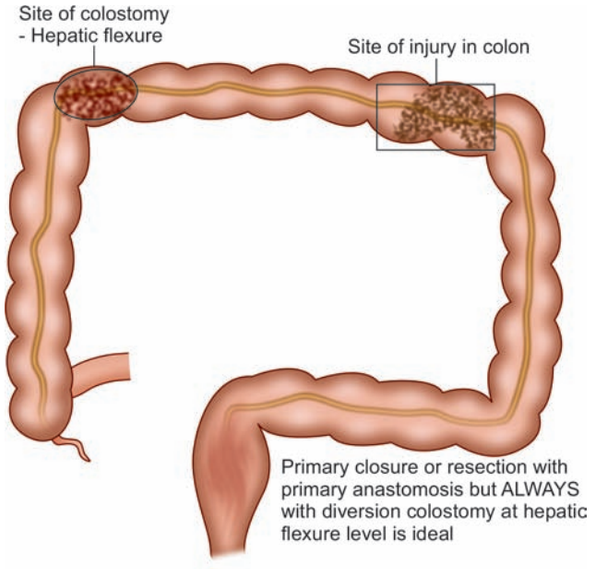

Site of colostomy
- Hepatic flexure
Site of injury in colon
Primary closure or resection with primary anastomosis but ALWAYS with diversion colostomy at hepatic flexure level is ideal

Fig. 8-53: If injury is in the splenic flexure level then colostomy is done at hepatic flexure level.

Maintenance of nutrition, TPN, antibiotics, fluid and electrolyte management are the other main required management for good outcome. Transfusion of blood may be required.

Rectal injury when it is high needs colostomy for 6 weeks. If it is low rectal injury, primary repair can be done perineally after thorough wound debridement and wash using warm normal saline.

Closure of the exteriorisation is done once sepsis is under control; patient recovers well.

Complications after surgery are – anastomotic leak; pelvic / intrapeitoneal abscess, sepsis, wound dehiscence, mortality.

RECTAL INJURIES

Rectal injuries are commonly penetrating type. It is often associated with pelvic injuries, urinary system injuries. It is difficult to manage. Blood on rectal examination is diagnostic. Injury should be assessed under general anaesthesia. Prior to that associated injuries and ultrasound abdomen for haemoperitoneum should be checked. Haematuria when present suspects associated bladder injury. Proctosigmoidoscopy should be done for proper assessment of rectal injuries.

Rectal injury can be *extraperitoneal or intraperitoneal.*

Treatment

Treatment is diversion colostomy, proper saline wash (very important), primary closure of the accessible rectal injury either perineally or through laparotomy. Unless rectal injury is small and low, diversion colostomy is a must. Presacral drainage after through wash of this space is a must. Otherwise retrorectal abscess may develop which is rather difficult to manage. Colostomy closure is done only after sepsis settles down and one must confirm that rectal or urinary fistulas will not develop **(Fig. 8-55)**.

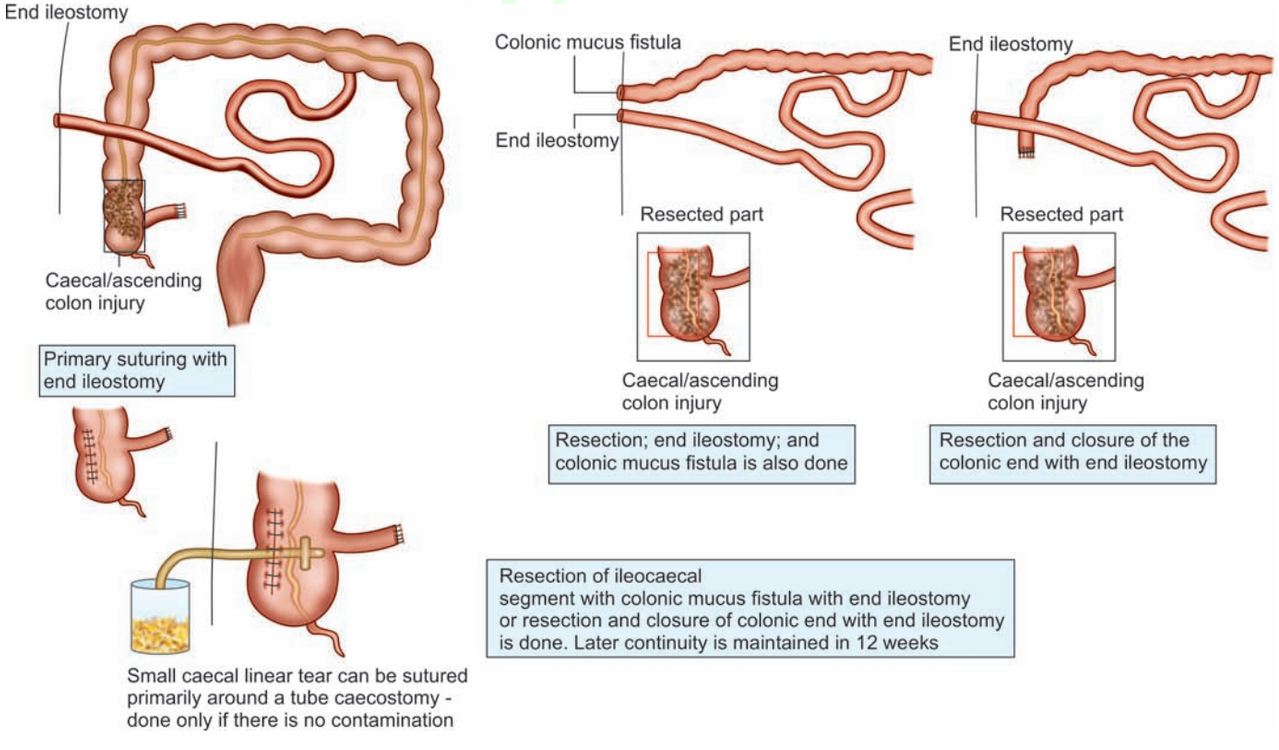

End ileostomy
Caecal/ascending colon injury
Primary suturing with end ileostomy
Small caecal linear tear can be sutured primarily around a tube caecostomy - done only if there is no contamination
Colonic mucus fistula
End ileostomy
Resected part
Caecal/ascending colon injury
Resection; end ileostomy; and colonic mucus fistula is also done
End ileostomy
Resected part
Caecal/ascending colon injury
Resection and closure of the colonic end with end ileostomy
Resection of ileocaecal segment with colonic mucus fistula with end ileostomy or resection and closure of colonic end with end ileostomy is done. Later continuity is maintained in 12 weeks

Fig. 8-54: Injury at caecal level needs ileostomy. Ileocaecal resection with end ileostomy with colonic mucus fistula or after resection colonic end is closed with end ileostomy. Ileostomy is closed in 3 months. If injury is not extensive tear can be sutured primarily with an end ileostomy. If linear small tear is present in the caecum without peritoneal contamination then closure of the caecal tear around a tube caecostomy can be done. All decisions are taken on table during surgery on individual case basis.

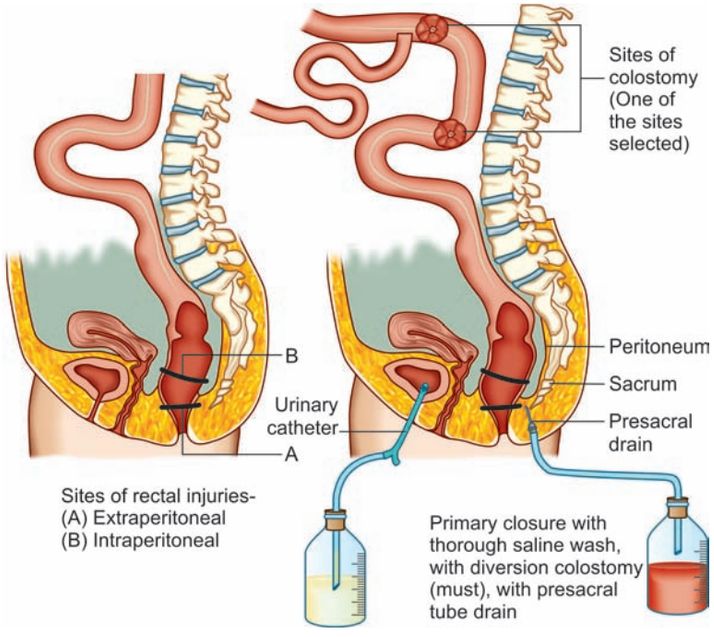


Fig. 8-55: Rectal injury can be intraperitoneal or extraperitoneal. Diversion colostomy; thorough saline wash; presacral drainage are the essential steps.

Associated urinary injury should be dealt with the help of urologists. Rectourinary fistula as a late complication is not uncommon.

Complications

Complications are abscess, sepsis, fistula, rectal incontinence, rectal stricture, sexual dysfunction, associated urinary incontinence due to damage to nerves and puborectalis.

RENAL INJURIES

Commonly it is due to a blunt injury. Often it is associated with other abdominal injuries—of liver, spleen, bowel, mesentery, etc. *Per se renal injury is extraperitoneal.*

Types

Small subcapsular; large subcapsular; cortical laceration; laceration with perinephric haematoma; medullary laceration with bleeding into the renal pelvis; corticomedullary complete rupture; hilar injury (most dangerous) **(Fig. 8-56)**.

Eighty five percent of renal injuries are minor. Minor injuries are treated nonoperatively. Major injuries means—deep corticomedullary injury with extravasation and renal pedicle injuries.

Grading of renal injury

1 – Subcapsular non-expanding haematoma without parenchymal laceration.
2 – Cortical laceration < 1 cm of parenchymal depth, no extravasation; perirenal haematoma.
3 – Cortical laceration > 1 cm depth; no urine extravasation.
4 – Parenchymal laceration extending through cortex and medulla with collecting system; with extravasation of urine.
5 – Renal pedicle avulsion; shattered kidney.

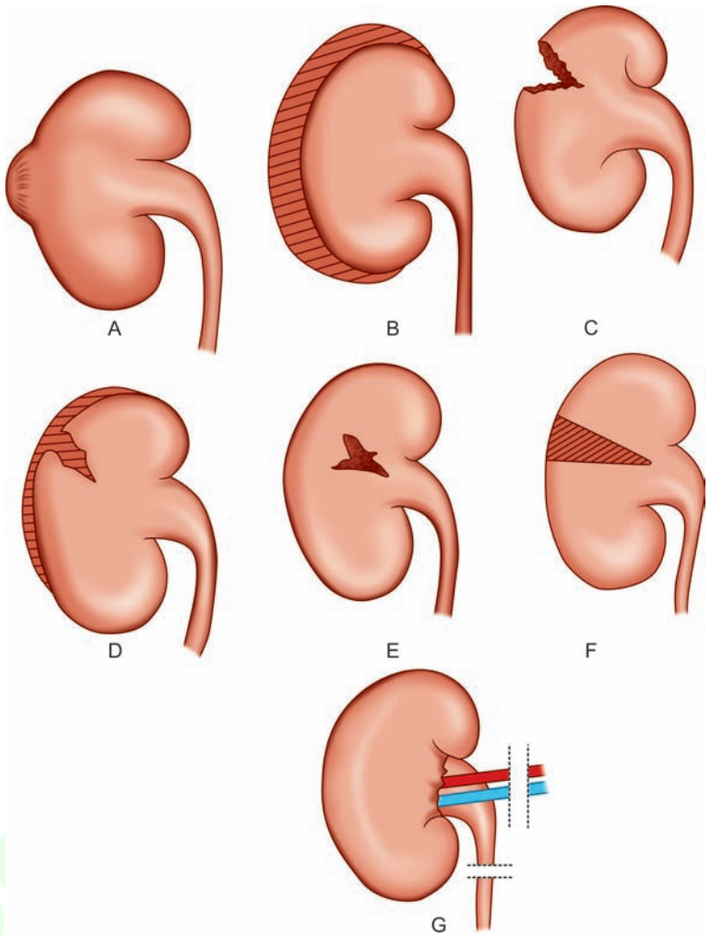


Fig. 8-56: Renal injuries: A: Small subcapsular. B: Large subcapsular. C: Cortical laceration. D: Laceration with perinephric haematoma. E: Medullary laceration with bleeding into the renal pelvis. F: Corticomedullary complete rupture. G: Hilar injury - most dangerous.

Clinical Features

Features of shock; Haematuria – may be mild to profuse depending on the type of injury; clot colic; bruising, swelling and tenderness in the loin; paralytic ileus with abdominal distension occurs due to retroperitoneal haematoma implicating splanchnic nerves.

Investigations

IVU (high dose) - Is the investigation of choice. Function of not only the injured kidney but also of the contralateral kidney can be seen. Often it is observed that opposite renal artery undergoes a reflex spasm, temporarily ceasing of function of the contralateral kidney occurs.

***US abdomen*:** Is done to see the type of injury, amount of haematoma and other associated injuries in the abdomen. US should be repeated at regular intervals to see the progress (at 12-24 hourly). Blood urea and serum creatinine should be repeated again at regular intervals. Acute renal failure is known to occur even in one sided renal injury; it responds well for temporary few haemodialysis until same side or/ and opposite side kidney start functioning. Blood grouping and cross matching is needed for blood transfusion.

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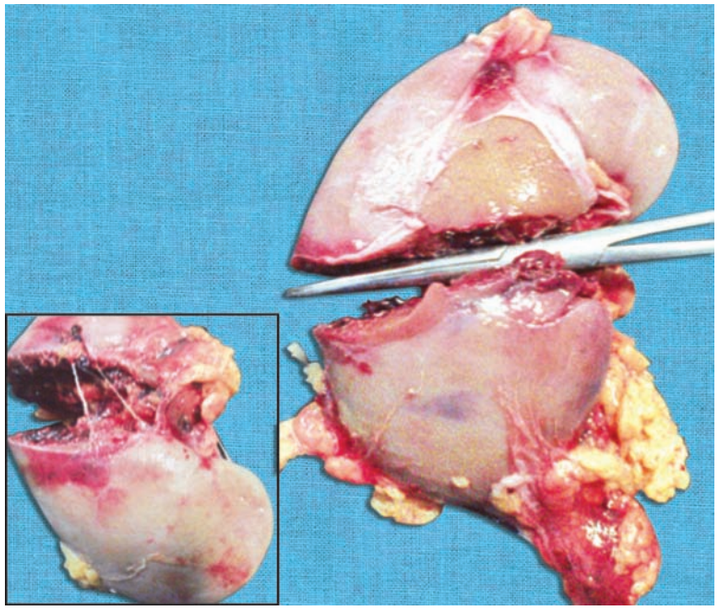
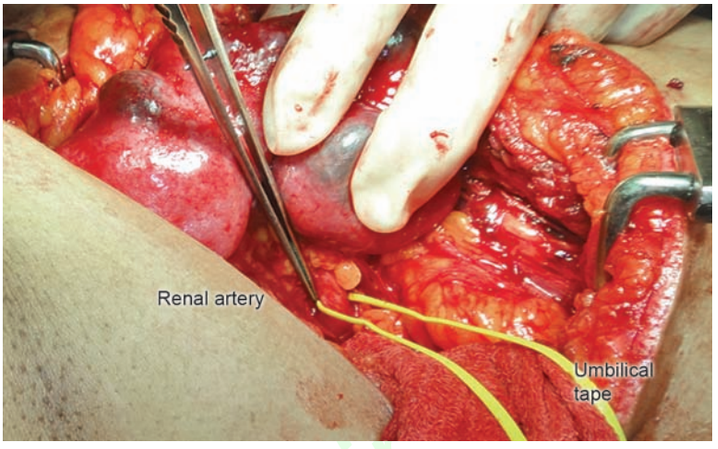


Fig. 8-57: Injury to the kidney causing near transection requiring emergency nephrectomy.



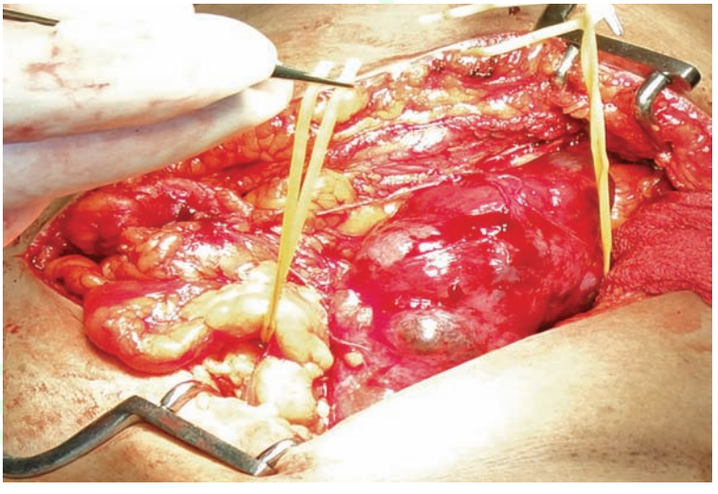


Fig. 8-58: Renal pedicle should be isolated and either using bulldog clamp or vascular clamp or umbilical tape renal artery and vein should be individually clamped. Renal artery clamp is most important.

Treatment

I. Initially always conservative – patient is catheterized and urine colour and output is observed; blood transfusion; strict observation with regular monitoring of the pulse, blood pressure, temperature; sedation, analgesic and antibiotics. 75% of patients respond to conservative management. While treating conservatively, regular monitoring of blood urea and serum creatinine is a must. If the patient goes in for renal failure, haemodialysis should be done for 6-8 weeks. Meanwhile, the other kidney will start functioning again and patient will recover without any further problem.

II. *Indications for surgical intervention* **(Fig. 8.57)**:
1. When there are signs of progressive blood loss with the condition of the patient deteriorating.
2. Formation of progressive perinephric haematoma.
3. When there are associated other injuries.
4. Hilar injury.

Surgery

Options:

a. Gentle suturing of the laceration. Often as kidney is friable, this is not easier technically. Here initially before opening Gerota's fascia and evacuating the haematoma, *renal vessels should be isolated* and either bulldog clamp or umbilical tape should be placed around. Suturing, wrapping, gelfoam, spongiston are other materials tried **(Fig. 8.58)**.

b. Then nephrostomy (Cabot`s) is done.

c. When the injury is in the poles - partial nephrectomy.

d. In hilar injury and severe laceration nephrectomy is the only choice **(Fig. 8.59)**.

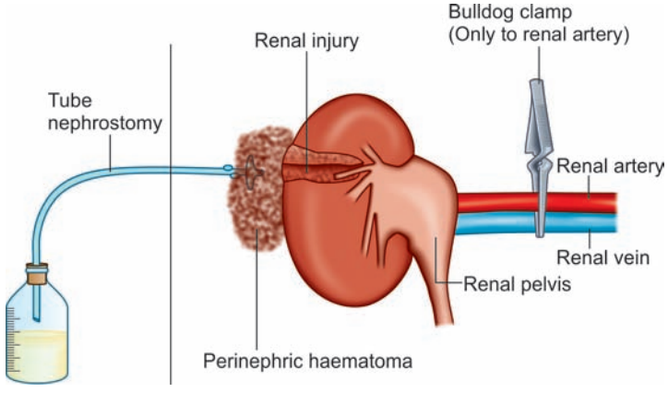


Fig. 8-59: Tube nephrostomy is better when there is significant renal and perinephric haematoma.

Type	*Treatment*
1. Only bruise/contusion	Conservative
2. Breach in calyceal system/rupture of one of the small branches of renal artery.	Conservative/nephrectomy
3. Rupture of pelvicalyceal system/renal substance.	Nephrectomy

Complications of renal injury

1. Clot retention in the bladder and may go for renal failure.
2. Pararenal pseudohydronephrosis.
3. Infection.
4. Perinephric abscess.
5. Aneurysm of the renal artery.
6. Renal failure.
7. Post injury renal hypertension.

ABDOMINAL COMPARTMENT SYNDROME

It is increased intraabdominal pressure more than 12 mm Hg. It is common in multiple traumas. Ileus and bowel oedema are the factors causing it. It is also seen in retroperitoneal haemorrhage, pancreatitis, long standing hernia after reduction into the peritoneal cavity. Upward displacement of the diaphragm, hypoxia, hypercapnia, acidosis, compression of IVC, decreased venous return to heart, increase in peripheral resistance, decrease in cardiac output and right atrial pressure, decreased renal blood flow and glomerular filtration, mesenteric venous hypertension, bowel wall oedema and ischaemia – are the effects. Oliguria, respiratory failure, cardiac arrest ensures if abdomen is not decompressed.

Intraabdominal pressure is measured using a *urinary catheter in the urinary bladder*. Pressure is graded *(Busch)* as I – 10-15 cm of H_2O; II – 16-25 cm of H_2O; III – 26–35 cm H_2O; IV – more than 36 cm H_2O.

Beyond grade III immediate decompression is needed. Initial volume preload is essential otherwise sudden decompression may cause cardiac arrest in asystole.

URETHRAL INJURY

It can be in membranous or bulbar urethra. It can be complete/incomplete; total/partial.

Rupture of Membranous Urethra (Posterior Urethra)

It is usually associated with pelvic fractures. Instrumentation, catheterisation, stone, obstetric causes are other etiologies. In complete rupture urethra puboprostatic ligament may be disrupted causing *floating prostate – Vermooten's sign*. *Maccullum – Colapinto classification* is based on ascending urethrogram findings – Type I: Elongation of posterior urethra but intact; Type II: Floating prostate; Type III: Total disruption of the urethra with extravasation urine above and below the sphincter.

Features

Difficulty and failure in passing urine; blood in external meatus; urinary extravasation into perineum/scrotum/abdominal wall are typical features. Digital examination of rectum reveals impalpable prostate—floating. X ray pelvis shows fracture. Urethrogram is diagnostic.

In Floating Prostate

As rupture is complete, bladder is opened from above. A metal bougie is passed from above through the bladder and one more metal bougie is passed from below through urethra and both are manipulated so as to meet each other. Lower bougie is negotiated along the upper one and so into the bladder. Red rubber catheter is tied to the tip of the lower (urethral) bougie which has already entered into the bladder. When lower bougie is pulled out per urethrally, catheter tied to it will pass through urethra from above, to which Foley`s catheter is tied and pulled up, so as to keep it in position. Bladder is closed with a SPC using Malecot's catheter – ***Railroad technique.***

In Incomplete Rupture

Two approaches:

First approach proposed by Mitchell: *Do not pass catheter from below* as it may further damage the urethra and also may damage sphincter mechanism and so may cause incontinence later. Here SPC is done using Malecot`s catheter. After three to six weeks, a urethrogram is done. Using endoscopy or along with open method Foley`s catheter is passed, often after dilatation.

Second approach advocated by Blandy: *Single attempt to pass a small soft catheter per urethrally* gently may lead into the bladder, which will be kept in situ, to maintain the continuity. If this fails SPC is done. On second day, in operation theatre, bladder is opened from above and flexible cystoscope is passed from below and using this, catheter is passed from below. Bladder is closed with a SPC. If patient with incomplete rupture presents later, then manage it once a stricture forms, accordingly as stricture urethra, after 3 months. Until then patient may require SPC. Other measures: Antibiotics, blood, fluid replacement, treat other injuries.

Complications

Urinary incontinence; impotence; stricture urethra; infection.

Rupture of Bulbous Urethra (Anterior Urethra)

Usually due to a fall astride a projecting object, like in sailing ships, cycling, over loose manhole cover, gymnasium.

Clinical Features: Triad

(1) Blood in external meatus (Urethral haemorrhage). (2) Perineal haematoma. (3) Retention of urine. X-ray pelvis and US abdomen are investigations. Condition is diagnosed clinically **(Figs 8-60 and 8-61)**.

Treatment

Patient should be told not to try to pass urine, if passed, then extravasation of urine occurs. In operation theatre, *one attempt of urethral catheterisation is tried gently*. If able to pass a catheter, then it is left in place. Often perineal haematoma which occurs has to be drained. Antibiotics should be given to prevent sepsis. *If catheter fails to pass*, then under general anaesthesia, in lithotomy position, SPC is done. Bulbous urethra is exposed through perineal midline incision and tear is sutured with an indwelling Foley`s catheter. Drain is then placed into the perineum. If suturing is not possible (sometimes), then *perineal urethrostomy* is done and at later stages continuity is maintained (usually after 3 months).

Complications

Infection, extravasation of urine, stricture urethra.

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Fig. 8-60: Urethral injury showing blood in the external meatus with extravasation.

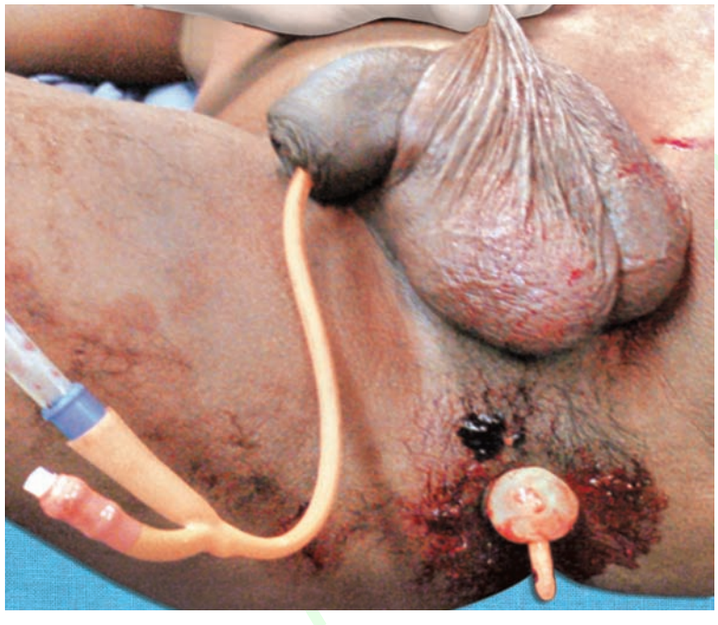

Fig. 8-61: Penetrating injury in the perineum causing rectal and urethral injury which is communicating. Note the catheter passed per urethral has gone into the rectum and come out into the anal canal. It needed colostomy and suprapubic cystostomy diversions (*Courtesy:* Dr Ashfaque Mohammad DNB, KMC, Mangalore).

RUPTURE BLADDER

Causes

Blow, kick or fall; road traffic accidents; stabs, gunshot injuries; endoscopic trauma; instrumentations. **Bladder injury can also occur** during hysterectomy both abdominal and vaginal, surgery of colon or rectum, repair of direct inguinal or femoral hernias.

Types

I: *Intraperitoneal rupture*—20% common. It occurs in fully distended bladder due to blow, kick, or fall.

II: *Extraperitoneal rupture*: 80% common. It is due to road traffic accidents, golf playing, fall over the manhole. Its features and management are same as rupture of posterior (membranous) urethra **(Figs 8-62 to 8-63)**.

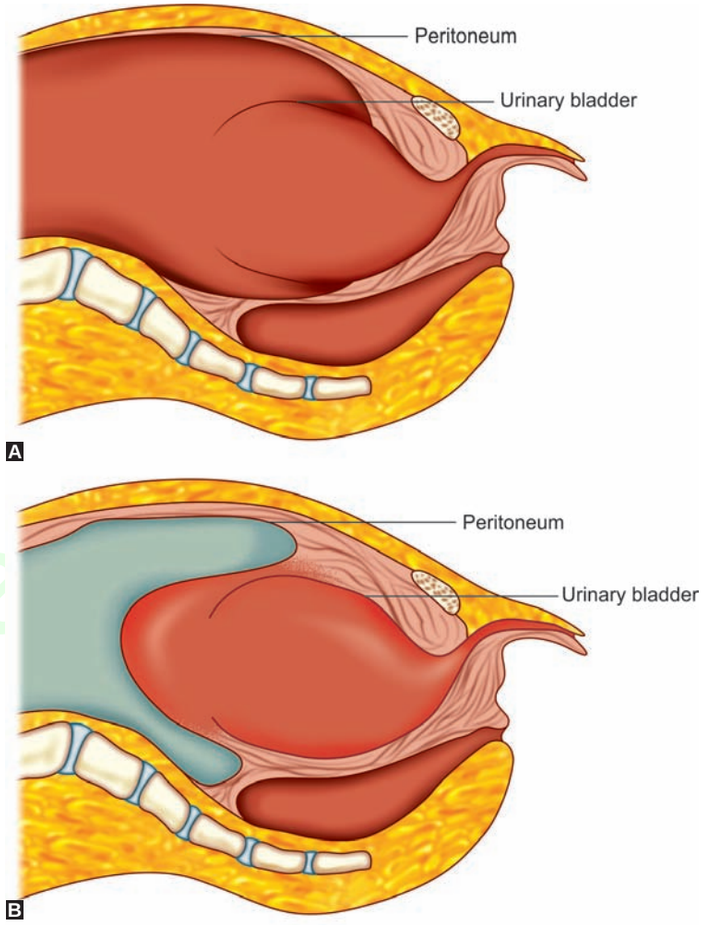

Fig. 8-62: Bladder rupture: (A) Intraperitoneal rupture. (B) Extraperitoneal rupture.

Intraperitoneal Rupture

It is 20% common. *It occurs in full bladder.*

Features: Sudden pain in suprapubic region; shock and syncope; diffuse abdominal pain; urine leaks into the abdominal cavity causing distension of abdomen; later it causes features of peritonitis, with guarding, rigidity, tenderness and rebound tenderness, dull flank. *Patient does not have the desire to micturate.*

Investigations: (1) Plain X-ray shows ground glass appearance. (2) Peritoneal tap to collect urine. (3) After passing a small catheter gently per urethra, water soluble iodine dye is passed to visualise the tear in the bladder and entry of the dye into the free peritoneal cavity. This can be done now through C-arm image intensifier easily. (4) US abdomen to look for other injuries in the abdomen.

Fig. 8-63: Extraperitoneal bladder rupture with extravasation of the urine.

Treatment: Emergency laparotomy is required. Bladder tear is sutured using polyglactic acid (vicryl) in two layers. Peritoneal wash is given. Malecot`s catheter is placed from above as SPC. Prevesical space and peritoneal cavity are drained separately. Foley's catheter from below is also passed. Adequate specific antibiotics are given to prevent sepsis.

Surgery is the only treatment for intraperitoneal rupture of the bladder. Without surgery mortality is 100%.

Complications of rupture bladder: Cystitis/and pyelonephritis; peritonitis; pelvic abscess; fistula formation (vesicovaginal or recto-vesical); paralytic ileus; haemorrhage.

Extraperitoneal Rupture of the Bladder

It is 80% common. It occurs in road traffic accidents, in a non-distended bladder.

Features: There is collection of urine and blood in the extraperitoneal space in front, with fullness, diffuse pain and tenderness in lower abdomen; swelling in the scrotum or labia and abdominal wall; strangury and inability to pass urine; often blood in the external meatus is noted. Features of shock and of other associated injuries may be noted.

Investigations: Plain X-ray pelvis shows fracture pelvis. Cystogram shows leak from the bladder. **During cystoscopy**, (1) Bladder cannot be distended; (2) Endoscopy light may be shining through the abdominal wall; (3) Irrigating fluid cannot be retrieved back.

Treatment: The bladder is exposed extraperitoneally, the tear is identified and sutured and the extraperitoneal space is irrigated with saline. Bladder is closed with a SPC using Malecot's catheter and a drain is placed in prevesical space (cave of Retzius). If there is urethral injury it should be treated accordingly.

SEAT BELT INJURIES

In an individual with tied seat belt, during impact *violent deceleration* of human body occurs. Seatbelt impinges heavily on its point of contact with trunk and viscera continue to move forward. It leads into severe contusion of abdominal contents; *detachment of bowel from its mesentery* due to free forward rapid mobility of the bowel over a relatively fixed mesentery. Solid organ injury occurs only occasionally.

Two point anchorages causes solid organ injuries like of liver/spleen. *Lap belt* causes contusion and bowel injury commonly.

It is often difficult to identify the injuries due to presence of more obvious other injuries. CT chest and abdomen diagnostic peritoneal lavage (DPL) are very useful.

Petechiae around iliac crest or costal margin are signs wherein one can suspect seat belt injuries.

Distraction fracture of lumbar spine (*chance fracture*) with hyperesthesia of T12 and L1 level is often associated. 10% of such fractures are associated with intraabdominal injuries.

Treatment is immediate laparotomy and proceed – bowel suturing/resection/suturing of the organ injuries/splenorrhaphy/splenectomy.

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Chapter

9

Principles of Surgical Treatment in Infections

Infections in different parts of the body are dealt in different ways. Infections may be in limbs, in body cavities or extending from outside to inside or multiple site infections.

It can be surface infections in skin and subcutaneous tissue. It can be deeper infection in the muscle, bone, joint and fascial planes. It can be infection in cavities like in peritoneum, pleura and cranial cavities.

PRINCIPLES

Once there is abscess, it should be drained. Abscess should be formed before drainage in most of the places except in breast, parotid, ischiorectal fossa, hand, and thigh. Pointing pus, excruciating pain, fluctuation, induration are the features of formed abscess. Pus is drained under general or regional anaesthesia. Digital block, brachial plexus block, Bier's block, wrist block, ankle block, sciatic blocks can be used. Local infiltration at the site even though is commonly practiced is unsatisfactory as it may not act due to acidic pus media and due to oedema at the site. Hilton's method of drainage is used to drain an abscess **(Figs 9-1 and 9-2)**.

Digital block is given using xylocaine 1–2% *without adrenaline* (plain) 1-2 ml on each prick site. By diluting with equal quantity of normal saline 0.5% strength can be made. 3 mg/kg is the dose.

Tourniquet should be used in limbs while draining or doing fasciotomy. Pneumatic tourniquet is used. Limb is elevated for 2 minutes for venous emptying prior to applying the tourniquet. Tourniquet inflated to a pressure 30 mm Hg more than systolic pressure of the patient. Tourniquet time for upper limb is 60 minutes; for lower limb it is 90-120 minutes.

Principles

- Always pus should be aspirated for confirmation.
- Adequate incision is the priority. One should not compromise the incision.
- Expose all layers in deeper abscess like psoas abscess, groin abscess, loin abscess.
- Drain should be placed – wick/tube/corrugated depending on need.
- All loculi should be broken. All communications should be drained.
- Proper saline (warm) irrigation to the cavity is essential.
- Pus should be sent for culture.
- In superficial/surface abscess wound is left open. In deep abscess like psoas abscess wound is closed in layers or single layer with a drain.
- Antibiotics should be started prior to drainage.
- General/regional anaesthesia is used.
- Deeper abscess can be confirmed by CT scan or ultrasound. Repeat ultrasound/CT scan for completion of drainage may be needed.

Hand Infection

Hand should be properly examined clinically for tendon functions; neurological problems – sensations (sweat test, two point discrimination test); for circulation (Allen's test); joint movements; examination of entire upper limb; opposite hand; axillary lymph nodes and relevant systemic examinations.

The principles of treatment are elevation to reduce oedema; splintage to prevent contracture; rest during initial stage of diffuse infection; early movements once inflammation subsides; early exploration of wound or surgical drainage of infective area; regional anaesthesia; usage of tourniquet; incisions when cross the flexor creases, it should be at 45° angle.

Rest is achieved by *plaster of Paris* applied on the ventral aspect of the hand. Elevation is achieved by suspending the arm from an overhead support. Flucloxacillin 500 mg 6th hourly, metronidazole 400 mg 8th hourly orally is given initially until pus culture sensitivity report is available.

During surgical drainage *site of incision should be marked* properly prior to anaesthesia. Length of the incision should be adequate. Superficial part of the deep abscess should be drained initially (collar stud part); and then deeper part is reached and drained properly. Pus should be collected for culture and sensitivity. Skin edge is trimmed using a fine scissor to create a *diamond shaped opening.* Thorough saline irrigation is done. Dressing is placed. Tourniquet is released. Arm is elevated. Dressing is opened and wound is inspected after 24 hours. Further dressings are done once in 1-2 days, depending on need. Continuation of antibiotics for longer period is done only if abscess is large; signs of bone or spreading infection **(Figs 9-3 to 9-6)**.

Apical Subungual Infection

It is infection of the space between subungual epithelium and the periosteum. It occurs after minor trauma or rarely after formation of subungual haematoma. Beneath the free edge of the nail, pus comes to the surface. Excruciating tenderness with small visible pus under the tip (summit) of the nail is the feature. Drainage with transverse incision at the tip of finger with removal of V shaped of wedge of nail over the summit is the treatment along with antibiotics. Osteomyelitis is *not common* here **(Fig. 9-7)**.

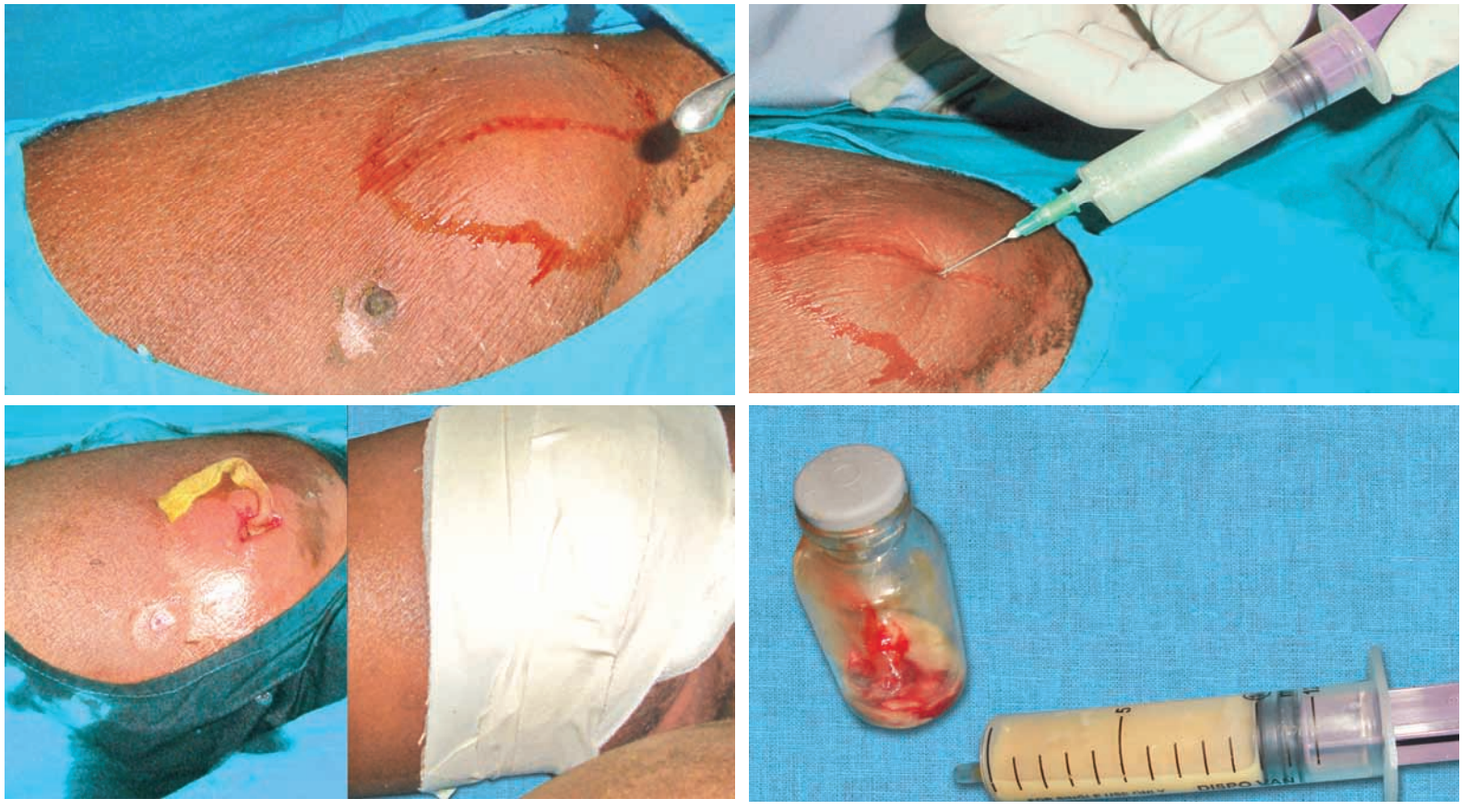


Fig. 9-1: Abscess is drained by Hilton's method of drainage. Abscess should be aspirated prior to making incision. Longitudinal adequate length incision is made over the skin. Pyogenic membrane is opened using sinus forceps. All loculi are broken using little finger or sinus forceps. Warm saline wash is given. Cavity is packed with gauze or drain. Pus should be sent for culture and sensitivity.

Paronychia

It is infection of nail fold. It can be acute or chronic. Acute is usually bacterial. Chronic is commonly fungal. Acute is usually due to Staphylococcus or Streptococcus. It occurs under the eponychium. Pus spreads under the nail causing hang nail or floating nail. Condition is precipitated by minor trauma. Excruciating throbbing pain and tenderness under nail root are the features. Digital block anaesthesia is used. Using fine scissors lateral nail fold is elevated; loose skin portion is removed; pus extrudes out; portion of this base of nail should be removed in floating nail as it is usually dead. Keeping drain or gauze wick is not needed. Pus is sent for culture. Dressing is done. In chronic paronychia entire nail may required to be removed **(Fig. 9-8)**.

Pulp Space Infection (Felon)

Terminal pulp space infection is common. Throbbing pain is common; but pointing pus may not be clear initially. It is initially treated by rest, elevation and antibiotics. Once pus points or maximum tender point is determined, drainage is done. But undue delay in draining should be avoided as osteomyelitis of terminal phalanx can occur due to blockage of the end artery of the terminal phalanx by infective thrombosis. Oblique deep incision directly over the pulp is needed. Superficial collar stud part is opened; then deeper part is opened adequately **(Fig. 9-9)**.

Web Space Infection

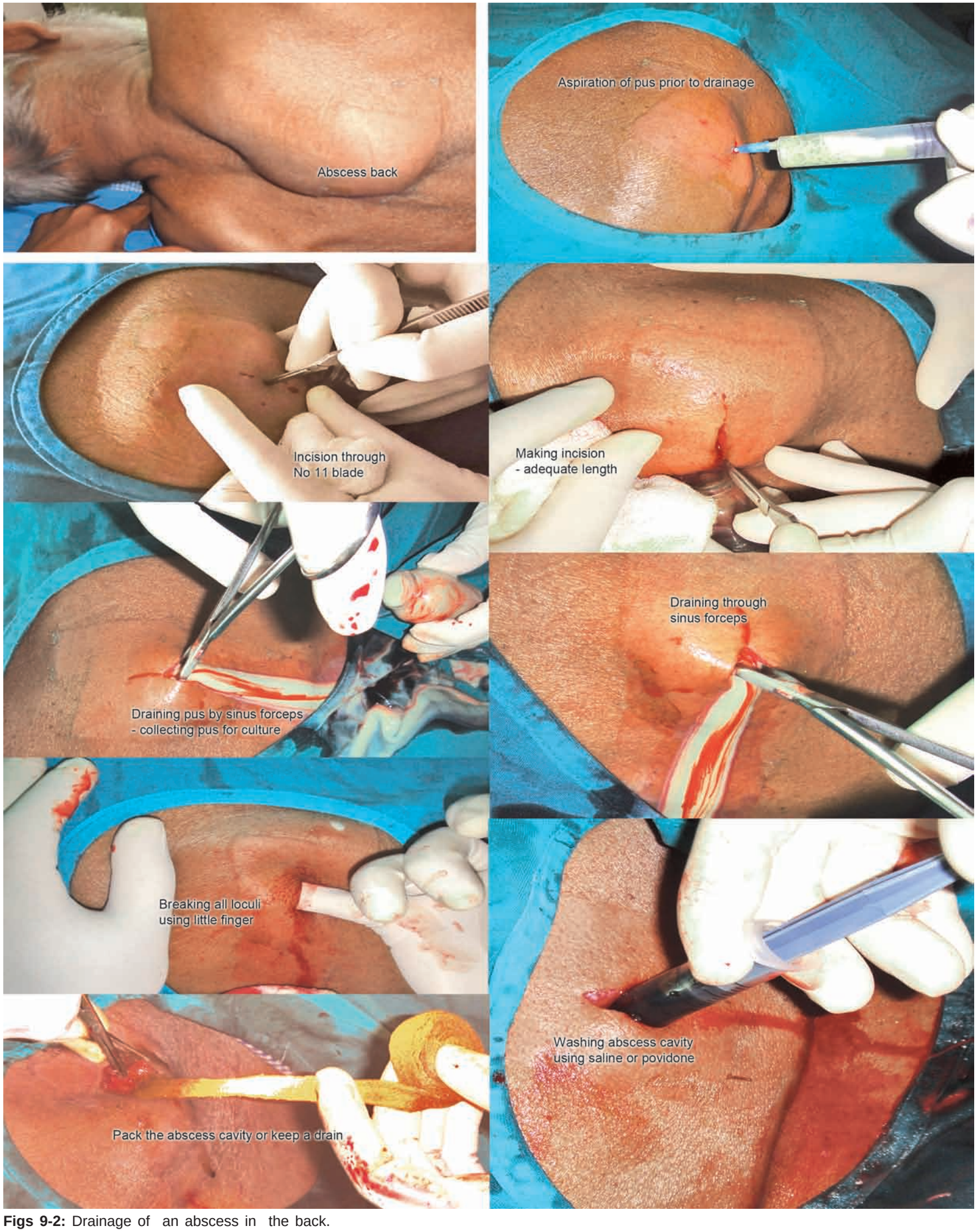
It is initially treated with splinting, elevation and antibiotics. It is drained under general or regional anaesthesia. A transverse incision is placed on the palmar aspect opposite the interdigital space and 1 cm proximal to the free edge of the web. Only skin is incised using no 11 blade. Deepening of the wound is done using sinus forceps by blunt dissection. It is important to go deeper to palmar aponeurosis otherwise drainage is incomplete. Dorsal counter incision is not needed. Vertical incision in the web should not be placed as it will cause bad contracture **(Figs 9-10 and 9-11)**.

Deep Palmar Space Infection

Midpalmar Space Infection

Midpalmar space (triangular shape) is bound by palmar aponeurosis in front; medial three metacarpals behind; a vertical line from lateral margin of middle finger (intermediate palmar septum) laterally; medial palmar septum medially **(Figs 9-12 to 9-14)**.

Proximally it begins from flexor retinaculum; distally it extends into distal palmar crease along 3rd and 4th lumbrical canals. It is on the inner half of the hollow of palm. It contains flexor tendons, lumbricals and neurovascular bundles. Posteriorly it is bounded by 3rd, 4th, 5th metacarpals and fascia covering interossei muscles of



Figs 9-2: Drainage of an abscess in the back.

Fig. 9-3: Finger infection causing oedema, discharge. It can lead into stiffness, osteomyelitis, and gangrene of the digit due to infective thrombosis of the digital artery.

3rd and 4th intermetacarpal spaces. Pain and tenderness in the palm; obliteration of the concavity of the palm; oedema of dorsum of hand (frog hand) due to lax skin and plenty of lymphatics; painful movements of metacarpophalangeal joint are the features. *Complications* like osteomyelitis of metacarpals, stiffness of hand, suppurative arthritis are common.

It is *drained* under regional/general anaesthesia by placing horizontal/oblique incision parallel to the palmar crease. One should avoid as much as possible to cross the crease line. Palmar aponeurosis is vertically incised carefully to avoid injury of the neurovascular bundles. Alternatively one of the *interdigital web spaces* is incised horizontally; *lumbrical canal* (3rd or 4th) is opened to reach the deep palmar space. Pus is drained. Thorough saline irrigation is a must.

Thenar Space Infection

Thenar space (triangular shape) is located anterior to the lateral two metacarpals. It is on the outer half of the hollow of the palm. Proximally it extends from flexor retinaculum; distally it extends to transverse palmar crease. It communicates to fascial sheath of 1st lumbrical. It is often associated with midpalmar space infection. It is drained similarly by placing incision on the lateral aspect of the palm or through the first web space incision along the *first lumbrical canal* on the radial side of the index finger **(Fig. 9-15)**.

Space of Parona Infection

Forearm space of Parona is a rectangular space situated in the lower part of the forearm above the wrist, in front of pronator quadratus, deep to long flexor tendons. Above it extends upto oblique origin of flexor digitorum superficialis, below upto flexor retinaculum communicating with midpalmar space. Flexor tendon sheath extends proximally into this space. Pus in this space is drained through lateral incisions in the lower part of the forearm.

Figs 9-4A to C: Different types of hand infections – ulcer, abscess, ulcers.

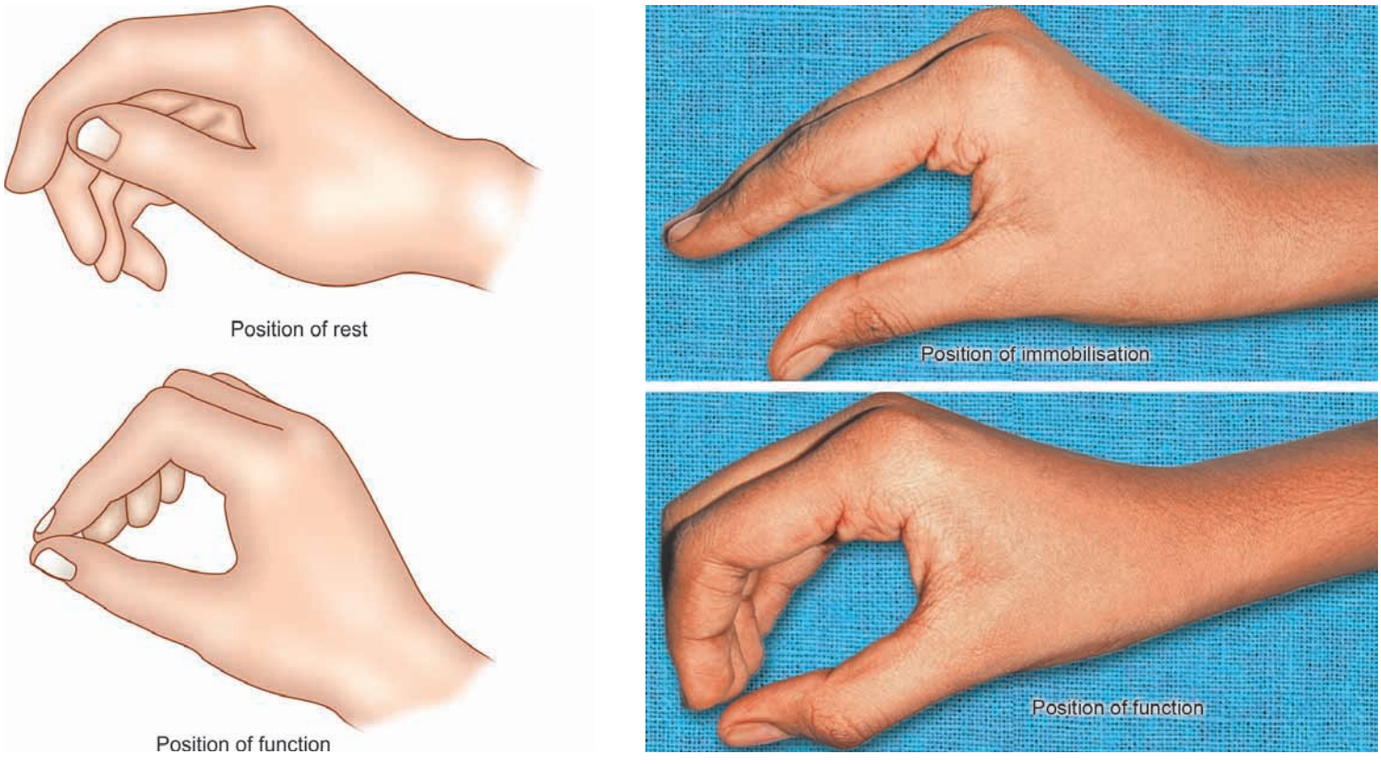
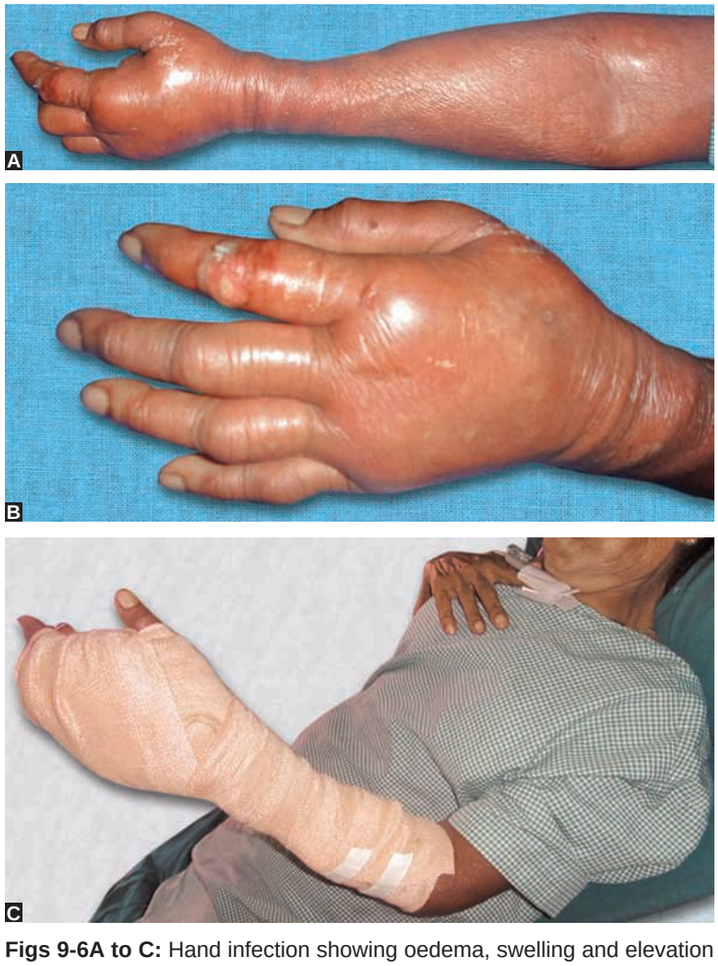


Fig. 9-5: Position of rest, function and immobilisation. Position of rest and immobilisation are same.



Figs 9-6A to C: Hand infection showing oedema, swelling and elevation after drainage.

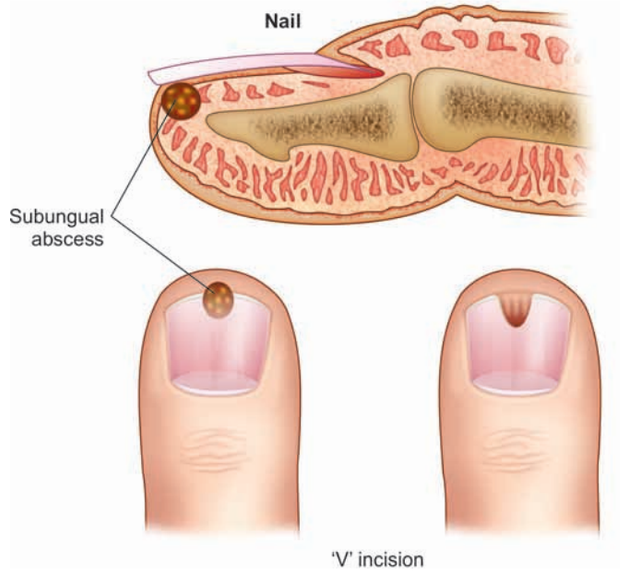
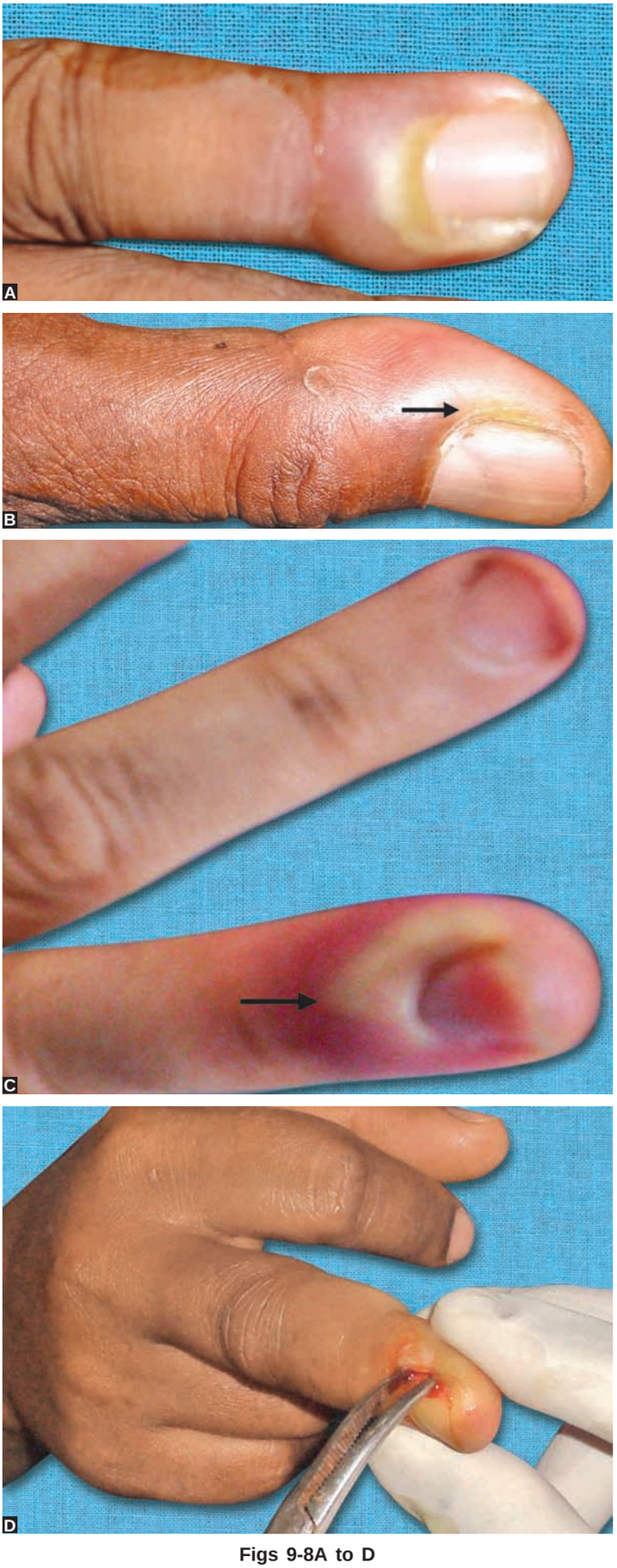


Fig. 9-7: Apical subungual infection and pus formation. Note the `V' shaped incision to drain the same.

Acute Suppurative Tenosynovitis (Tendon Sheath Infections)

Radial bursa is synovial sheath of flexor tendon of thumb which extends into the *digit*. Ulnar bursa is synovial sheaths of the medial four flexor tendons of hand which extends into the digit of the *little finger*. Radial and ulnar bursas communicate with each other in 80% of cases. Extensor tendons are *devoid* of sheaths. It presents with symmetrical swelling of entire finger. *Hook sign* with flexion of finger is typical. Oedema of the



Figs 9-8A to D

Fig. 9-8E

Fig. 9-8: Acute paronychia. Pus even though is in small quantity, it should be drained.

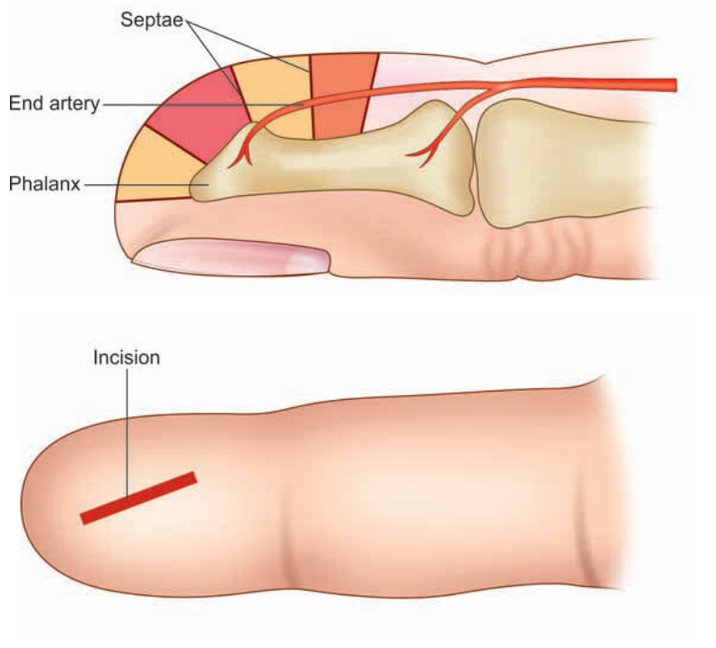


Fig. 9-9: Anatomy of pulp space. Artery supplying the terminal part of the distal phalanx of the finger passes through the septae on the pulp. This artery is an end artery. So infection in the pulp space increases the pressure inside leading to infective thrombosis and blockage of end artery causing osteomyelitis of the terminal phalanx. Terminal pulp space infection should be drained through an oblique pulp incision. Decompression with breaking of septae is important.

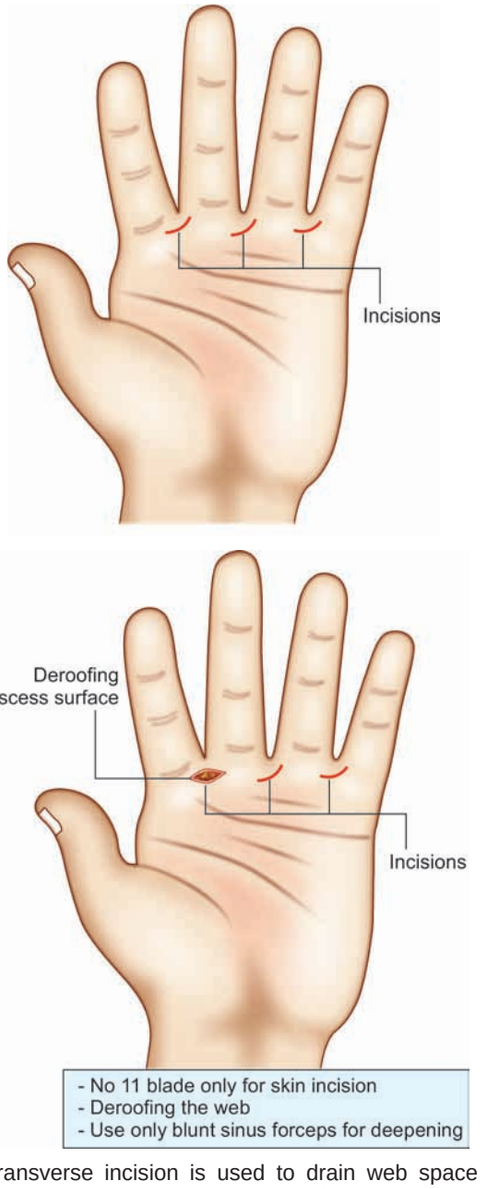


Fig. 9-10: Transverse incision is used to drain web space infection. Deroofing of the incision and web space is done.

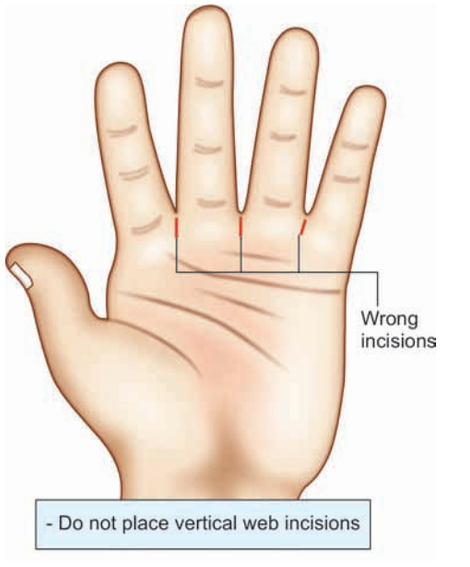


Fig. 9-11: Vertical incision to drain web space infection is *avoided.*

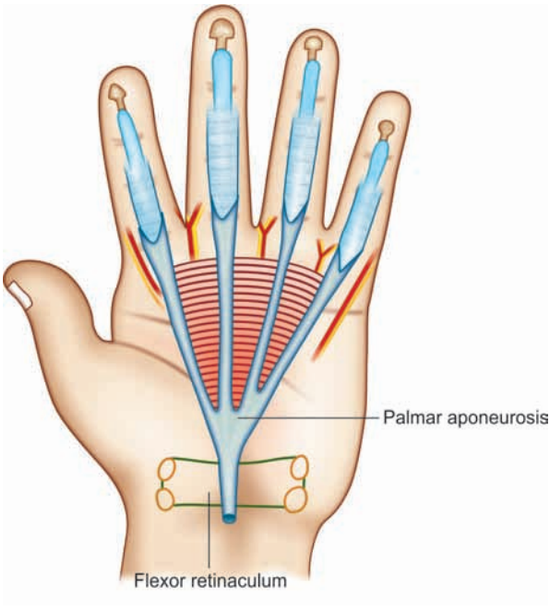
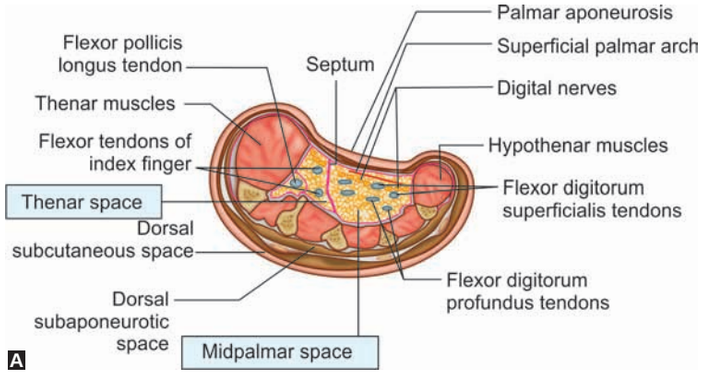
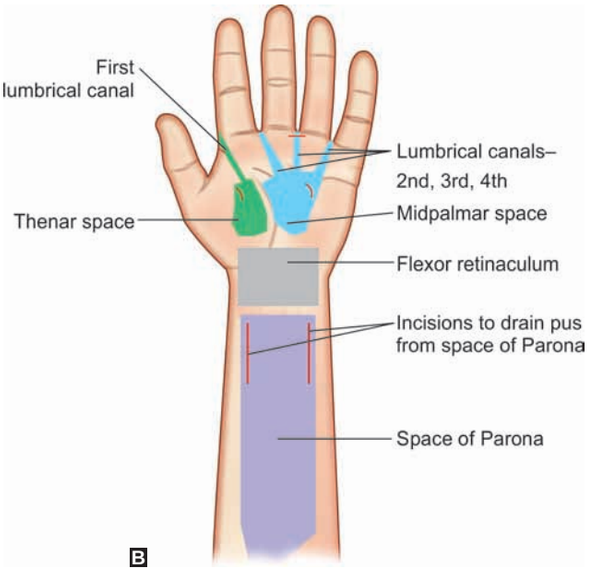
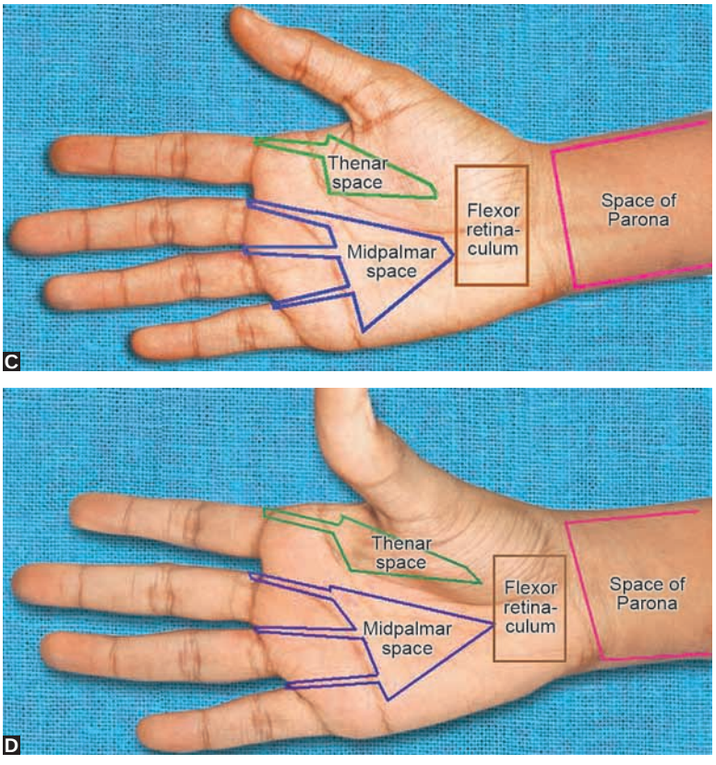


Fig. 9-12: Flexor retinaculum – anatomy.





Figs 9-13A and B



Figs 9-13C and D

Figs 9-13A to D: Anatomy of palmar spaces of the hand and forearm. Midpalmar space is on the medial aspect; thenar space is on the lateral aspect. Space of Parona is on the lower forearm.

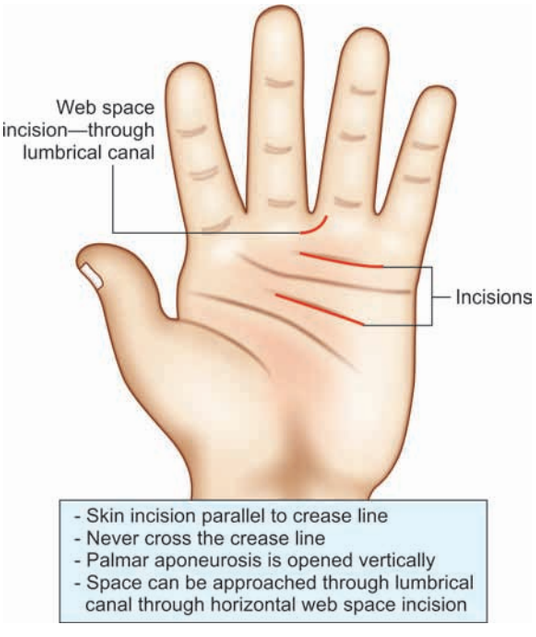

Web space incision—through lumbrical canal
Incisions
- Skin incision parallel to crease line
- Never cross the crease line
- Palmar aponeurosis is opened vertically
- Space can be approached through lumbrical canal through horizontal web space incision

Fig. 9-14: Incisions to drain midpalmar space infection.

dorsum of the hand, tenderness extending into the little finger in infection of ulnar bursa; extending into the thumb in infection of radial bursa; swelling extending proximal to flexor retinaculum; positive Kanavel signs are obvious. *Kanavel signs* – swollen finger held in flexion; exquisite pain on passive extension; tenderness over tendon sheath; greatest point of

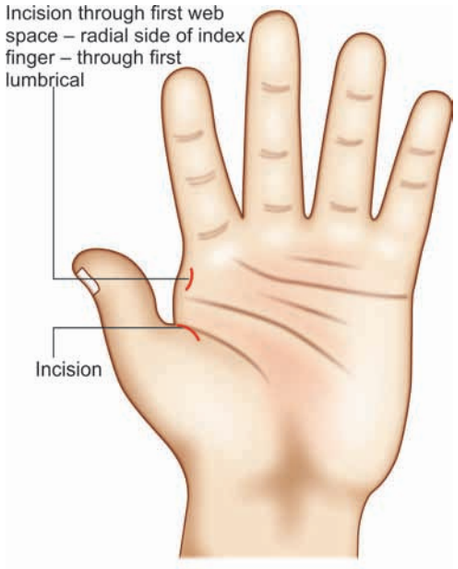


Fig. 9-15: Incision and drainage of thenar space abscess.

tenderness is between two transverse creases. *Complications* are proximal spread to forearm; hand and finger stiffness; suppurative arthritis; osteomyelitis; median nerve palsy; septicaemia **(Fig. 9-16)**.

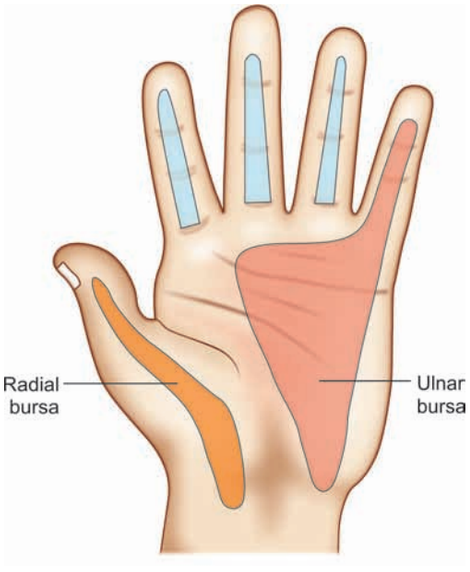


Fig. 9-16: Radial and ulnar bursae in hand. Radial bursa communicates with the sheath of the thumb; ulnar bursa communicates with sheath of little finger.

It is *drained through two incisions* - one over the proximal part of the sheath; other over the distal part of the sheath in the digit - along the crease lines. A fine catheter is passed into the sheath from proximal incision and irrigated with normal saline through this catheter. This catheter is left in situ for further regular irrigations, splinting of hand is necessary with boxing glove dressing **(Fig. 9-17)**.

Compound Palmar Ganglion

It is chronic tenosynovitis of flexor tendon sheaths due to tuberculosis or rheumatoid arthritis. Smooth, soft, non-tender cross fluctuant swelling

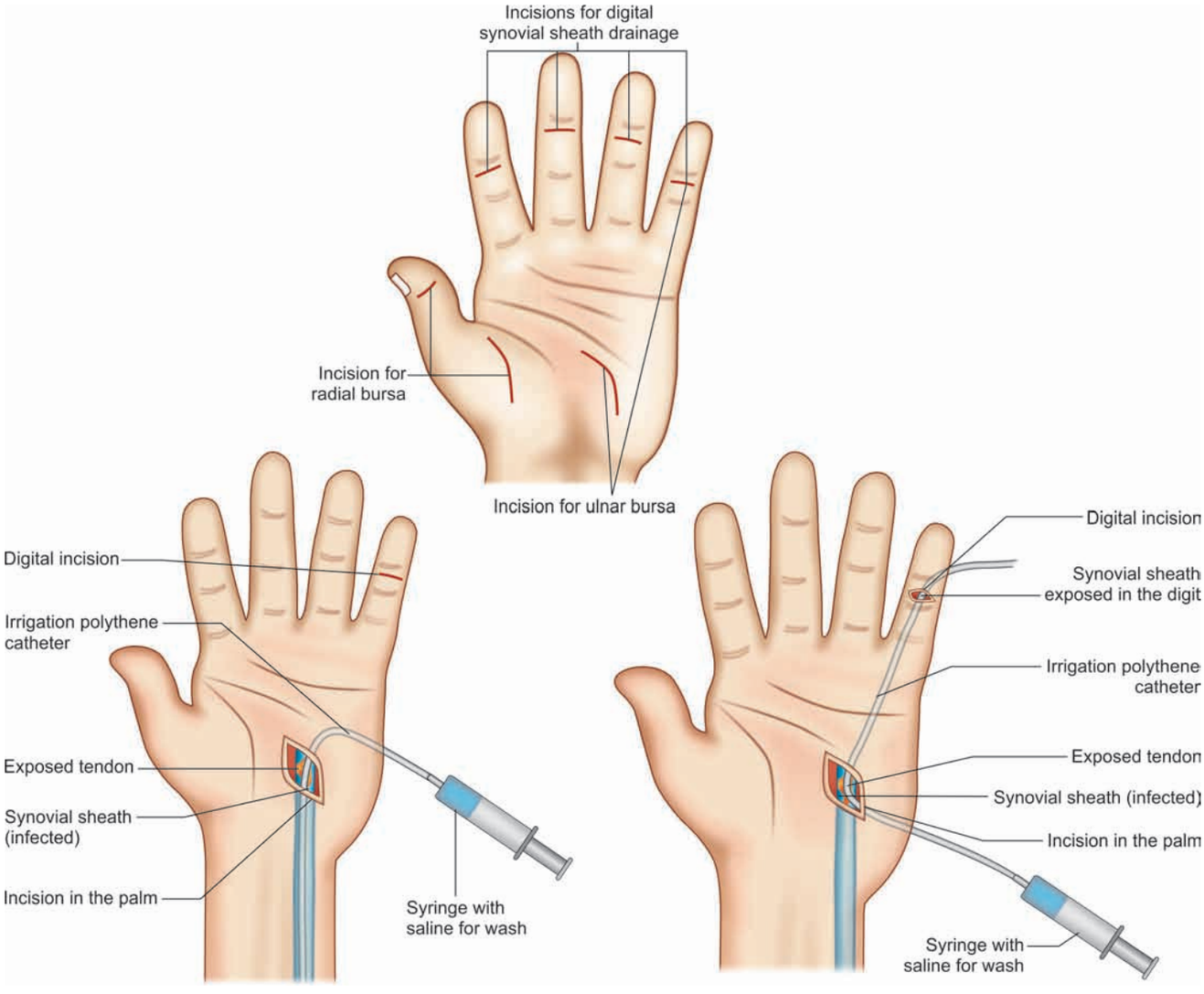


Fig. 9-17: Suppurative tenosynovitis is drained through incision at proximal part and another at digital sheath. Often by placing fine polythene catheter into the sheath saline wash is given into the area.

in the hollow of palm is typical. *Melon seed bodies* are characteristic. It is treated surgically after beginning of the antituberculous drugs. But surgical treatment is not easy. With tourniquet in place, under general anaesthesia, tendon sheath is exposed widely by a vertical incision. Diseased tendon sheath shows adhesions and ramifications on the median and ulnar nerves. With meticulous careful dissections, tendon sheath is excised. All diseased tissues and melon seed bodies are removed. Thorough irrigation is given. Often fine polythene catheter is placed over the sheath for further irrigations postoperatively. Streptomycin irrigation is often used in case of tuberculosis.

Fasciotomy for Compartment Syndrome

Compartment syndrome is a special entity; common in leg, forearm, thigh and arm; is due to increased intracompartmental pressure within a limited space area. *Causes* are – narrowed space due to tight dressings/plaster cast, lying on one limb in comatous patient; increased content of the compartment due to trauma/fractures, oedema, ischaemic injury, haematoma, positioning after trauma, burn injury, etc; high pressure injection injuries like gun injury, oil based material injury as in extravasation of chemotherapeutic drugs; snake bite. It compromises circulation mainly of muscle and nerves. It often maintains the normal colour and temperature of the fingers and distal pulses may not be obliterated in spite of severe muscle ischaemia. Muscle ischaemia for more than 4 hours causes muscle death and myoglobinuria. Irreversible nerve damage develops if ischaemia persists for 8 hours. Progressive, persistent severe pain which is aggravated by passive muscle stretching is the diagnostic sign. Tense tender regional lymph node is typical. Pulse is usually normally felt in compartment syndrome; but may become absent if there is associated arterial injury. Compartment pressure more than 30 mm Hg is an indication for fasciotomy **(Fig. 9-18)**.

Fig. 9-18: Fasciotomy is done in compartment syndrome. Often incision has to be extended into the arm also.

Fasciotomy of anterior compartment of forearm is specific method. Carpal tunnel *should be released* by *cutting flexor retinaculum*. Incision begins at the junction of the thenar and hypothenar area; extends proximally initially transverse across flexion crease of the wrist at the ulnar border; then across forearm towards radial side of forearm; then in proximal forearm towards medial side creating convex flap towards lateral side. In the elbow it crosses along the medial border to reach the arm where it runs along the medial side of the anterior arm. Injury to major nerves, palmar cutaneous branch of median nerve should be avoided while placing the incision. Incision should be deepened by cutting the deep fascia along the entire length of the incision **(Fig. 9-19)**.

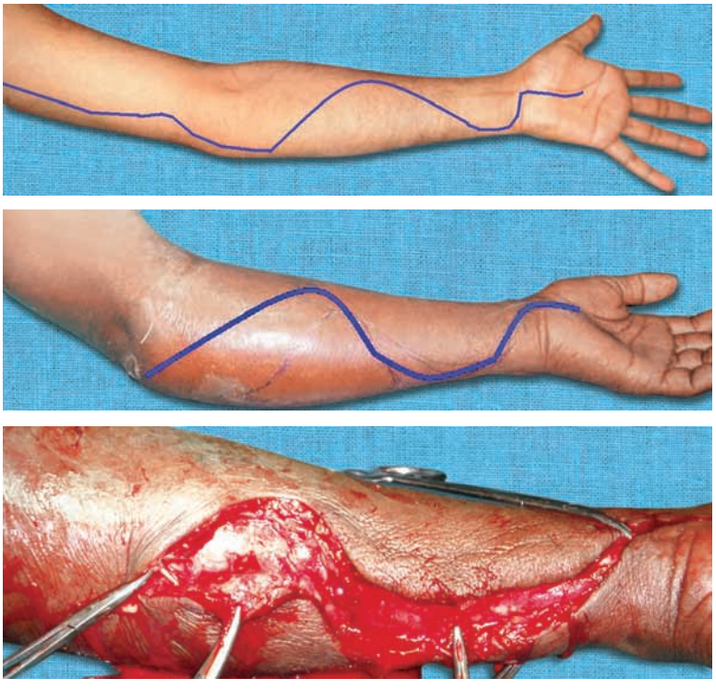


Fig. 9-19: Incision for fasciotomy in upper limb begins at flexor retinaculum extending into the forearm with a convex flap towards radial side eventually leading towards medial epicondyle of the elbow joint.

Dorsal fasciotomy should be added by placing longitudinal lengthy incision in the midline. Two longitudinal incisions on the dorsum of the hand also should be made **(Fig. 9-20)**.

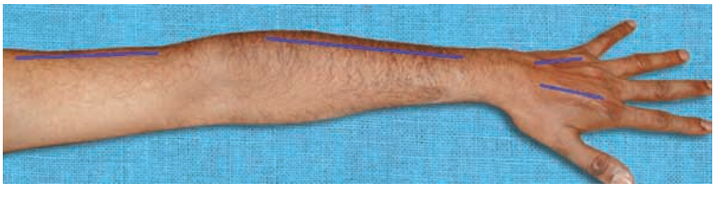


Fig. 9-20: Fasciotomy on the dorsum of forearm.

In lower limb also lengthy fasciotomy is done. Often multiple fasciotomies are required. Longitudinal, deep, lengthy incisions to expose the muscle underneath are required. Fasciotomies are done in different compartments – anterior, posterior and lateral **(Fig. 9-21)**.

Delayed secondary suturing in 5-10 days with split skin grafting is needed. Blood transfusions, antibiotics, hyperbaric oxygen are needed. Mannitol may be needed to prevent renal failure.

Chronic ischaemic contracture, gangrene, sepsis, renal failure, disability are the complications.

Fig. 9-21: Fasciotomies done for lower limb.

DRAINAGE OF AN ABSCESS

Drainage of an abscess depends on location of the abscess; whether abscess is formed or not. Superficial/surface abscess is drained by *Hilton's method* of drainage.

Deeper abscess: It is drained after confirmation by CT scan/MRI, etc. It is approached by layer-by-layer incision and drainage. Thorough warm saline irrigation is given. Drain is placed and closed in layers. Pus should be sent for culture.

Pus in the joint: It is confirmed by X-ray/total count, MRI features like pain, warmness, swelling, tenderness, oedema, restriction and pain in all movements of joint . It is usually aspirated under guidance. **Arthroscopy** and wash can be given. Often open drainage is done.

Intraabdominal Abscess

It can be drained percutaneously by placing percutaneous catheter under guidance. Open drainage when needed should be undertaken if aspiration or percutaneous drainage fails.

Laparotomy is done to drain intraabdominal abscesses. Abscess may be in bilateral subphrenic, lesser sac, prepancreatic, interloop, anastomotic site, mesenteric or pelvic. Except pelvic abscess all are drained transperitoneally, and is through upper midline incision **(Figs 9-22 to 9-24)**.

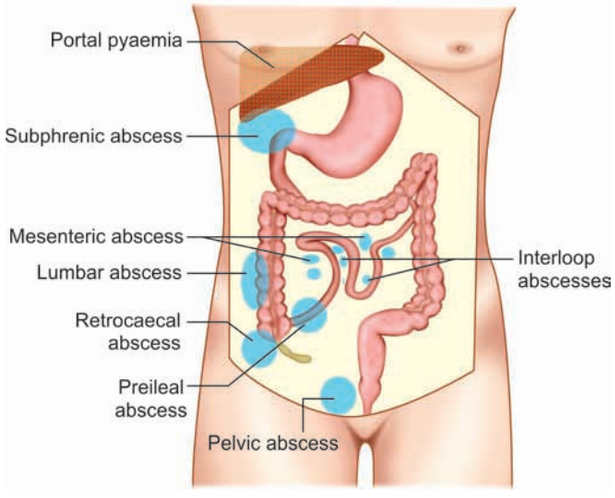


Fig. 9-22: Different intraabdominal abscesses.

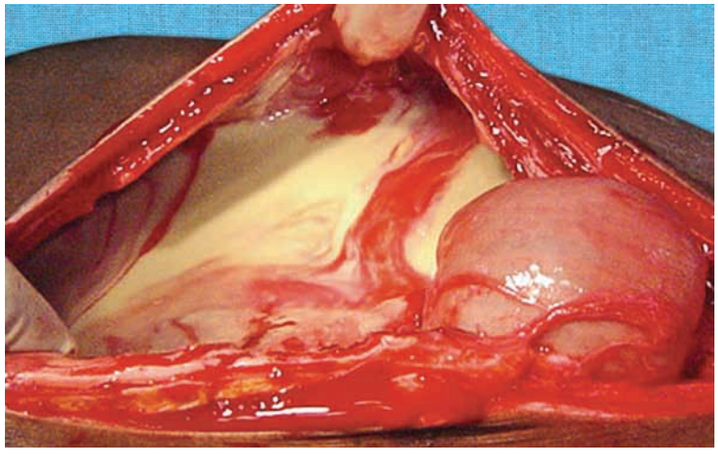


Fig. 9-23: Pus in the peritoneal cavity is drained through laparotomy incision.

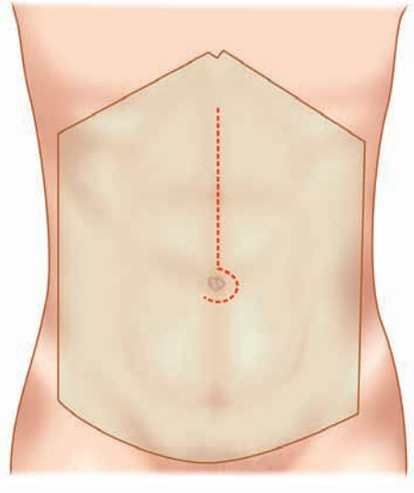


Fig. 9-24: Upper midline laparotomy incision is used for transperitoneal drainage of intraabdominal abscesses. It is also used for open drainage of liver abscess, transperitoneal drainage of subphrenic abscess when needed.

Technique

Urinary catheter and nasogastric tube should be passed. Anaesthetist often prefers a central line. General anaesthesia with epidural support is used. Lengthy midline incision is used. If patient has undergone recent laparotomy, same incision with extension above and below is used. Peritoneum is opened over new extended part of the incision as it is virgin and chances of bowel adhesions underneath is less likely. Falciform ligament is identified and used as a guide for further dissection. By lifting the ligament dissection is carried out gently using pulp of the finger and gauze. Care should be taken as much as possible to avoid opening of bowel lumen during separation. Right and left suprahepatic and infrahepatic spaces are reached to clear the pus. Lesser sac is approached through gastrohepatic ligament along the lesser curvature of the stomach or through the omentum along the greater curvature of the stomach. Both right and left paracolic gutters are exposed to clear the pus. Often entire small bowel should be freed to clear the pus from interloop areas. Pelvis is reached by pulling the entangled bowel upwards from the pelvis. Pus should be sent for culture and sensitivity. Thorough warm saline wash (10 litres) is given. *Feeding jejunostomy is always* better to be done. Two tube drains/sump drains are placed on either side. Abdomen is closed by *Smead – Jones closure* method.

Subphrenic Abscess

Early diagnosis; considering that subphrenic abscess is thoracoabdominal in extension; drugs and early drainage; initial percutaneous guided catheter placement; when needed open surgical drainage are essential parts always to be remembered in dealing with subphrenic abscesses **(Figs 9-25 to 9-27)**.

Fig. 9-25: CT scan showing subphrenic abscess.

Percutaneous Catheter Drainage

It is the standard initial treatment for subphrenic abscess. US or CT guided placement of catheter is done. One has to remember that *aspiration alone is not done* in subphrenic abscess.

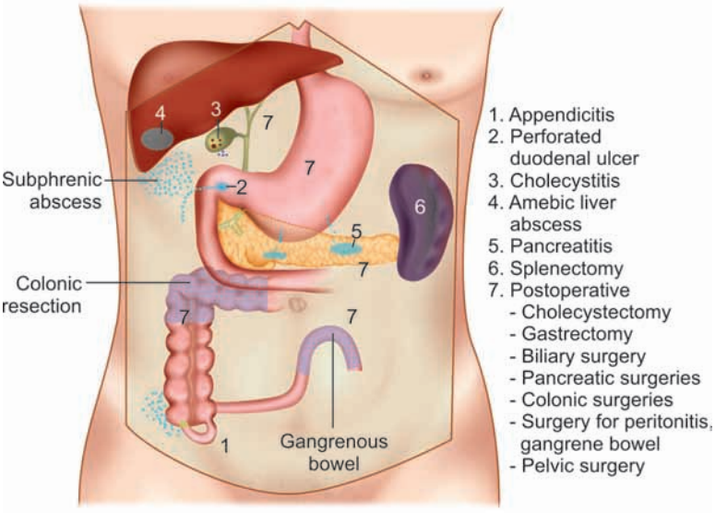


Fig. 9-26: Causes of subphrenic abscess.

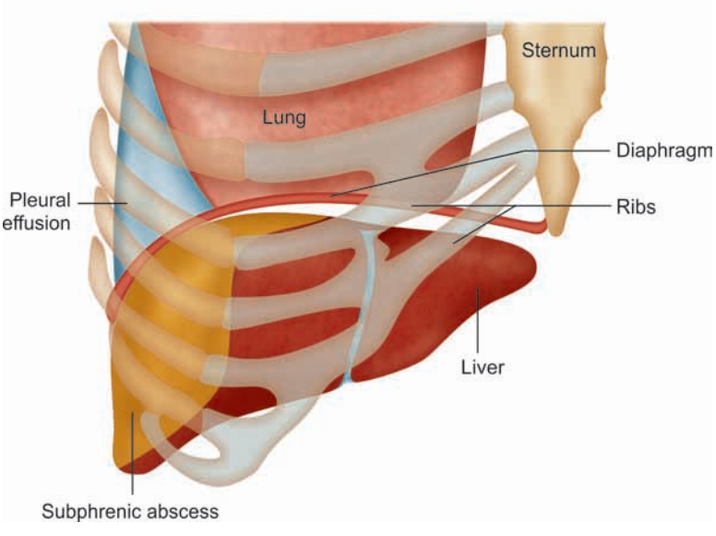


Fig. 9-27: Subphrenic abscess – common site.

Open Drainage

It is drained by extraperitoneal and extrapleural (*extraserosal*) approach. Aspiration/placing percutaneous catheters under guidance (CT/US) are also used. *Preoperative preparation* - CT scan is very essential diagnostic. Antibiotics should be given – aminoglycosides, amoxicillin, metronidazole. Nasogastric tube should be placed.

Anaesthesia – Procedure is done under general anaesthesia with epidural support for postoperative pain relief.

Technique – Subphrenic abscess is second common intrabdominal abscess. 30% of subphrenic abscess patients can be asymptomatic. *Boyd* classified subphrenic spaces into right suprahepatic and infrahepatic; left suprahepatic and infrahepatic **(Fig. 9-28)**.

Position – Lateral position with body kept obliquely no the table. Patient should be supported properly before cleaning and draping.

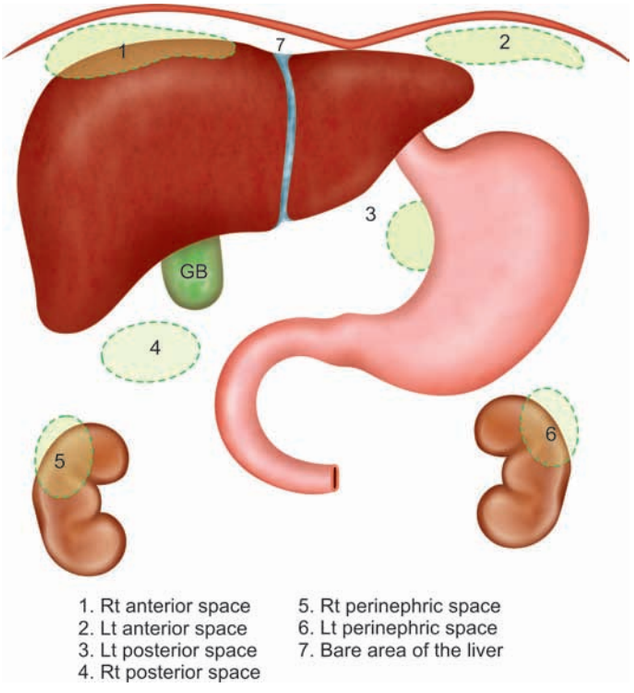


Fig. 9-28: Subphrenic spaces anatomy.

Incision – Anterior extraserous approach is like a subcostal incision (10–12 cm) from the outer margin of the rectus muscle laterally up to the anterior axillary line towards tip of eleventh rib. *Left anterior extraserous* approach is called as *Clarimount approach.*

Posterior extraserous approach is oblique incision 2 cm from the midline over the bed of 11th rib with opening the periosteum and resecting the rib. Care must be taken not to enter the pleura.

Layers – Skin, subcutaneous tissue, superficial fascia, external oblique muscle, internal oblique muscle are cut. Skin is incised using no. 22 blade. Remaining layers are cut using cutting and coagulation monopolar cautery. 9th intercostal nerve is visualised and often needs to be cut. Transverse abdominis muscle is usually split but can be cut if needed. Splitting is started from behind from posterior aspect as here muscle is not adherent to peritoneum unlike in front. Once muscle is split transversalis fascia with peritoneum can be visualised clearly. Transversalis fascia is cut using blade. One must take care *not to open the peritoneum.*

Technique - Using gauze in sponge holding forceps or finger peritoneum is pushed downward and medially to reach under the costal margin above the liver towards the surface of the subphrenic abscess. Area of induration is felt with finger. Abscess surface is opened using long sinus forceps or by blunt finger dissection. Pus gushes out. Loculi are broken carefully using finger or sinus forceps. Pus is collected for culture and sensitivity. Abscess cavity should be opened widely. Warm saline wash is given into the abscess cavity using 50 ml syringe. Tube drain is placed. One tube drain is sufficient if cavity collapses after drainage. Many tube drains are placed if abscess cavity is large and do not collapse after drainage. Wound is closed in layers using polyglactic acid zero or no 1 suture. Layer by layer closure is done. Many advocate a mass single layer continuous suture which is also accepted. Skin is closed with interrupted sutures or using skin staplers **(Figs 9-29 and 9-30)**.

Fig. 9-29: Subphrenic abscess – open drainage steps – extraserosal approach.

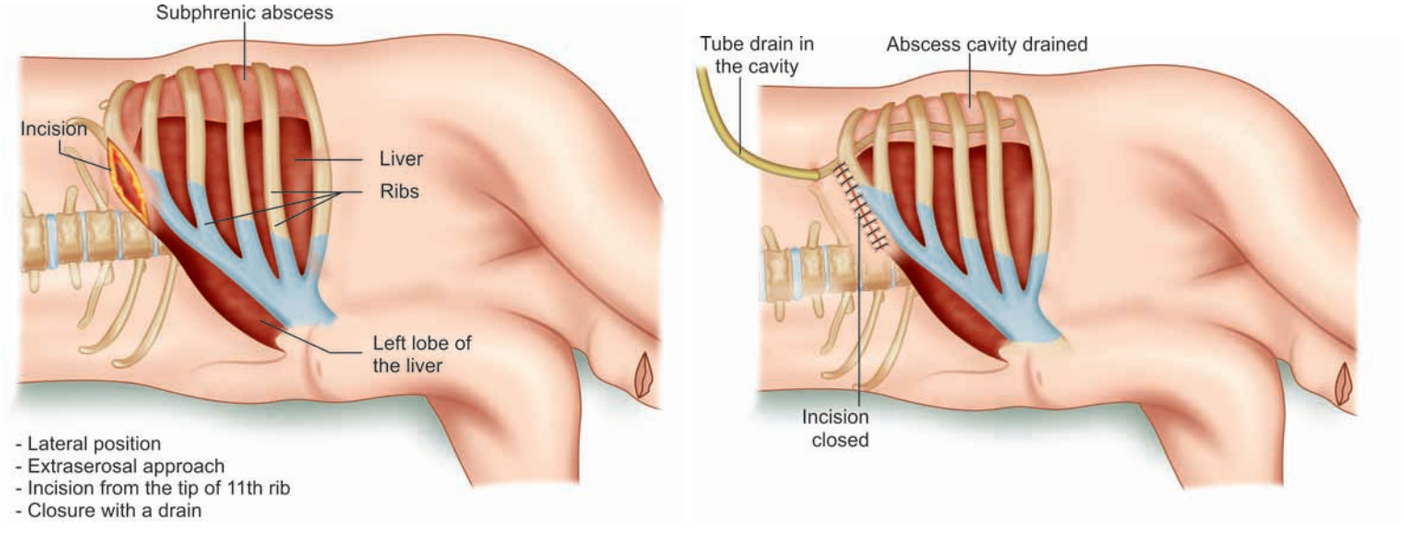


Fig. 9-30: Subphrenic abscess – incision, approach and closure.

If the abscess cavity has large thick rigid wall, it takes long time to collapse and often needs regular irrigation of the cavity using one of tube drains **(Fig. 9-31)**.

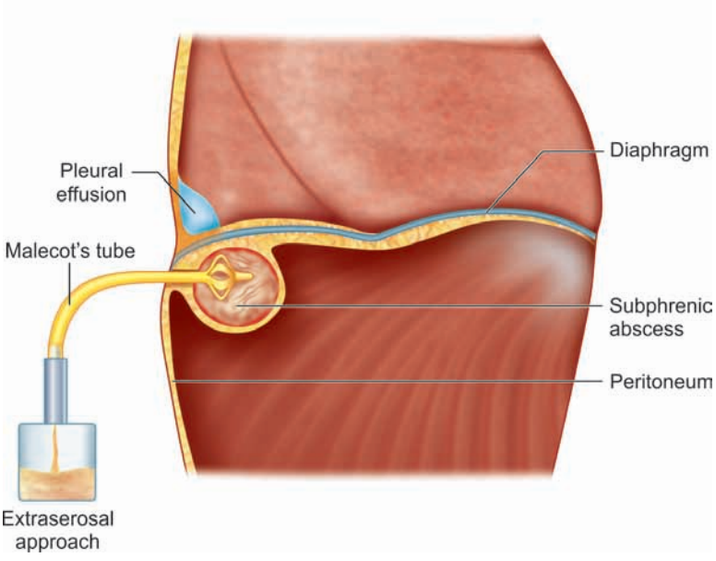


Fig. 9-31: Subphrenic abscess – open drainage by placing a tube.

Drain is *removed* in 10–14 days or after collapse of abscess cavity or after confirmation of the obliteration of the cavity by ultrasound or CT scan or contrast dye study using C ARM.

Often it is advised to keep a drain in the subcutaneous tissue. If there is more contamination, skin and subcutaneous tissues are left without suturing but covered with a dressing until healthy granulation tissue develops and wound becomes clean to take up for secondary suturing. Antibiotics are continued.

Complications

Injury to pleura, colon, liver, spleen; bleeding; sinus/fistula formation; incomplete drainage. Other intraperitoneal abscesses may be missed through extraserosal approach.

Transperitoneal Approach

Often transperitoneal approach is needed. Now it is proved that transperitoneal approach is safer. Bilateral subphrenic abscesses, multiple abscesses/more than one cavity or more loculations or subphrenic abscess due to anastomotic leak postoperatively (wherein leak site can be inspected and necessary repair can also be undertaken) are sure indications for *transperitoneal approach*. Upper *midline* approach is used.

Liver Abscess

In developing countries amoebic liver abscess accounts for 80%. In western countries pyogenic abscess accounts for 80%. Fever, chills, abdominal pain, tender hepatomegaly, decreased right sided diaphragmatic movement, sympathetic pleural effusion are the presentations. Raised total count; abnormal liver function tests; anaemia; effusion in chest X-ray are common. US (90% sensitivity) and CT (95% sensitivity) are useful methods. MRI is useful when associated biliary pathology is suspected and when multiple follow-ups are needed **(Figs 9-32 to 9-34)**.

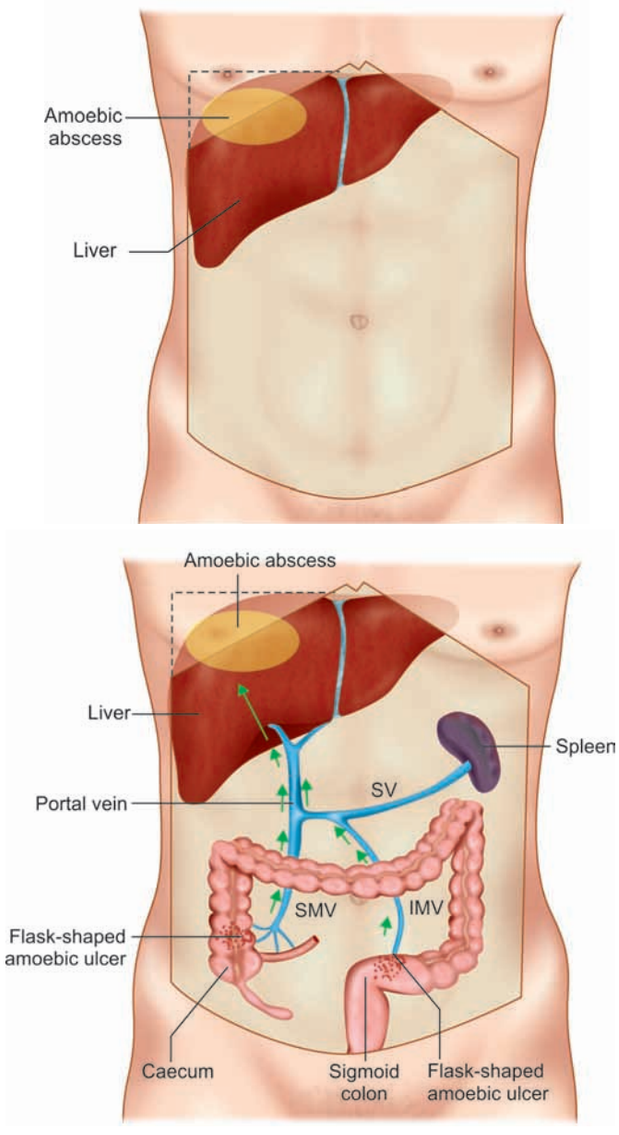


Fig. 9-32: Amoebic liver abscess is common in right lobe of the liver. Trophozoites reach liver from the colon.

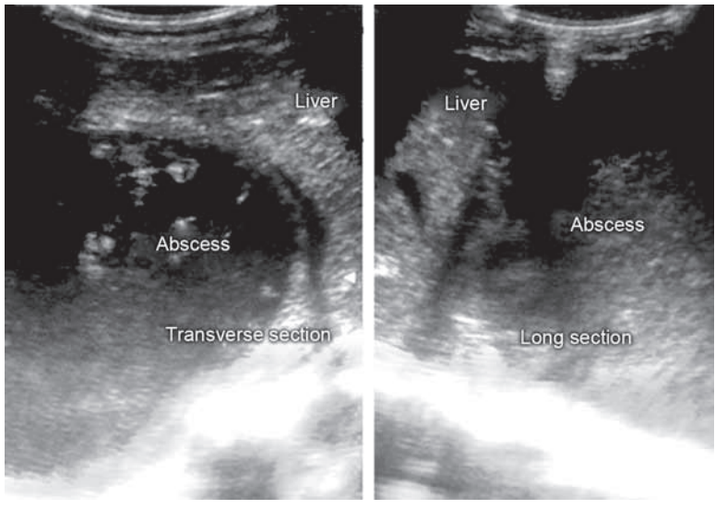


Fig. 9-33: Amoebic liver abscess ultrasound picture.

Fig. 9-34: CT scan showing multiple liver abscesses.

Aspiration

It is aspirated under US/CT guidance. Wide bore needle is used. Prothrombin time should be corrected if elevated using transfusion of FFP or by injection vitamin K. Needle is placed directly over the abscess or in right intercostal space in midaxillary line **(Fig. 9-35)**.

Percutaneous Drainage

Under US guidance pigtail catheter is placed into the abscess cavity percutaneously to drain the pus. Catheter tube and abscess cavity has to be washed and irrigated at regular intervals with normal saline. It may fail if there is thick pus, multiloculated abscess, and multiple abscesses. Procedure may cause bleeding and infection **(Fig. 9-36)**.

Surgery

Open drainage is done only when indicated. Indications are –filling of cavity after repeated aspirations; thick pus; multiloculated pus; left lobe abscess; ruptured abscess; caudate lobe abscess; multiple abscesses. It is done usually transperitoneally.

Procedure: Through transperitoneal approach, abscess area is opened, pus is evacuated. Malecot's catheter/suction tube drain/sump drain is placed and brought out through a separate wound. The catheter/tube is kept in situ until it completely stops draining. Complete drainage of pus will be confirmed by repeat US. During discharge, advice is given to avoid alcohol. Chloroquine 250 mg bd for 10 days and Diloxanide furoate 500 mg tid is given for 10-14 days **(Figs 9-37 and 9-38)**.

Complications

Anaesthetic problems; bleeding; liver failure (in cirrhotic patients); intraperitoneal abscess formation; bile leak – bile peritonitis and fistula.

Follow up: At regular intervals is important. Avoiding alcohol; repeat LFT; repeat ultrasound to confirm the complete resolution of the abscess cavity.

Laparoscopic drainage of liver abscess is becoming popular.

Pelvic Abscess

It is commonest intraabdominal abscess. Postoperative being the commonest cause, pelvic diseases, pelvic surgeries, gastrointestinal causes, perforation and peritonitis are other different causes. Tenesmus, diarrhoea, lower abdominal pain, tenderness, guarding and rigidity, fever and tachycardia are the features. US/CT is diagnostic. It is initially treated with antibiotics. When it is progressive or symptoms persist it should be drained.

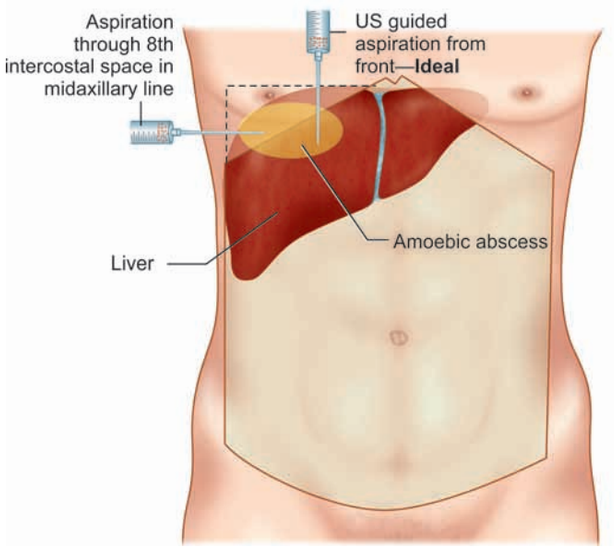

Aspiration through 8th intercostal space in midaxillary line
US guided aspiration from front—Ideal
Amoebic abscess
Liver

Fig. 9-35: Amoebic liver abscess aspiration is commonly done under ultrasound guidance. Prothrombin time should be normal prior to aspiration; if it is widened injection vitamin K 10 mg IM once a day for 5 days or 3 units of FFP should be given to make prothrombin time normal. While passing the needle into the abscess cavity, patient should hold the breath. After aspiration patient is monitored for 6-8 hours. Repeat US is needed after 7 days and 14 days to confirm that abscess has not reformed again.

It is drained pervaginally through posterior colpotomy or per rectally in males. Urinary catheter should be passed prior to surgery. Under general or spinal anaesthesia cleaning and draping is done in lithotomy position. Gloved finger is passed into the rectum to feel the soft boggy swelling in front above the prostate level. Incision is made over the swelling in the rectal mucosa to reach the abscess cavity. Pus is drained; collected for culture. Thorough saline irrigation is given. Often tube drain is placed in the cavity across rectum, which is removed in 24 hours. Follow up US in 4-5 days is needed to confirm the resolution of the abscess cavity. In females it is drained in lithotomy position. Incision is made over the posterior fornix pervaginally; pus is drained **(Fig. 9-39)**.

Drainage through laparotomy is usually not necessary.

Fig. 9-36: Ultrasound guided percutaneous drainage is commonly used in amoebic/pyogenic liver abscess.

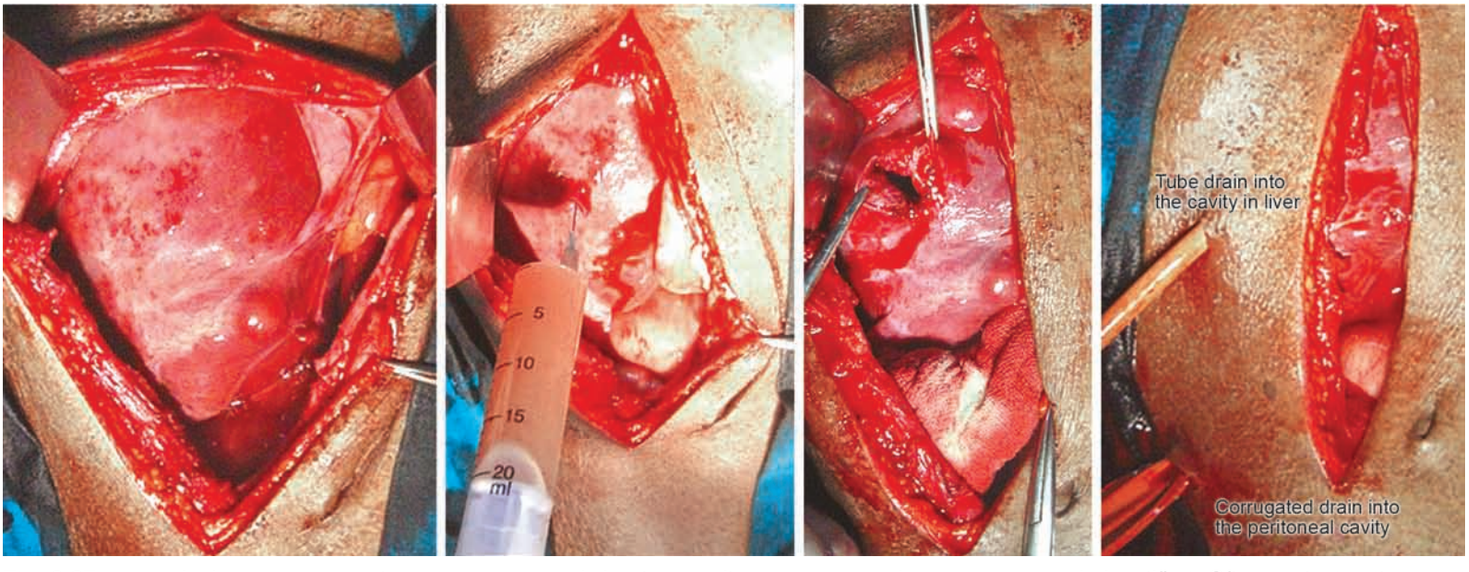
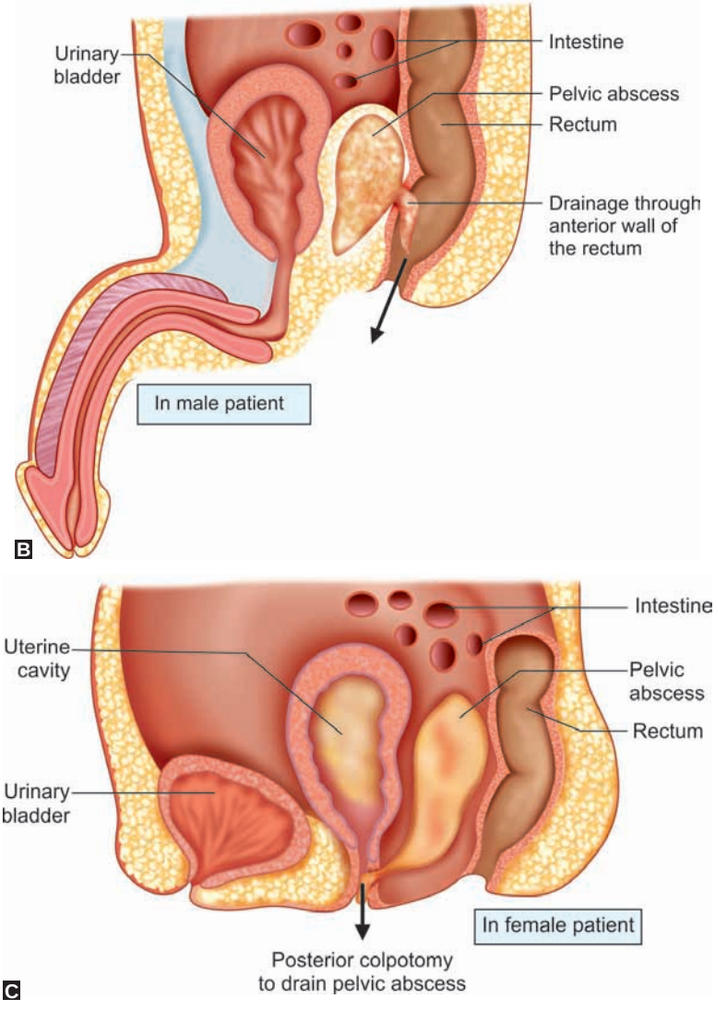


Fig. 9-37: Amoebic liver abscess on table look. Upper midline transperitoneal approach is used. Abscess is identified. Often on table ultrasound may be useful. Initially abscess cavity is aspirated and confirmed. Liver tissue on the surface is incised using cautery. Anchovy sauce pus is drained; collected for culture; for trophozoites last part of the pus should be collected. After giving saline/metronidazole wash to the cavity separate tube. Malecot's catheter drain is placed into the abscess cavity. Peritoneum is drained separately using a tube. Abdomen is closed in layers.

Fig. 9-38: Open drainage of amoebic liver abscess. Typical Anchovy sauce pus of amoebic liver abscess contains dead liver cells, RBCs, necrotic material.

Fig. 9-39A



Figs 9-39B and C

Figs 9-39A to C: CT scan of pelvic abscess. Pelvic abscess is drained through rectum in males and through posterior fornix of the vagina in females.

Perinephric Abscess

It is pus in the perinephric region. Trauma, haematoma, tuberculosis of kidney, blood spread, extension from other area and lymphatic spread are the causes. Fever, loin fullness, tenderness and rigidity, scoliosis towards same side are the features. Loss of downward displacement of kidney is observed in intravenous urogram (*Mathe's sign*). CT is useful to confirm. It is drained percutaneously by placing catheters or by open drainage. Lateral position is used for open drainage. Lumbotomy incision is placed behind over the loin (lumbar incision) to reach the perinephric area. Drain (tube drain/*Malecot catheter*) should be placed **(Fig. 9-40)**.

Pyonephrosis

It is drained by nephrostomy – ***Percutaneous/Cabot's open method/ Tresidder's method***. Percutaneous method is done under guidance. Cabot's nephrostomy is open method; is done under general

anaesthesia through loin incision with patient in lateral position. Tube/Malecot's catheter is placed into the renal pelvis across posterior convex surface of the kidney parenchyma. In Tresidder's method, tube is passed across renal parenchyma and pelvis and comes out in two places. Its advantages are – it drains from two places through a single tube; it can be replaced with a similar new tube by railroad technique. But it is technically more difficult. *Complications* – bleeding, sepsis, blockage of nephrostomy tube **(Fig. 9-41)**.

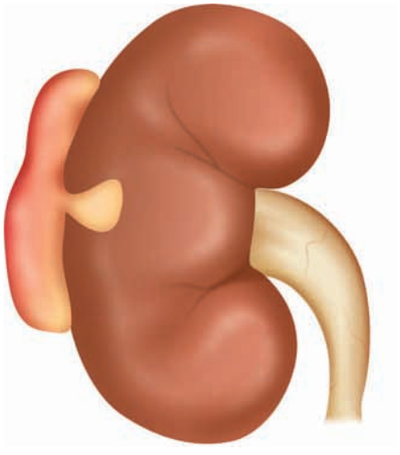
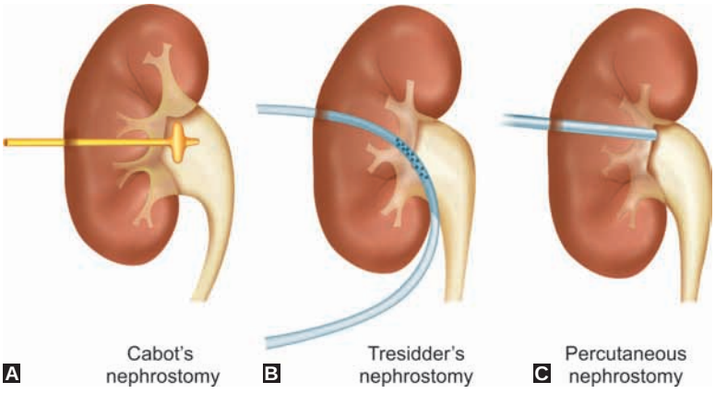


Fig. 9-40: Perinephric abscess. It is drained through a lumbotomy incision.



Figs 9-41A to C: Different types of nephrostomies used to drain pelvis of the kidney in obstruction/pyonephrosis.

Psoas Abscess

It can be pyogenic or tuberculous origin. *Psoas spasm*, with typical flexion position, tender swelling in the iliac fossa are *typical* features. It should be differentiated from iliac artery aneurysm, ovarian cyst, and soft tissue tumour. It is drained extraperitoneally through incision at lumbar region **(Fig. 9-42)**.

CT confirms the diagnosis **(Figs 9-43 and 9-44)**.

It is drained under general anaesthesia or spinal anaesthesia.

Position of the patient is slight lateral tilt. *Urinary catheter* should be passed. Antibiotics should be started.

Technique – Oblique incision at the level of the umbilicus extending medially and downwards up to the rectus muscle. Skin, subcutaneous tissue, superficial fascia, external oblique, internal oblique is incised in the line of incision using cautery. Transverse abdominis is split or cut. Often abscess wall is adherent to transverse abdominis and opens while incising the transversus abdominis. Peritoneum is pushed medially without opening it – *extraperitoneal approach*. Abscess

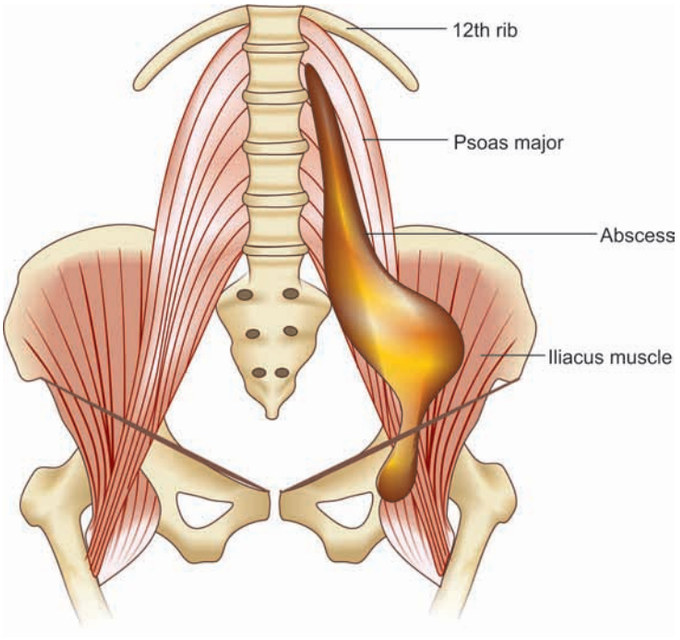


Fig. 9-42: Anatomical location of psoas abscess.

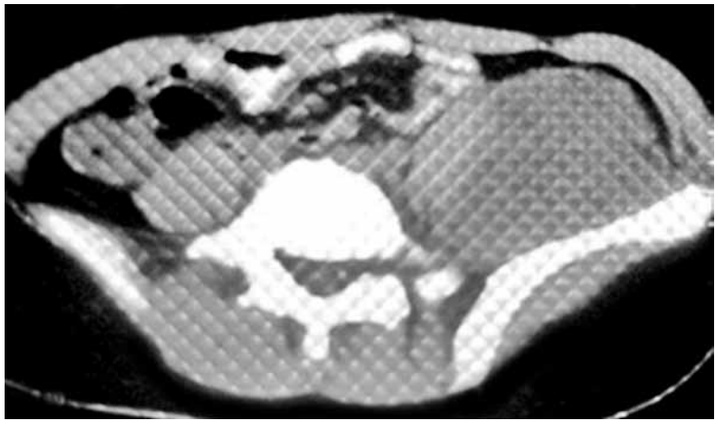


Fig. 9-43: CT scan showing left sided psoas abscess – unilateral.

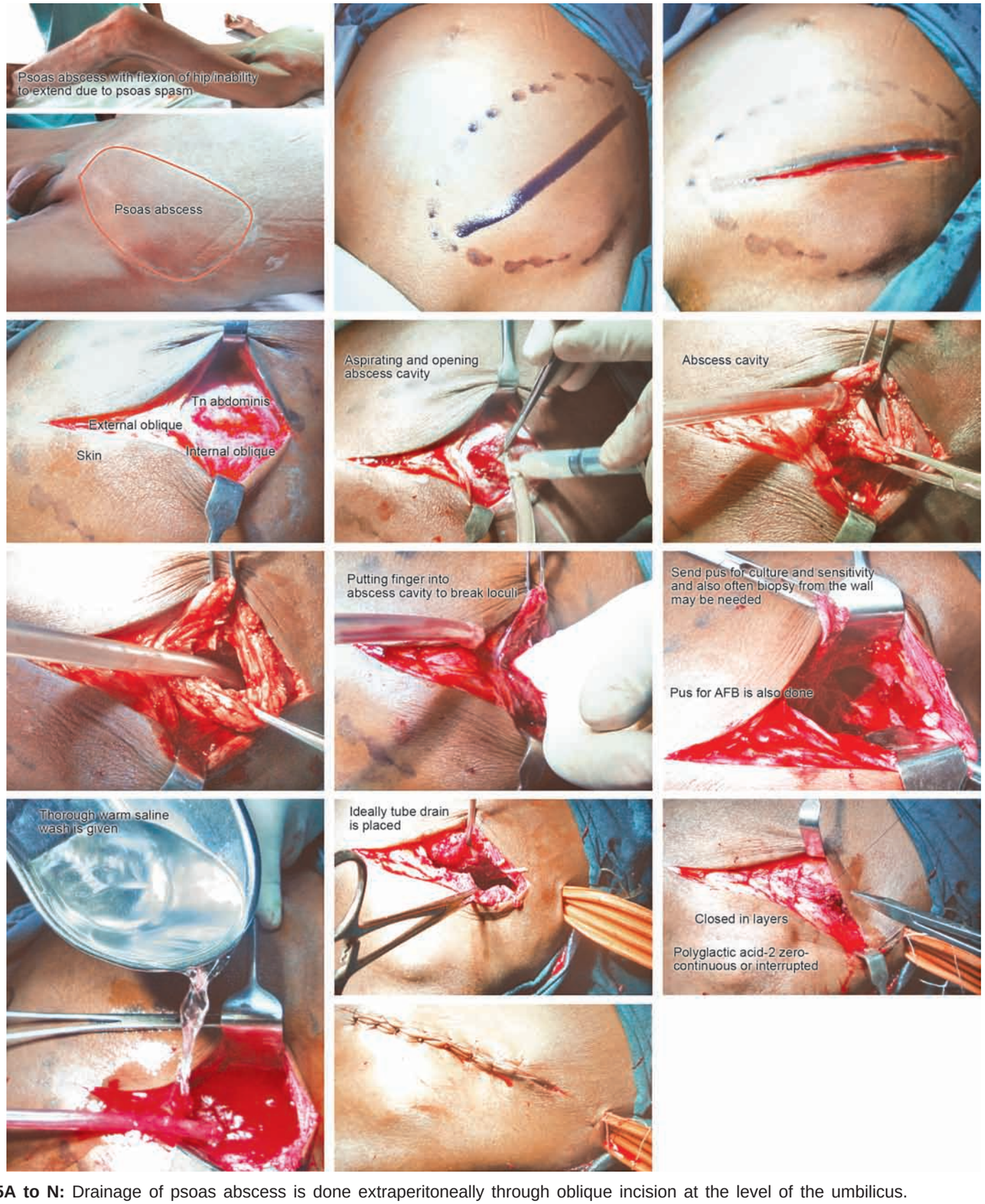
Fig. 9-44: CT scan showing bilateral psoas abscess.

cavity is opened. Pus drained and collected for culture and AFB. Often biopsy from the abscess wall is done. Occasionally psoas abscess will be located within the psoas muscle sheath or in the muscle. In such occasions sheath is opened longitudinally or muscle fibres are split to reach the abscess cavity. After draining pus properly, thorough warm saline wash is given. In tuberculosis of spine anterolateral decompression of the vertebra followed by vertebral fixation is done. Antituberculous drugs should be started. Tube drain is placed; wound is closed in layers **(Fig. 9-45)**.

Drain is removed in 10-14 days after confirming of obliteration of the cavity (Fig. 9-46).

Complications

Peritoneal opening may cause peritoneal contamination. Injury to iliac vessels often can occur. Often iliac vein wall undergoes pressure necrosis and causes life threatening haemorrhage. In such occasions it is difficult to do repair of the vein with sepsis underneath. Best way is putting a pack or ligating the vein.


Psoas abscess with flexion of hip/inability to extend due to psoas spasm
Psoas abscess
Tn abdominis
External oblique
Skin
Internal oblique
Aspirating and opening abscess cavity
Abscess cavity
Putting finger into abscess cavity to break loculi
Send pus for culture and sensitivity and also often biopsy from the wall may be needed
Pus for AFB is also done
Thorough warm saline wash is given
Ideally tube drain is placed
Closed in layers
Polyglactic acid-2 zero-continuous or interrupted

Figs 9-45A to N: Drainage of psoas abscess is done extraperitoneally through oblique incision at the level of the umbilicus.

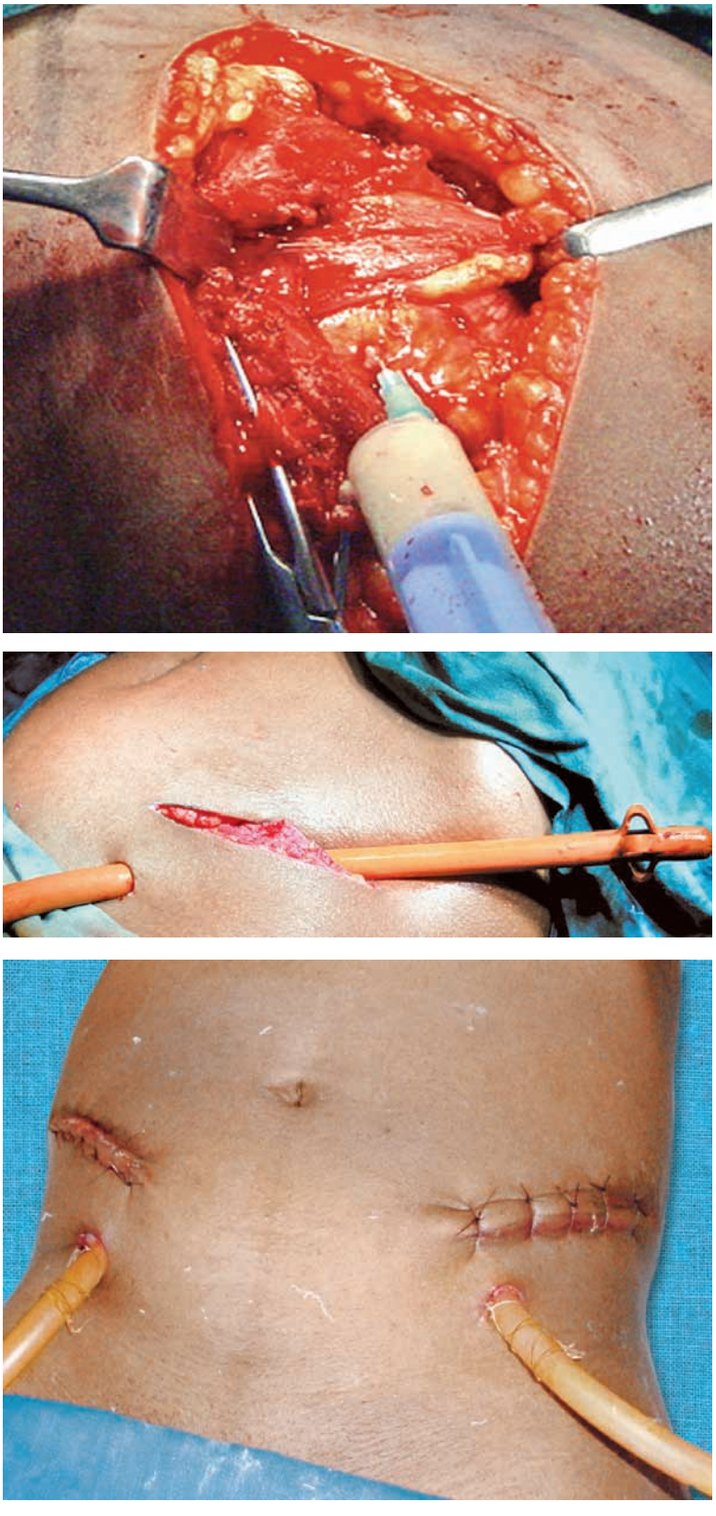


Fig. 9-46: Confirmation of pus in psoas abscess by needle aspiration. Drainage of psoas abscess by placing Malecot's catheter.

Other Abscesses

Pancreatic abscess is aspirated under CT guidance or drained by transperitoneal open drainage method or laparoscopic method.

Mesenteric abscess/bowel interloop abscess are drained through laparotomy – midline incision.

Abscess neck is drained under general anaesthesia. Usually horizontal incision is placed.

Abscess in the axilla is drained under general anaesthesia through crease incision placed in the lower part of the axilla.

Intracranial abscess is drained through craniotomy/burr holes using Dandy's brain cannula. It may be due to trauma, infective endocarditis, spread from infected sinus, untreated suppurative otitis media. CT brain localizes the site of abscess. Headache, fever, localising symptoms, convulsion, systolic hypertension, vomiting and drowsiness are the typical clinical features. Antibiotics, anticonvulsants, supportive treatment are essential **(Fig. 9-47)**.

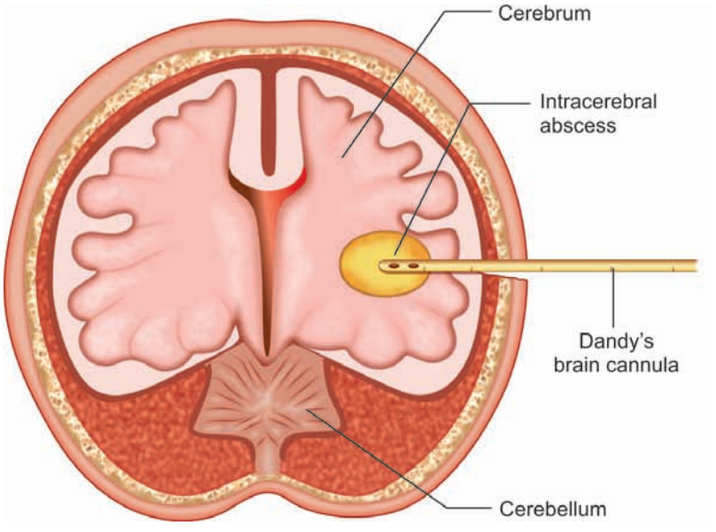


Fig. 9-47: Intracerebral abscess is drained by burr hole and passing Dandy's brain cannula into the abscess cavity.

Lung abscess is difficult to drain. It needs thoracotomy; exploration; often lobectomy. Empyema is drained using intercostal tube drainage.

Brodie's abscess is abscess in the bone (metaphysis). It is drained by open methods—saucerisation and sequestrectomy.

Bartholin cyst is retention cyst due to blockage of duct of the gland. Bartholin glands are greater vestibular glands (similar to Cowper's glands in males) lying in superficial perineal space, overlapped by the posterior ends of the bulbs of the vestibule. Each gland on either side has a 2 cm long duct which opens on either side on the margin of the labia minora posteriorly. Once it gets infected abscess forms. Drainage with marsupialisation is the treatment. 2 cm elliptical incision is made on the skin over the inner side of the cyst. Skin is excised; corresponding elliptical incision is also made over the cyst wall. It is often difficult to incise skin and cyst separately even though it is ideal; in such situation both skin and cyst wall are incised together. Cyst content with pus is drained. Edge of the incised cyst wall is sutured to the corresponding part of the incised edge of the skin using fine – 4 zero absorbable polyglactic acid to create a stoma. *Marsupialisation*—Stoma drains, granulates and heals with less chances of recurrence **(Fig. 9-48)**.

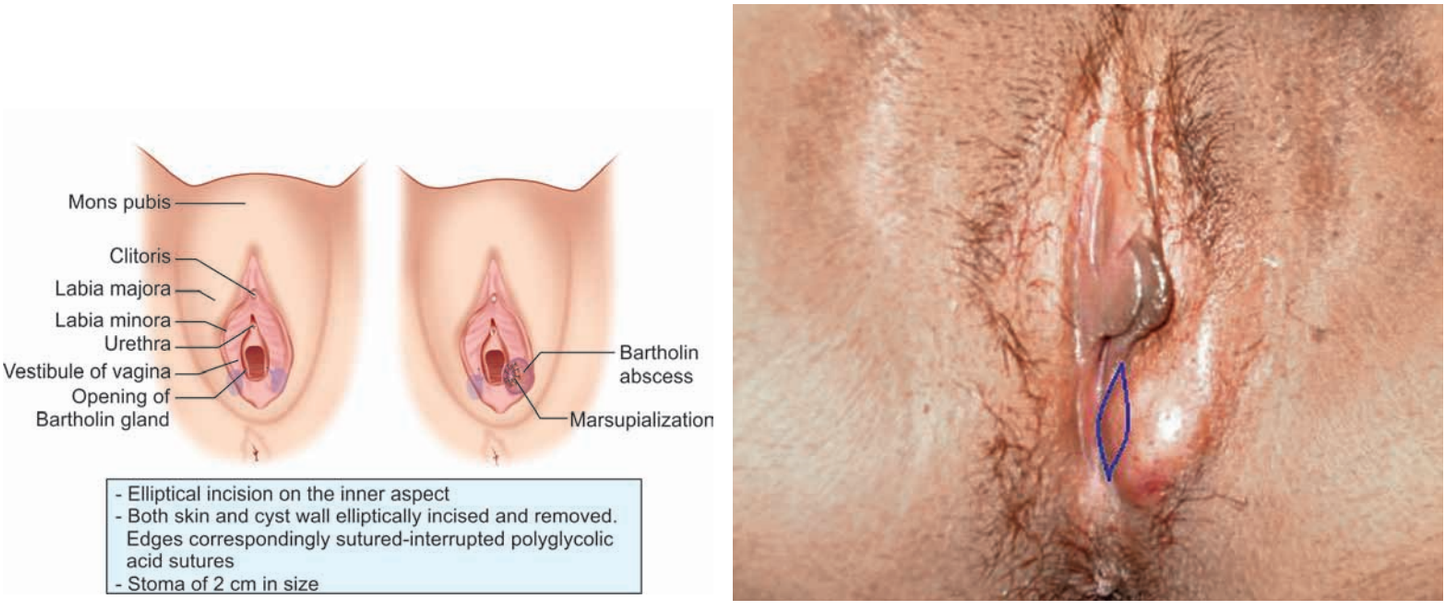


Fig. 9-48: Bartholin abscess occurs on the posterior aspect of the vestibule over labia minora. It is drained by marsupialisation.

Chapter

10

Amputations

Amputation is done as life saving procedure especially in sepsis, diabetic gangrene, gas gangrene, etc. It is also often a therapeutic approach for malignancies in distal limb wherein conservative approach is not possible. Olden days amputation was a procedure done for leprosy and ergotism. Amputation needs proper planning of the flaps, prosthesis, initial mobilisation later rehabilitation and psychological support. It is one of the ancient surgical procedures. Sir William Fergusson in 1867 said, "Amputation is the one of the meanest, yet one of the greatest operations in surgery; mean, when resorted to where better may be done great, as the only step to give comfort and prolong life". Ambroise Pare in 16th century did functional stumps and used the ligatures for major vessels. In World War I and II amputations were commonly done procedures along with invention of prosthesis.

Amputation is a procedure that removes a part through one or more bones. With exception of penectomy for carcinoma of penis which is called as amputation of penis.

Disarticulation is removal of part through the joint.

INDICATIONS

(Dead, dying, devitalized or dead, deadly/dead loss)

Gangrene due to atherosclerosis, embolism, thromboangiitis obliterans, diabetes, ergots, frostbite, trauma (complete devitalised distal tissues); to save life in crush injuries; severe electric burns; neoplasms; osteosarcomas; Marjolin`s ulcer; melanomas; gas gangrene; severe sepsis; after nerve injury if part of the limb is completely paralysed with disabling trophic ulcers occasionally severe elephantiasis, madura foot, osteomyelitis, septic arthritis when all other methods were not of help. Disabling congenital deformities like complete fibular hemimelia, tibial hemimelia, femoral deficiencies and severe acquired deformities are also rare indications for amputations.

Types

Cone bearing
End bearing
Weight bearing
Non-weight bearing.

Types of Flaps

Long posterior flap like in below knee amputation **(Fig. 10-1)**.
Equal flaps like in above knee amputation.

Elective amputation is planned one with flap. Infection should be absent. Viability of muscles and healthy skin are basic requisites for elective amputation. Level of amputation should be decided properly. Major blood vessels are ligated individually at same level. Nerve is pulled down adequately and cut without ligation. Cut bone margin should be made smooth using a rasp. Muscles should be closed over the bone. Suction drain ideally or corrugated drain is inserted on the lateral margin of the same wound which is removed in 48 hours. After removal of drain, firm pressure dressing is needed to control oedema and to prevent haematoma formation and which is left in situ undisturbed for 5 days. Early temporary prosthetic device may be used. Later permanent prosthesis is used after 3 months once stump forms a smooth round surface.

Fig. 10-1: Below knee amputation stump with long posterior flap.

Emergency amputation is done in trauma, gangrene leg or severe sepsis. Here skin, muscles and bone are cut at the same level without suturing as in *guillotine amputation*. Later once sepsis subsides and patient recovers stump is revised for a proper flap.

In vascular diseases tourniquet should not be used during amputation.

Present Classification of Amputation

Present classification of amputation is as –
Open or closed amputation.

Open Amputations

- Open amputation with skin flaps.
- Circular open amputation.
- Guillotine amputation.

Open amputation with inverted skin flaps – Skin flaps are elevated longer than normal. Muscles are divided distal to the intended level of bone transection. After amputation, edge of skin flap is sutured at the corresponding level along with subcutaneous tissue and fascia using interrupted absorbable sutures creating rolled flaps. Once good granulation tissue appears, infection subsides, flaps are closed after 14 days.

Circular open amputation – Skin and muscles are divided circularly at a lower level than bone and left alone. Flap is closed at a later date once sepsis comes under control.

Guillotine amputation – Here all tissues of the limb are divided at the same level and left exposed. It is used in machinery trapping or severe sepsis. It is primitive type of amputation. Revision amputation is needed at a later period. *Definitive closure* is done using reamputation at proximal level; revision amputation; repair of the stumps.

Closed Amputations

It is widely used definitive amputation wherein stump is covered with flaps which should be ideal, highly functional and suitable for proper prosthesis. *Tourniquet* is used except in vascular cases. General/spinal/epidural anaesthesia is used.

Level of amputation is decided based on the identification of the level of adequate perfusion. It is assessed by skin temperature; systolic pressure (ankle systolic pressure should be more than 40 mm Hg); Doppler; transcutaneous oxymetry (PO2 more than 40 mm Hg); arteriography; digital plethysmography; thermography; isotope clearance and dye attenuation studies.

IDEAL STUMP

- It should have adequate blood supply. It should heal adequately by first intention.
- It should have rounded gentle contour; with adequate muscle padding, conical shape with distal tapering is better. Stump should be free from tenderness and conical.
- Opposing groups of muscles should be fixed together over the end of the bone to attain optimum power and control of the muscles at the stump. Smooth, pain free/tenderness free stump should be obtained.
- Joint proximal to the amputation stump should show full range of movements without any contractures. Skin should have a clean incision which should be sutured tension free. Freely mobile skin over the bone and soft tissues should be achieved to get free movement of the prosthesis to be placed later. Socket of prosthesis with mobile skin creates a piston to bone to move like a joint. Transverse posterior scar is better which will not expose to pressure.
- It should have sufficient (optimum) length to bear prosthesis. For below knee amputation (B-K) 7.5 (minimum) to 12.5 cm from ischial tuberosity; for above knee amputation (A-K) 23 cm from greater trochanter. For above and below elbow 20 cm stump is used.
- It should have thin scar which does not interfere with prosthetic function. Scar should be in a place where it is not exposed to pressure. Skin should not be folded. Redundant soft tissue should not be there.
- It should have adequate adjacent joint movement.

Conical bearing

- Here healing is by primary intention.
- Bone should not be projecting.
- Myoplastic.
- Neuroma formation is not there.
- Scar should not be tender.
- Proximal joint should be supple.

Postoperative Period

Physiotherapy is advised. Regular dressings are done. Crutch is used initially, after 3 months prosthesis is placed. Rehabilitation is important.

COMPLICATIONS OF AMPUTATIONS

- **Early**
  Haemorrhage, haematoma, infection.
- **Late**
  Pain, ulceration of stump, ring sequestrum formation, flap necrosis, painful scar. ***Phantom Limb*** - Feeling of amputated part in toto or partially with pain over it.

Haematoma is identified by pain, swelling over the stump underneath the flap. It is aspirated using a wide bore needle. Haematoma may delay healing; may precipitate infection or flap necrosis due to pressure. After aspiration, pressure dressing is needed. If haematoma reforms after 2-3 aspirations, it should be drained by opening the wound on one corner and inserting haemostat into the wound.

Infection of the stump may cause abscess formation, delay in healing of wound, flap necrosis, giving way of the wound. Removing few or all sutures to relieve pressure and draining the pus underneath is needed. Infection may also lead into poor scar, adherent scar which causes difficulty in placing the prosthesis **(Fig. 10-2)**.

Flap necrosis is *common* complication. Main causes for flap necrosis are poor blood supply, infection, haematoma underneath, inadequate length of the flap causing stretching of flap. Small area of necrosis can be excised. Wider area needs laying open of the wound or revision of the stump or higher level amputation. Anaemia, poor nutrition, deficiencies, diabetes mellitus, immunosuppression, smoking and old age are other factors causing flap necrosis.

Stump neuroma can occur due to proliferation of the nerve fibrils beyond the point of nerve division and is usually due to failure of cutting of the nerve more proximal to the level of division of the bone. It causes pain and tenderness over the stump. It is usually relieved by analgesics, reassurance and prosthesis. Occasionally it may require reexploration of the wound, excision of end neuroma and also cutting of nerve more proximally.

Fig. 10-2: Infection of the below knee stump exposing the cut end of tibia.

Fig. 10-3: Ulcer in amputated stump.

Stump pain after amputation is *a common problem*. Causes are – infection, poor blood supply, causalgia, stump neuroma, phantom pain/limb, deep vein thrombosis, adherent scar, formation of spurs and osteophytes at amputated bone end. Scar adhesion to bone is prevented by keeping adequate length of deep fascia underneath intact. Spurs and osteophytes are confirmed by X-ray and needs removal using bone nibbler after appropriate skin incision.

Phantom limb is *typical* awareness of sensation that as if amputated part is still present; often such part may be painful or disturbing or hyperaesthetic. Exact cause is not known; but it is probably due to presence of severe pain at the amputated part just prior to amputation making brain area for the part in alert situation causing phantom limb. Reassurance, prosthesis, analgesics control the condition. It is said that it can be prevented by proper pain control for 24 hours prior to amputation; but it is often difficult.

Ulceration over the stump is *not uncommon*. It is due to necrosis, infection, lengthy bone stump pressing on the summit of the flap, prosthesis, deficiencies, diabetes mellitus, ischaemia. Ulcer may be small/large; superficial/deep. Callous chronic ulcer at the end of the stump is called as *Douglas ulcer*. Small ulcer is treated by regular dressings and suturing later. Large ulcer needs flap to cover the defect. *Osteomyelitis of the stump* should be ruled out in chronic stump ulcer. *Ring sequestrum* may be typical in such situation. Revision amputation is needed for stump amputation **(Fig. 10-3)**.

Contracture of the joint proximal to the amputated stump is *common.* It is mainly due to improper positioning after amputation; due to pain, poor exercise and occasionally due to inflammation of surrounding soft tissues. Contracture interferes with proper fitting and functioning of the prosthesis and delays rehabilitation. Proper positioning, passive stretching and strengthening exercises correct it. Rarely needs surgical release of the contracture.

Other complications like scar hypertrophy, skin thickening, hyperkeratosis, papilloma, eczema, lymphoedema, boils, bursae over bony point can occur, which are treated accordingly.

Evaluation of the patients who need amputation

- Haematocrit, control of anaemia by transfusing blood/packed cells.
- Control of infection using antibiotics.
- Decision of level of amputation by skin temperature, arteriography, arterial Doppler, transcutaneous Po2, laser evaluation.
- Informed consent.
- Plan for prosthesis and rehabilitation by physiotherapist and rehabilitation team.

Different incisions for amputations

- *Circular incision amputation*– skin and muscles are divided circularly at a lower level than that of bone
- *Elliptical/oval incision* amputation
- *Racquet incision amputation*–for digital disarticulation
- *Amputation using flaps*–it may be of equal flap (above knee amputation) or with long posterior single flap (below knee amputation). Total length of single flap or combined length of two flaps should be equal to $1^1/_2$ times the diameter of the limb at the line of amputation. Flap should be semicircular to get a conical stump, not rectangular

PRINCIPLES IN AMPUTATION

- Adequate blood supply of the flap should be maintained.
- Proper marking of the skin incision is essential. Skin should not be crushed or traumatised. Clean cut on the flap is essential. Opposing two equal flaps or long single flap is used. Total length of single flap or combined length of two equal flaps should be 1½ times the circumference of the limb at the level of bone section. Equal anterior and posterior flaps (above knee amputation) or long posterior flap (below knee amputation) is commonly used. Tension free flap suturing should be achieved.
- When unequal flaps are used, shorter flap should be broader than longer flap so that skin edges sutured as equal length. Adequate blood supply of the flap should be ensured.

- Tourniquet *should not be used* if amputation is done for vascular diseases. Other cases like in trauma and tumour it can be used. When it is used, it should be released before skin closure to achieve proper haemostasis.
- Proximal part of the flap contains muscle component but distal part should contain only skin and deep fascia. Deep fascia is cut along with the skin and reflected along with skin. Earlier in conventional amputations, muscles are cut at the level of transection of bone. But now myodesis or myoplasties are routinely done. In *myodesis,* opposing muscle groups are sutured/anchored to bone end using drill holes. Myodesis is contraindicated in peripheral vascular disease. In *myoplasty*, opposing muscles which are divided 5 cm distal to bone transection are sutured to one another adjacent to bone end. It is preferred in peripheral vascular disease.
- Flap length should be adequate; not short. It should be ideally *semicircular* not rectangular to get a conical stump.
- Nerve should be pulled down and cut using a sharp knife and allowed to retract into the soft tissue otherwise neuromas may develop.
- Major vessels should be individually isolated and ligated. Mass ligature should be avoided.
- In crush injury/entrapment injury/sepsis - *guillotine amputation* is done. Later skin is pulled down by using skin traction, eventually to have better skin coverage.
- Bone should be cut with beveling and all sharp margins should be rounded using rasp. *Osteoplasty* can be done by raising a sleeve of periosteum over the bone; after cutting the bone periosteum is closed over the bone end.
- Usually drain is placed (tube drain) through the wound which is removed in 48-72 hours. *Conventional soft dressing* using gauze, wool and crepe bandage is used. Amputation in weight bearing area like lower limb, *rigid dressing* using plaster of Paris cast is used to reduce oedema, stump pain, early stump maturation and proper healing. Rigid dressing may cause pressure necrosis, ischaemia and infection. *Intermittent pressure* as a controlled environment chamber in a plastic sleeve is also used. A *true prosthetic cast* may be used if weight bearing ambulation is anticipated in immediate postoperative period **(Fig. 10-4)**.
- Postoperatively patient is mobilised using axillary crutches. After 3 months, once scar has matured and stump has become supple, proper prosthesis is fit. *Berlamont* first started immediate postoperative fitting of prosthesis to leg for early mobilization. *Plaster pylon* is applied to the stump and a prosthetic extension is fit to facilitate partial weight bearing immediately after surgery. It has got more stump complications and so it has not become popular **(Fig. 10-5)**.
- Position of the stump in postoperative period is important. Stump should be elevated by raising the foot end of the bed. In above knee amputation avoid placing pillow below or on inner aspect of the stump so as to prevent fixed flexion or abduction contracture.
- Stumps can be side bearing (sutures are on the side); end bearing/ conical (sutures are on the end) or cylindrical.
- Postoperatively active exercise should be given to the proximal joint so that prosthesis can be fit to it properly.
- If there is sepsis especially in gangrene limb, flaps should be left open or loosely sutured otherwise flap necrosis occurs.
- Proper anatomy of muscles and neurovascular bundle around should be known in all amputations.

Fig. 10-4: Rigid and soft dressings used for amputation stump.

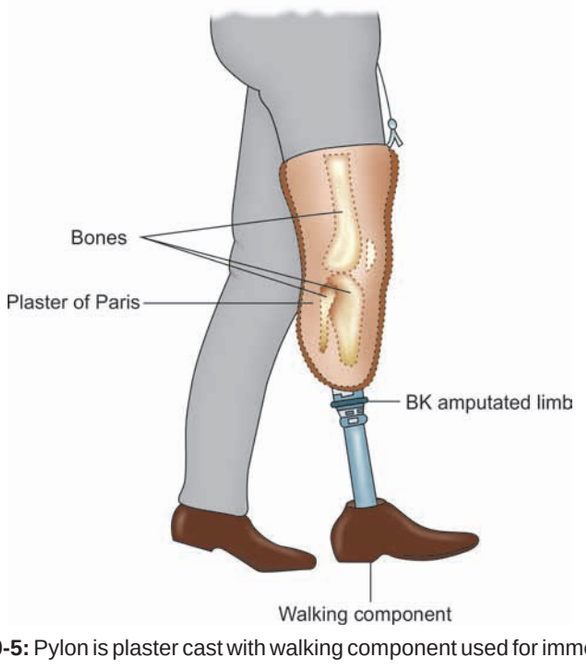


Fig. 10-5: Pylon is plaster cast with walking component used for immediate mobilization after below knee amputation.

DIFFERENT AMPUTATIONS (FIGS 10-6 AND 10-7)

Fig. 10-6: Different levels of amputation in lower limb.

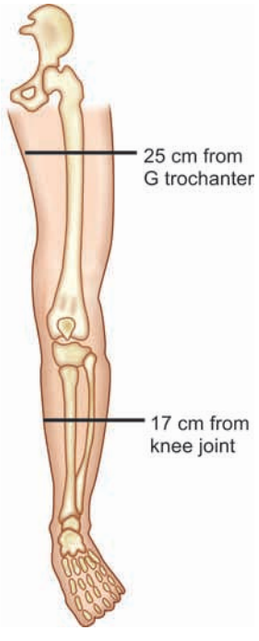


Fig. 10-7: Levels of bone transactions in above knee and below knee amputations.

Toe Amputation

In conditions like trauma, other than vascular or septic causes toe can be amputated at the base of first phalanx so the joint capsule of metatarsophalangeal joint is kept intact. One or two toes can be amputated with retaining remaining toes. If three or more toes need amputation then all toes should be amputated. When only 2nd toe is amputated it is done at or close to the first interphalangeal joint, otherwise if amputated more proximally it will cause valgus deformity of great toe which can be distressing **(Figs 10-8 to 10-10).**

Fig. 10-8: Second toe amputation.

Fig. 10-9: Lateral two toes (4th and 5th) amputation.

Fig. 10-10: Great toe amputation in vascular disease. Here flap is kept open; not sutured.

Ray Amputation

Amputation of toe is done with removal of corresponding head of metatarsal or metacarpals. Amputation of one or more toes causes loss of push off power during walking. Racquet incision is placed at metatarsophalangeal joint. Incision is deepened directly to the bone; then proximally flap is raised close to the bone. It is important to keep the scissor/knife blade to keep close to bone to maintain the blood supply of flap. Digital vessels of the toe are ligated near distal end of the wound. Head of the respective metatarsal should be removed as granulation tissue may not form over it when wound is left open like in vascular cases; or necrosis of metatarsal head can occur; or extra callus may be formed once walking is started. Metatarsal head can be cut using bone cutter. Alternatively toe is amputated with same racquet incision initially at the metatarsophalangeal joint level; then head of the metatarsal is removed using bone nibbler by piecemeal. In vascular cases it is better not to suture the flap rather than closing it. Suturing when done, only skin flap is closed using 3 zero polypropylene or polyethylene sutures. Dressing placed. Sutures removed in 7-10 days **(Fig. 10-11)**

Fig. 10-11: Ray amputation for toes – racquet incision.

Transmetatarsal Amputation (Gillies')

Here amputation is done proximal to the neck of the metatarsals, distal to the base. It is done if skin over the distal part of the dorsum of foot between toes is necrosed and non-viable. Patient can wear a normal shoe with this amputation. But volar and proximal parts of the foot should be viable for this amputation. Plantar part of the incision is close to digits. Dorsal part of the incision is much more proximal than plantar one – 3 cm distal to the base of toes. First plantar incision is placed which is deepened up to the metatarsals and flexor tendons. Flexor tendons are individually divided. Volar flap is raised close to the metatarsals. All metatarsals are transected 2 cm from the base. Dorsal incision which is much proximal is deepened to cut soft tissues to remove the distal part of the foot to retain the stump. Deep fascia is sutured. Skin is sutured with suture line on the dorsal aspect. Drain is placed underneath **(Fig. 10-12)**.

Incision plantar aspect
Dorsal incision 3 cm from the base
Line of cutting on the bone 2 cm from base
Bases of matatarsals
Incision dorsal aspect

Fig. 10-12: Transmetatarsal amputation.

Lisfranc's Amputation

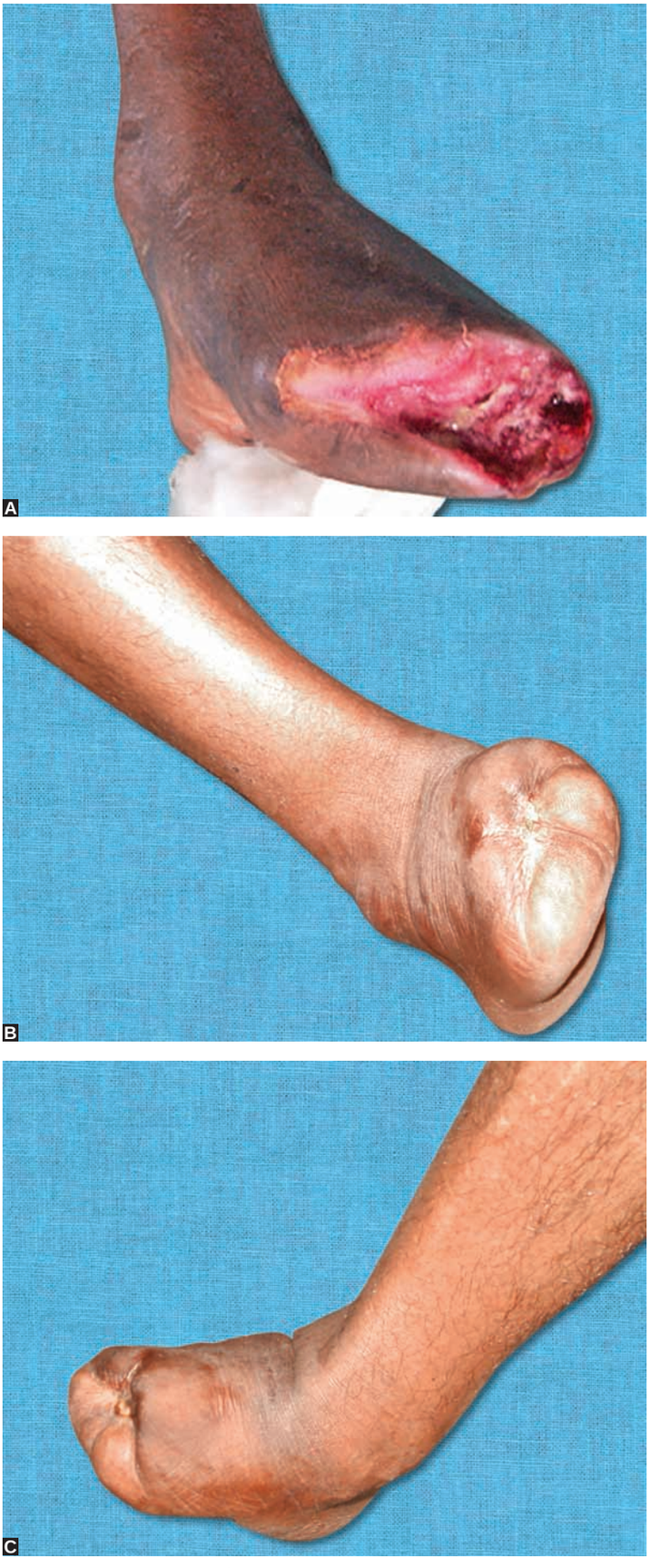
Tarso metatarsal amputation – Here tarsometatarsal joint is disarticulated with a long volar flap (between tarsals and metatarsals). Long plantar sole flap is used. Tarsometatarsal joint is disarticulated. Flexors and extensors are sutured to soft tissues. It needs a surgical boot. But there is inevitable development of equinovarus deformity. So stabilisation of midtarsal and ankle joints is needed. In *Hey's modification*, 2nd metatarsal is cut at base instead of disarticulation.

Chopart's Amputation (Midtarsal Amputation)

Here talonavicular joint and calcaneocuboid joints are disarticulated (only talus and calcaneum are preserved). Tibialis anterior muscle is sutured to drilled neck of the talus bone. A long volar flap is used and limb is immobilized for 6 weeks after surgery with ankle in neutral position. *Equinovarus deformity* is the problem **(Fig. 10-13)**.

Syme's Amputation

It is removal of the foot with calcaneum and cutting of tibia and fibula just above the ankle joint with retaining heel flap (dividing both malleoli). Heel flap is supplied by medial and lateral calcaneal vessels (branches of posterior tibial artery). *Elephant boot* is used for the limb after Syme's which is inexpensive. Many patients walk well with Syme's stump without difficulty. It is presently mainly used in trauma (crush injury), congenital deformities of foot wherein amputation is inevitable, nonischaemic damage of foot and malignancies in distal part of the foot. In vascular diseases, calcaneal vessels may not be adequate to maintain the viability of the flap. Ulcer in the heel, cosmetic view if considered, Syme's amputation cannot be done.

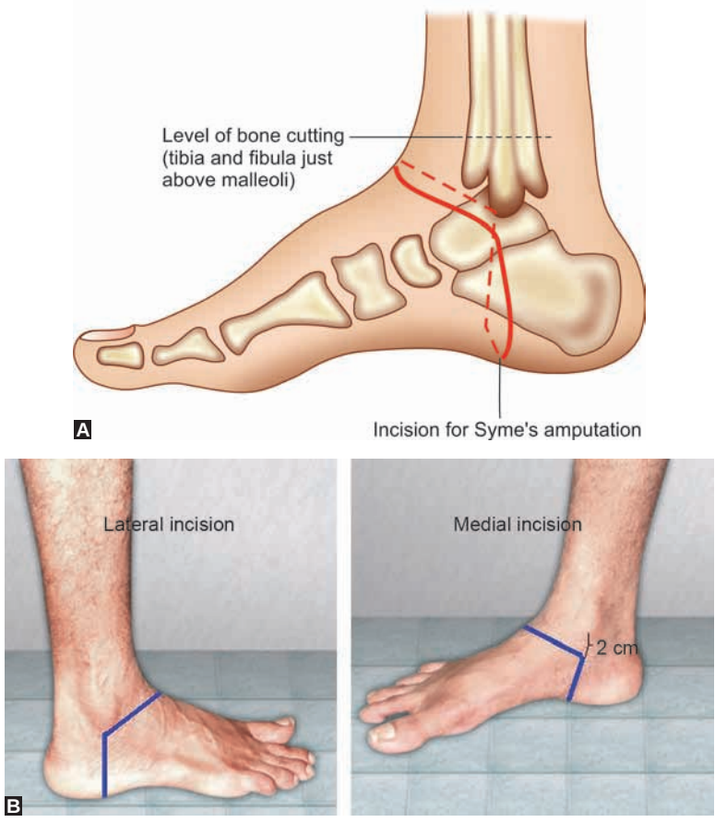


Figs 10-13A to C: Forefoot amputation.

Incision is from the tip of lateral malleolus to a point 2 cm below the medial malleolus. While raising the flap knife should be very close to the calcaneum so as to avoid injury to calcaneal vessels and to maintain the flap vessels viable – subperiosteal dissection of the calcaneum along posterior flap. Anteriorly retinaculum and tendons are divided. Anterior joint capsule of the ankle is incised; medial and lateral ligaments are divided. Tibia and fibula are cut just 0.6 to 1.0 cm above the ankle. Plantar fascia is sutured to soft tissues in front of tibia. In *Wagner's method* deep fascia of heel is sutured to drill holes made on the anterior edge of tibia and fibula. *Above knee cast* is essential. Drain placed is removed after 48 hours. Plaster cast to heel pad in 7th day; weight bearing rocker is added in 3rd week; definitive prosthesis is used after 8 weeks.

Advantages are – It is an end bearing stump having good proprioception. Patient can walk without prosthesis. Low energy consumption ambulation is possible.

Disadvantages – Posterior displacement of heel pad; poor cosmesis **(Figs 10-14 to 10-16)**.

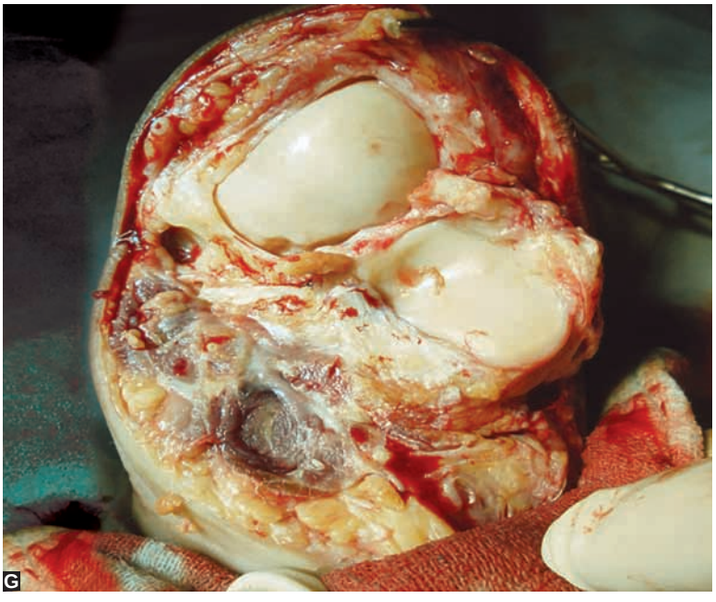


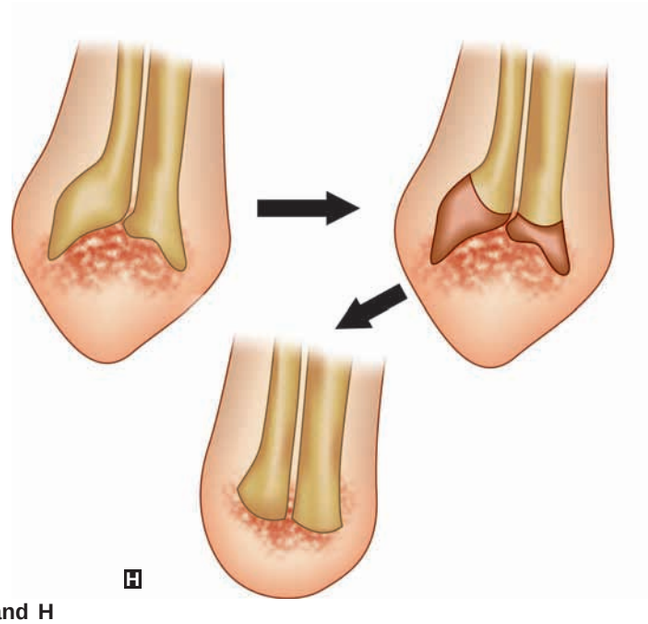
Figs 10-14A and B: Incision for Syme's amputation and level of amputation.

Two stage Syme's amputation is done when there is gross forefoot infection. First stage – With an incision 1 cm distal and anterior to malleoli, ankle joint is disarticulated with closure of flaps with suction irrigation. Second stage – Formal elliptical incision and removal of malleoli.

Boyd's amputation – Anterior part of the calcaneum is excised (osteotomy) just distal to the peroneal tuberosity and calcaneotibial arthrodesis is created. It is done to prevent posterior migration of heel pad.

Figs 10-15A to F





Figs 10-15G and H

Figs 10-15A to H: Syme's amputation technique.

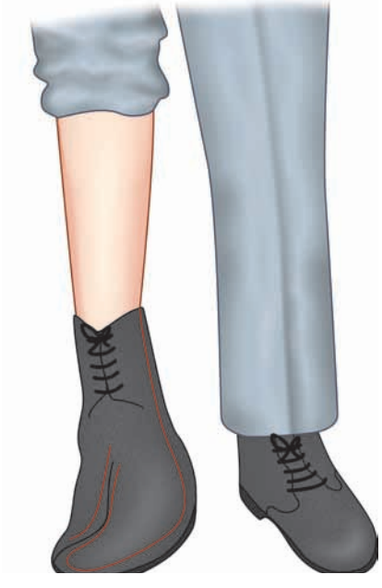


Fig. 10-16: Elephant boot used after Syme's amputation.

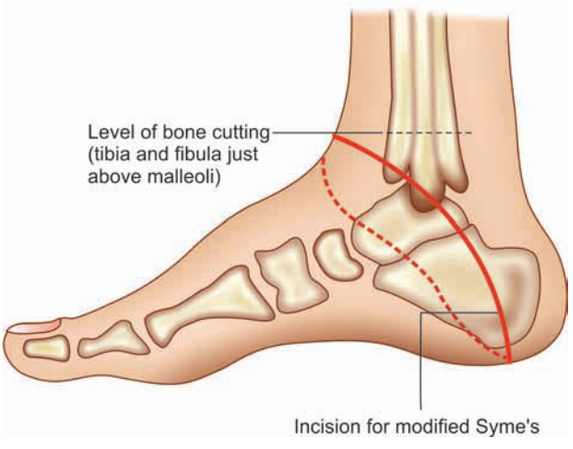


Fig. 10-17: Modified Syme's incision is elliptical one.

Modified Syme's Amputation

Here heel flap is elliptical. Tibia and fibula are divided slightly higher. But variation here is the elliptical flap **(Fig. 10-17)**.

Pirogoff's Amputation

It is like Syme's amputation except posterior part of the calcaneum is retained along with heel flap. It provides longer stump than Syme's amputation **(Fig. 10-18)**.

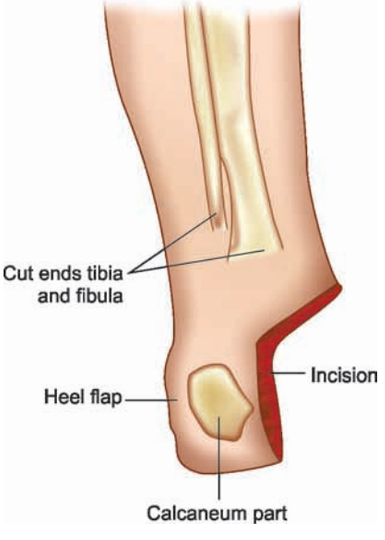


Fig. 10-18: Pirogoff's amputation.

Below Knee Amputation

It is done in peripheral vascular disease, trauma, infections and tumors. In peripheral vascular disease, posterior flap is used. In trauma equal flap may be a choice. It is contraindicated in stump if

becomes less than 7.5 cm, flexion deformity of 30^0 or more, restricted knee joint movement, motor neurological diseases which prevents prosthesis function.

Here long posterior flap with scar placement over anterior aspect is used. Prosthesis placement is better here with greater range of movements without limp and without support. It is also called as *Burgess amputation*. Fibula should be divided first; higher (1 cm) than the proposed site of cut of tibia otherwise its sharp end will press on the skin flap. Tibial stump should be beveled anteriorly. Its edge is smoothened using rasp. Vessels are isolated and individually ligated using silk at the level of the stump. Nerve is pulled down sufficiently and cut at more proximal level without any ligature. Muscle is cut tapering towards the distal end of the flap. Soleus muscle is cut, gastrocnemius is trimmed on the edge to reduce the bulk. Posterior muscles are sutured across the bone end, to the periosteum in front. In more proximal type of below knee amputation, fibula often is removed to allow the proper use of flap. Length of the flap should be $1^1/_2$ times the circumference of the site (around 12 cm). Stump length is 14-17 cm from knee joint. Minimum length required for prosthesis is 8 cm. Anything proximal, it is better to do above knee amputation. Suction drain ideally or corrugated drain on the edge of the same wound is placed and kept for 72 hours. Adequate dressing pads should be placed over the stump and pressure bandage using crepe is placed. Often posterior slab/cast are used up to mid thigh to prevent patient from keeping the knee in flexed position. Stump maturation occurs in 8 weeks. Modern artificial limbs like *suction socket prosthesis* are used now **(Figs 10-19 to 10-21)**.

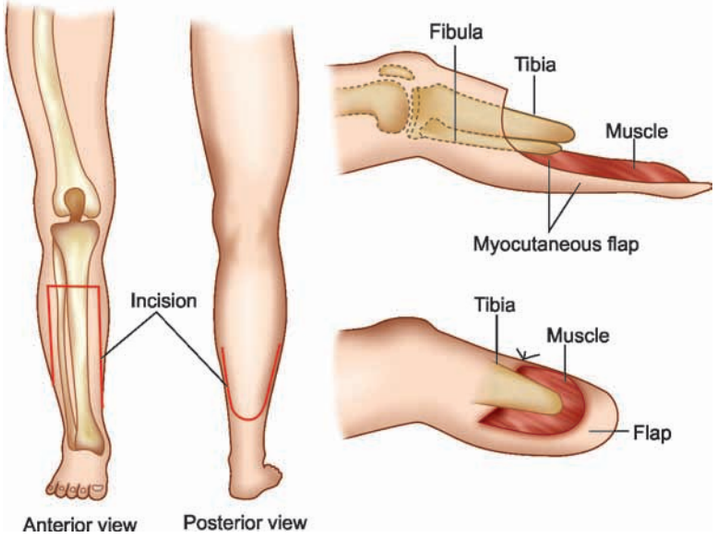


Fig. 10-19: Below knee amputation technique – incision, flap and levels of cutting bones.

Skew flap with skin flaps are equal on medial and lateral aspects but single posterior muscle flap is sutured anteriorly to the tibia. Flap is along long saphenous vein and saphenous nerve medially; and along small saphenous vein and sural nerve laterally **(Fig. 10-22)**.

Periosteum from tibia can be raised from distal to the level of transection of the tibia which is swung over the cut end of fibula to create a synostosis bridge of periosteum between tibia and fibula. This is used when amputation is done in young individual.

Prosthesis fit to below knee stump makes patient to walk normally **(Figs 10-23 to 10-26)**.

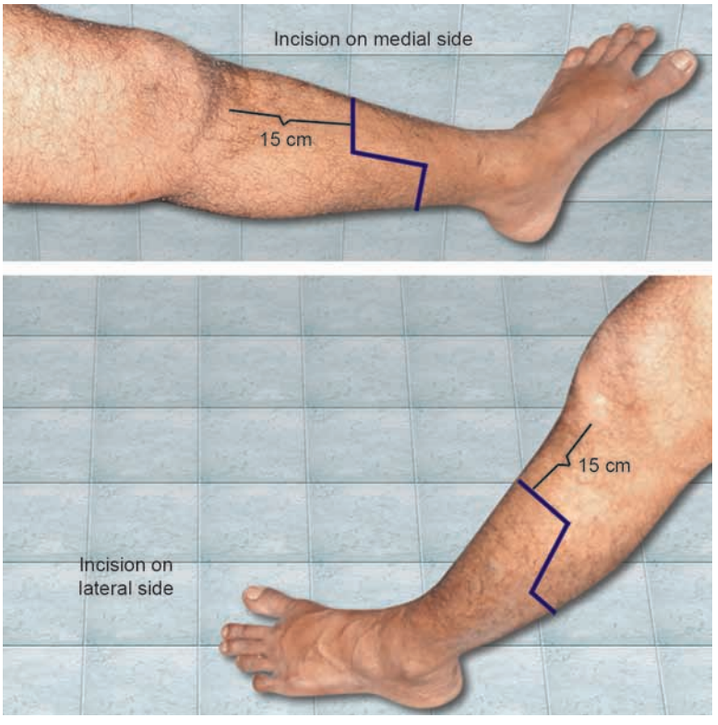


Fig. 10-20: Incision for below knee amputation.

'Peg-Leg' Amputation

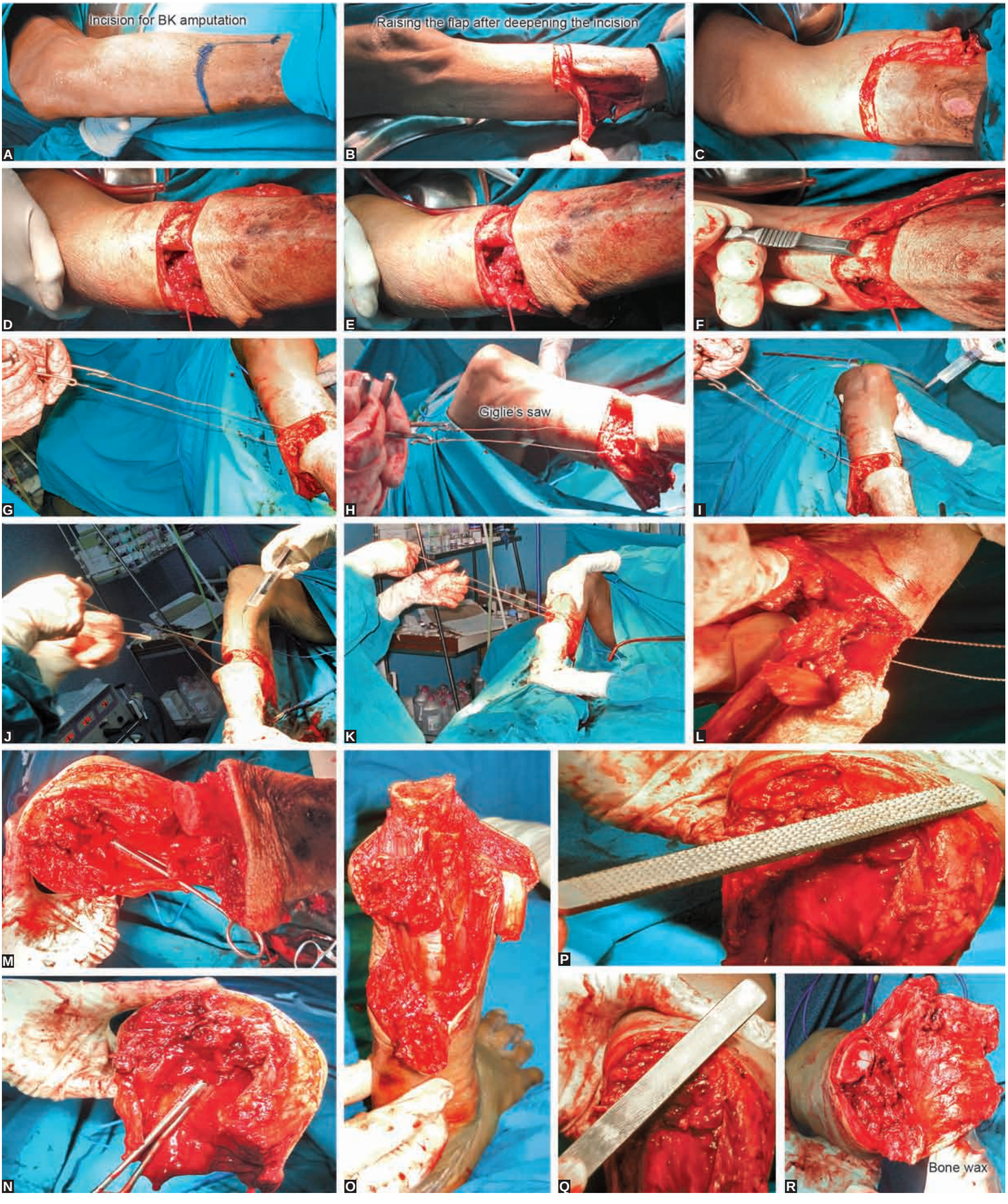
It is amputation 5 cm below the knee level – proximal most below knee amputation. It is *not practiced* nowadays. Here anterior flap is rotated posteriorly like a hood and patient kneels and bears weight which is well accustomed to pressure. It is done whenever prosthesis cannot be used probably due to economic causes (in developing countries) **(Fig. 10-27)**.

Knee Joint Disarticulation

It is done in non-functional damaged knee joint wherein below knee amputation is not possible; amputation in non- ambulating bedridden patient; very ill patients; patients who need locked knee prosthesis or *end bearing stump*. It is *preferred in children* than doing above knee amputation. Its bulbous end allows suspension of prosthesis without thigh corset.

It is contraindicated in ischaemic conditions. It is cosmetically inferior; less vascular; poor healing; prosthesis controlled gait is difficult to achieve **(Fig. 10-28)**.

It is done in *prone position* through an anterior incision from a point mid way between lower pole of patella and tibial tubercle to a point 5 cm laterally below the joint line. Incision posteriorly curves towards midline in popliteal fossa 2.5 cm above joint line. Flaps are *medial and lateral*; medial is larger. Incision is deepened in posterior aspect first; vessels and nerves are divided; posterior muscles and joint capsule is cut; joint is opened; cruciate, medial and lateral ligaments are cut; patellar tendon is cut; patella is retained. Once joint is disarticulated patellar tendon is sutured to cruciate ligaments and retinaculum is sutured to hamstrings. Anteroposterior longitudinal scar is formed. Drain should be placed.



Figs 10-21A to R

Figs 10-21S to W

Figs 10-21A to W: Technique of below knee amputation.

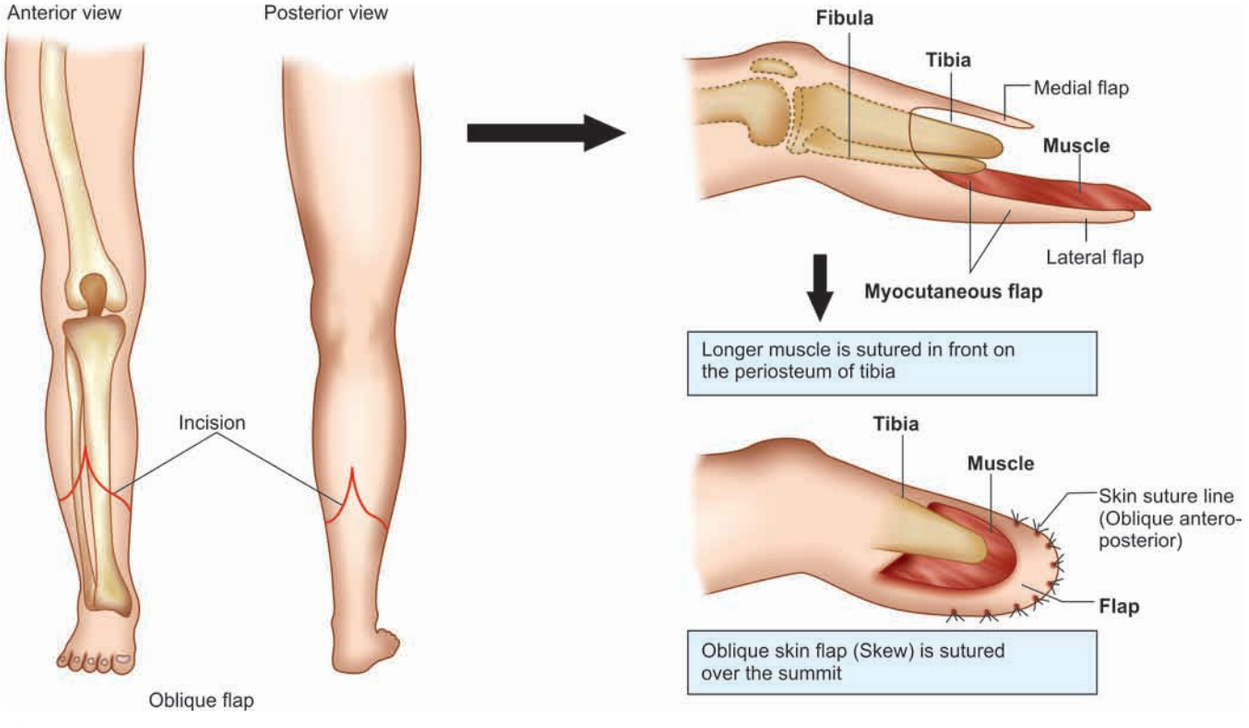


Fig. 10-22: Skew flap for below knee amputation.

Fig. 10-23: Below knee amputation – long posterior flap. Note the placing of the drain.

Fig. 10-24: Below knee amputation flap necrosis has occurred which eventually granulated with regular dressings. Area is ready for skin grafting.

Fig. 10-25: Below amputation with flap necrosis in which later wound got granulated well. Knee joint contracture is a great problem in rehabilitation.

Transcondylar/Gritti-Stokes Amputation with Long Posterior Flap

It is done in supine position; long anterior flap extending below the patella is used (flap is not raised posteriorly). Patellar tendon is cut; joint is entered from front; posterior soft tissues and muscles are divided. Femur is divided just above the articular surface; articular surface of the patella is shaved off; patella is anchored to the divided femur through drill holes with wires passed through drill holes; patellar tendon is sutured to hamstrings. Femur may be divided 30° obliquely anteroposteriorly as a modification. There is risk of non-union between patella and femur. This procedure is *no longer performed* **(Figs 10-29 and 10-30)**.

Above Knee Amputation

It is done in ischaemia, trauma, sepsis and gangrene which is spreading above. Often patient might have undergone below knee

Fig. 10-26: Below knee amputation stump which is badly infected, this may need above knee amputation.

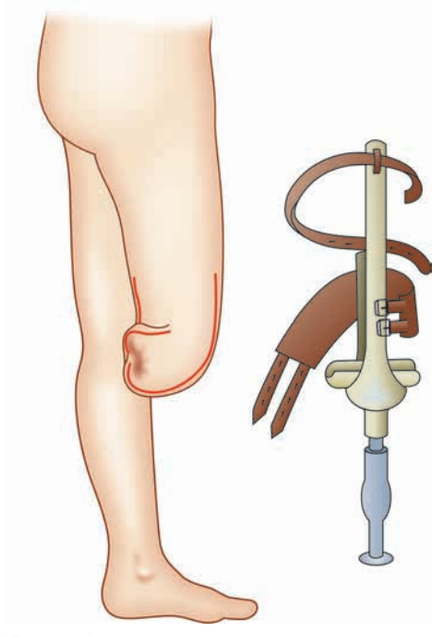
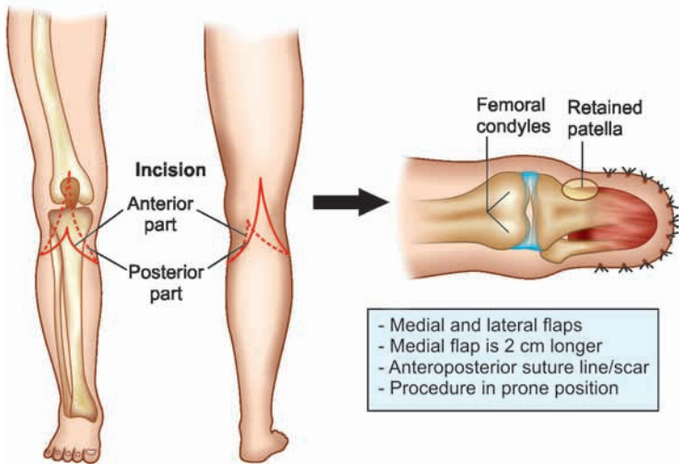


Fig. 10-27: 'Peg leg' amputation is below knee amputation done close to the knee joint (5 cm stump) with folding flap and metallic support down. It is not used now.



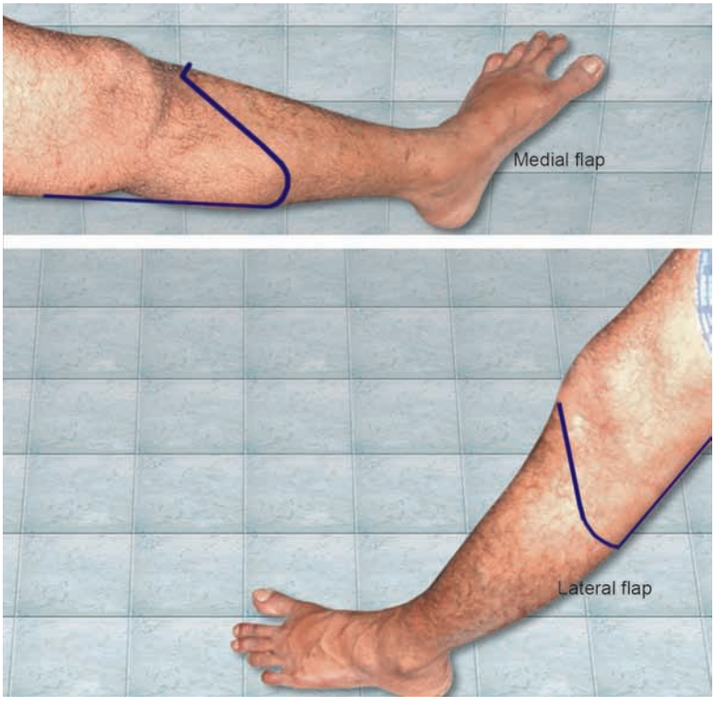


Fig. 10-28: Technique of knee disarticulation.

amputation earlier but now as indicated for above knee amputation as either BK flaps are not good or sepsis is extending above. It is usually contraindicated in children (done only in undue definitive indication) or if stump is less than 7.5 cm.

Advantages are technically easy, healing chances are better and faster. Disadvantages are cosmetically poor, rehabilitation is difficult, and prosthesis fitting is not proper, patient needs a third support for walk with often a limp.

Usually equal anterior and posterior flaps are used. Alternatively long anterior flap may be used.

Lower third and middle third level amputations are done. Ideally the required length of the femur as stump is 25 cm from the tip of the greater trochanter. Length lesser than 10 cm is not possible and one needs to do hip disarticulation. In children as growing epiphysis of femur is at the lower end, as much length of femur as possible should be preserved.

Femoral vessels are individually ligated two times. Femur is cut with anterolateral bevel. Sciatic nerve is pulled and cut; accompanying artery, arteria nervi ischiadii when needed should be ligated separately not along with sciatic nerve. Quadriceps is sutured to hamstrings or the drill holes made in cut distal end of the femur. This myodesis prevents muscle imbalance. Suction drain and soft crepe bandage dressing is placed. Patient is advised to lie prone for 15–30 minutes a day to prevent flexion contracture of hip joint **(Figs 10-31 to 10-34)**.

Hip Disarticulation

It is done whenever it is not possible to save the minimum 10 cm length of the femur. Incision used is either single posterior flap – Solcum's approach (better) or anterior racquet incision – Boyd's approach. Posterior flap stump is better to fit prosthesis. Anterior racquet incision begins as a vertical incision along the femoral vessels with medial and lateral flaps curving posteriorly; medial flap is longer. Scar here will be away from perineum. In the posterior flap the length of the flap should be 1½ times the anteroposterior diameter of the limb at

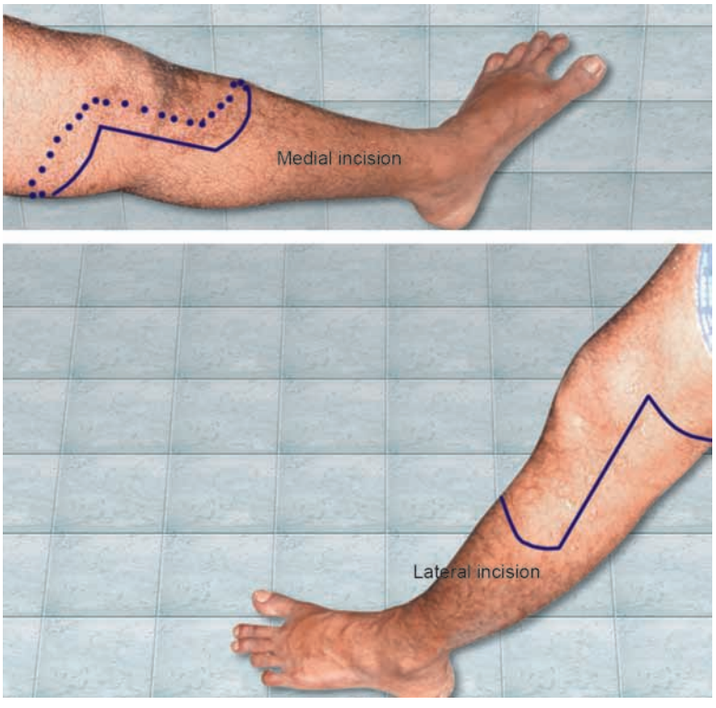


Fig. 10-29: Incision for Gritti-Stokes amputation.

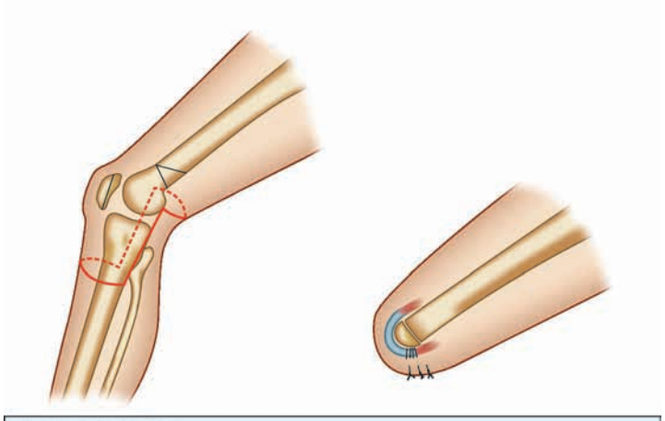

- Long anterior flap
- Femur is cut just above the condyles straight or obliquely
- Patellar articular surface is shaved and apposed to cut surface of femur
- Quadriceps/patellar tendon is sutured to hamstrings
- Procedure is done in supine position

Fig. 10-30: Gritti-Stokes amputation.

hip joint level. The anterior part of the incision is 2.5 cm below and parallel to inguinal ligament. Anterior part of the incision is deepened; muscles are divided in the line of incision; joint is opened from front; adductors, hamstrings and gluteus maximus are divided with retaining part of it in posterior flap. Joint capsule and short muscles are cut to complete the disarticulation. Muscles and flaps are sutured to create a stump **(Fig. 10-35)**.

Hind Quarter Amputation

Interinnominoabdominal amputation (Sir Gordon Taylor amputation): Removal of one side pelvis with innominate bone, pubis, muscles

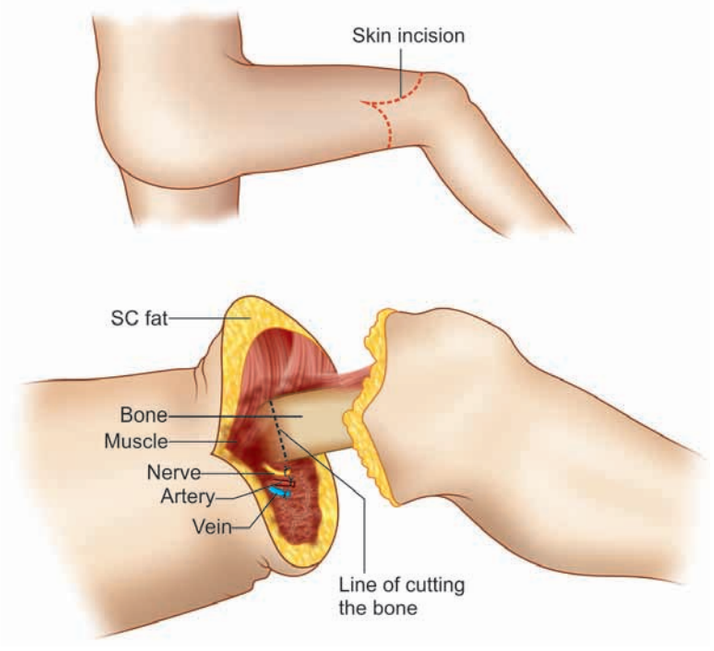


Fig. 10-31: Above knee amputation incision and approach.

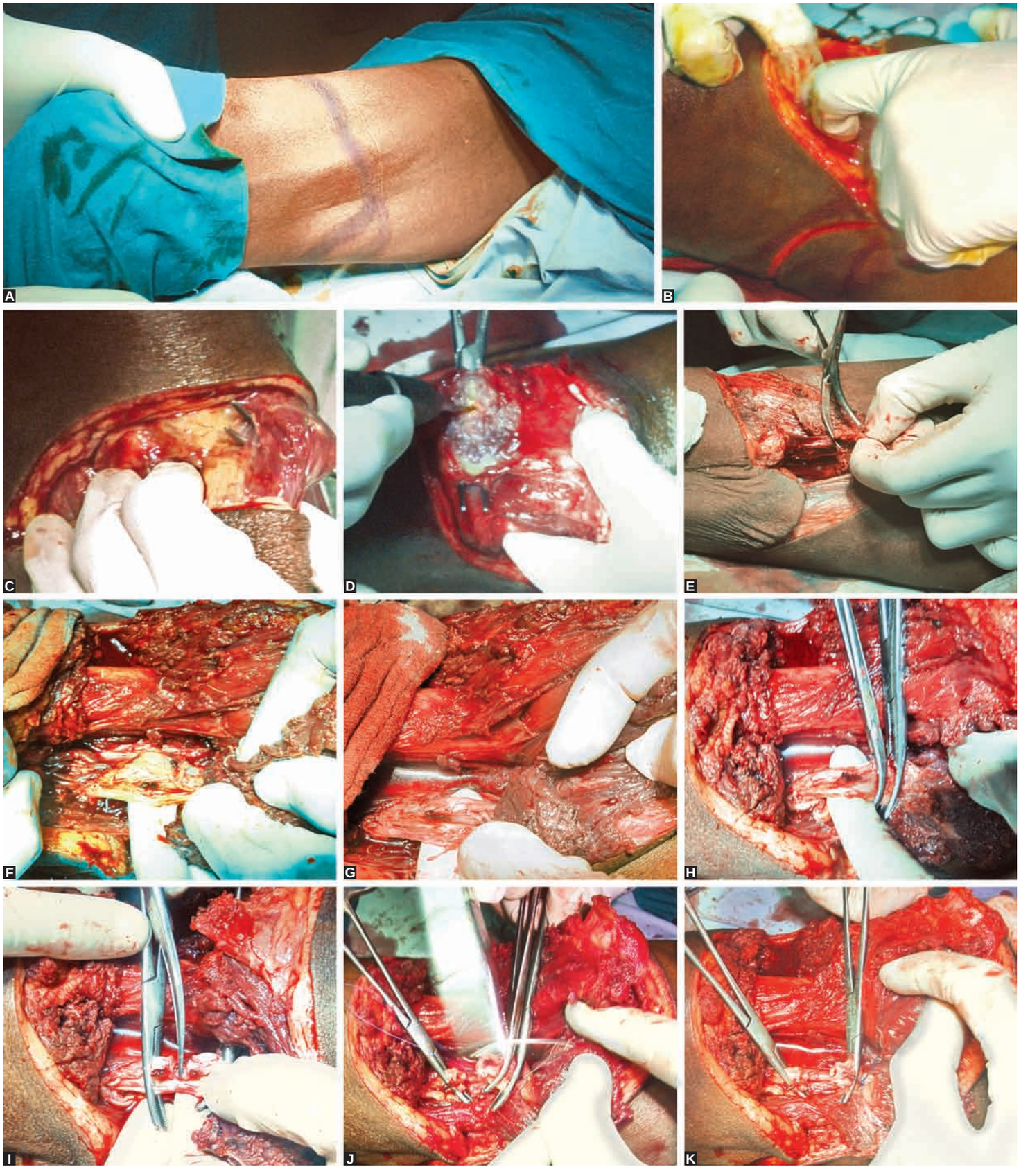
and vessels. Original ligation of common iliac artery is modified to individual ligations of external and internal iliac vessels. Internal iliac artery is ligated beyond the origin of the superior gluteal artery to keep the large posterior flap viable. *Now hind quarter name is replaced by hemipelvectomy*. It may be *standard hemipelvectomy* with classic gluteal flap; *extended hemipelvectomy* with removal of posterior part of the sacrum; *conservative hemipelvectomy* with retaining part of the pubis, ilium bones on that side. *Internal hemipelvectomy* is new method wherein hemipelvectomy is done with preserving the limb.

It is done in malignant diseases of soft tissues of pelvis or thigh; severe congenital malformations; failed above knee amputation or hip disarticulation. Procedure needs proper prior preparation of the perineum and limb to prevent sepsis. 6 units of blood should be kept ready as bleeding is common. Initial position is supine with long narrow sand bags placed under shoulder and buttock of same side. Later patient is rolled to lateral position for posterior flap dissection.

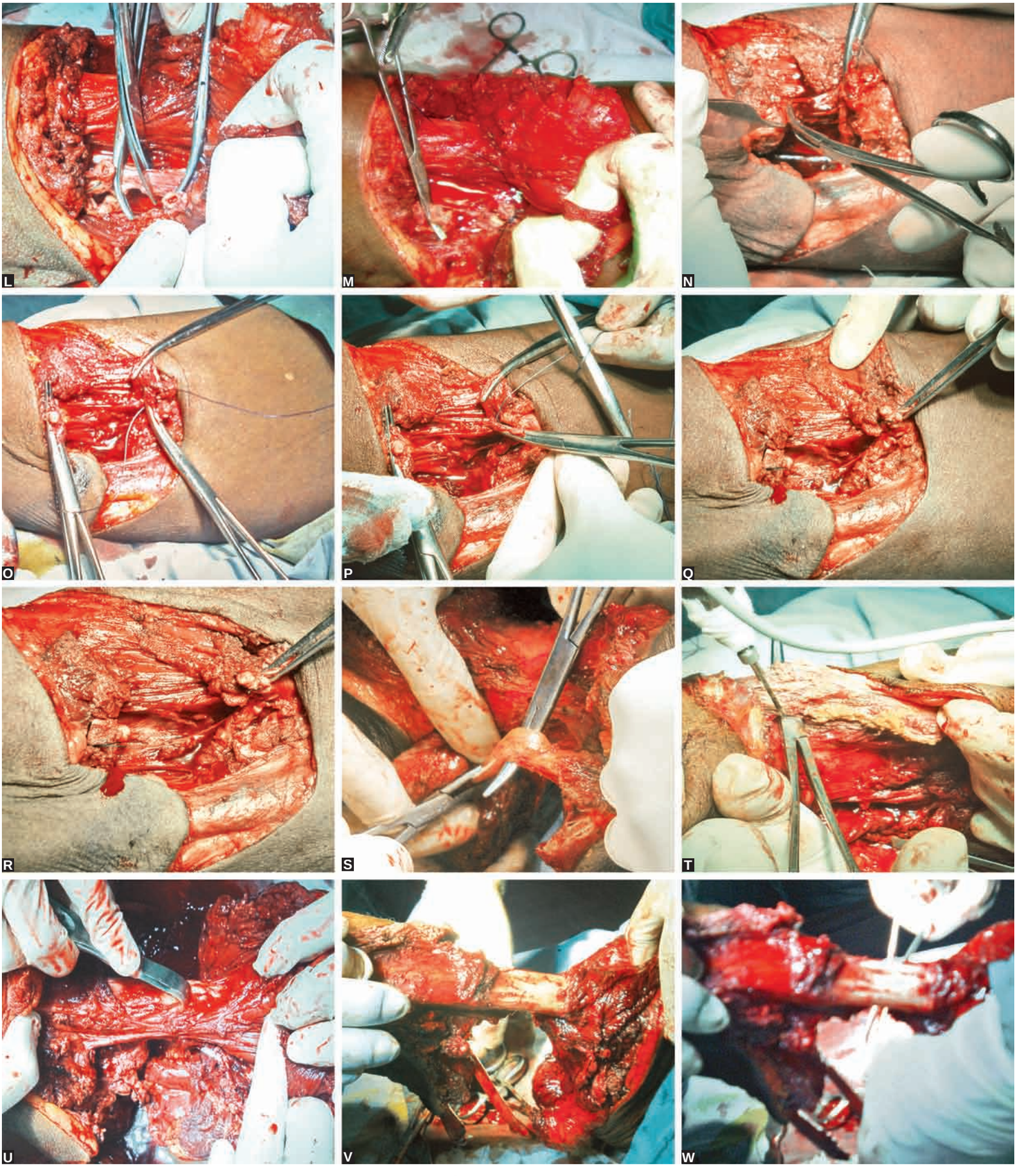
Standard hindquarter amputation is done with an elliptical incision with anterior abdominal muscles are divided in the line of incision. Inferior epigastric vessels are ligated. Pubic symphysis is divided. Peritoneum and ureter are pushed medially with blunt dissection. Internal iliac artery is ligated distal to origin of the superior gluteal artery. External iliac vessels are divided. Ilium is divided across greater sciatic notch. Main part of the gluteus maximus is retained in the flap supplied by superior gluteal artery. Remaining soft tissues and nerves are cut. Obturator, pudendal, other gluteal vessels are ligated. Flap is sutured after proper haemostasis **(Fig. 10-36)**.

UPPER LIMB AMPUTATIONS

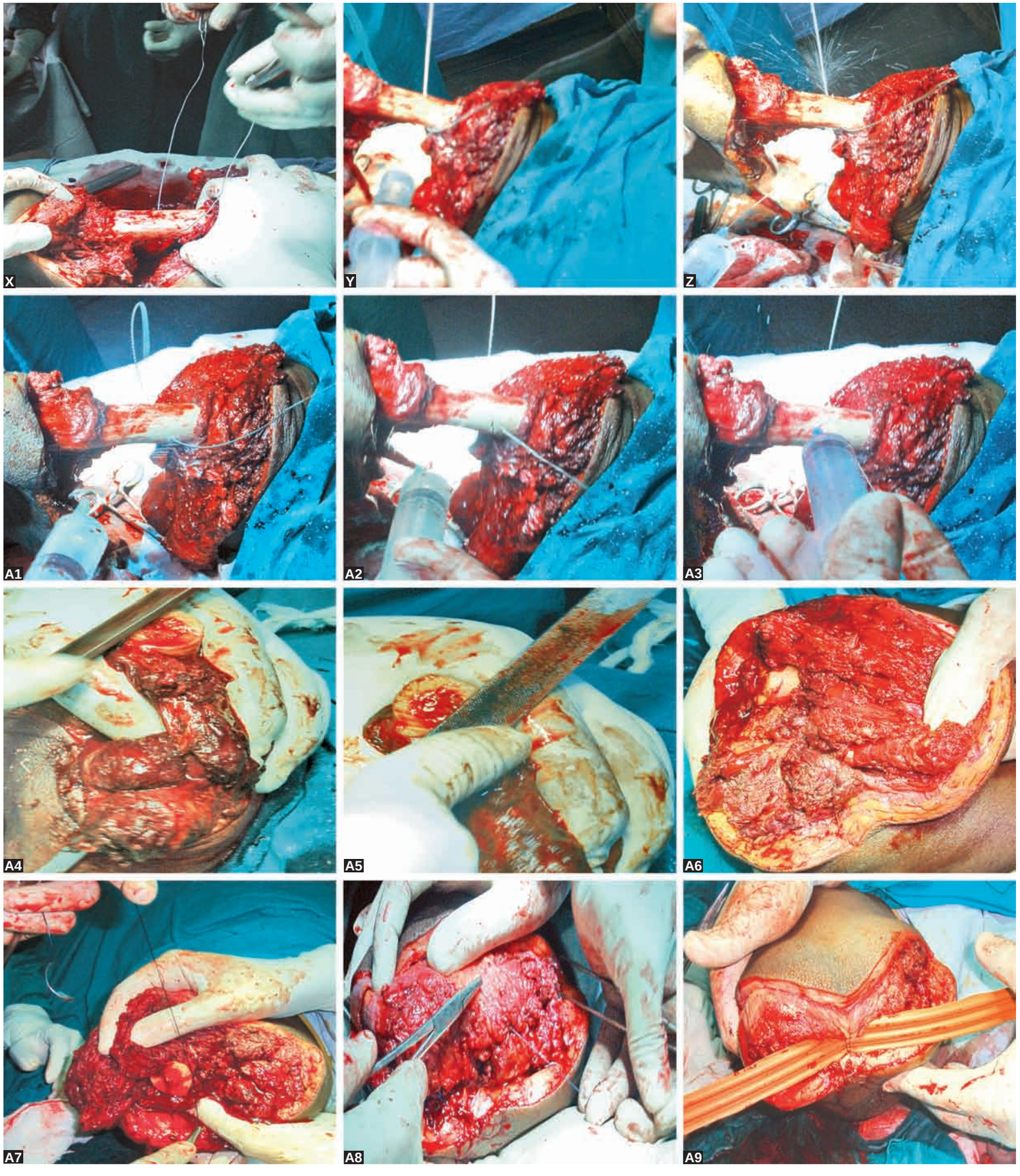
Upper limb amputations are less commonly done (3-15%) as compared to lower limb amputations. Trauma, malignant tumour, gangrene are the indications. All possible length should be preserved to improve the efficacy of the prosthesis. In distal amputations, prosthesis function will be better **(Fig. 10-37)**.



Figs 10-32A to K



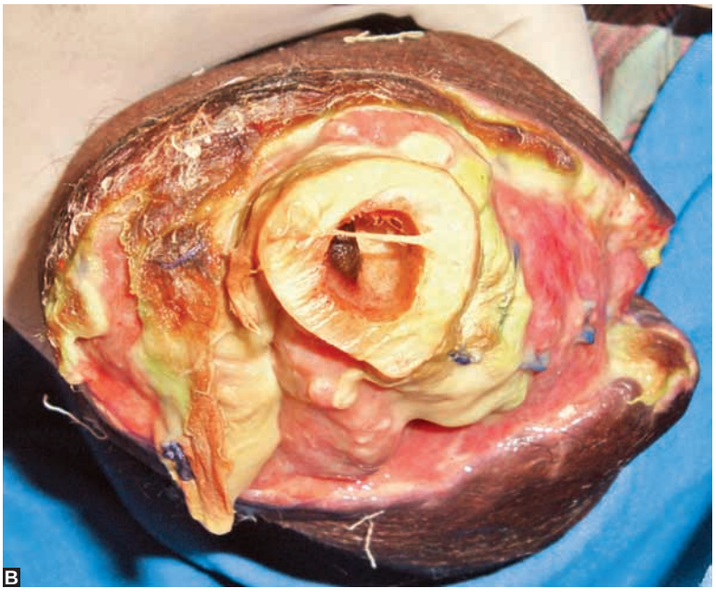
Figs 10-32L to W



Figs 10-32X to A9

Figs 10-32A10 and A11

Figs 10-32A to A11: Steps in above knee amputation.



Figs 10-33A and B: Above knee amputation wound which is infected in a diabetic patient with exposed cut end of femur. After above knee amputation is seen in another photo.

Fig. 10-34: Above knee amputation for osteosarcoma of upper end of tibia.

HAND AMPUTATIONS

Loss of blood supply is the only absolute indication. Five tissue areas are observed – skin, tendon, nerve, bone and joint. If three or more tissues are damaged then amputation may be needed. In traumatised finger if skin is retained but not bone and tendons, then this skin with its blood supply can be used to cover defect locally. Any retained tissue may be used for reconstruction in the hand elsewhere like bone, tendons.

Flaps used for amputations in hand are usually long volar with scar on the dorsal aspect. Digital nerves should be cut 6 mm proximally. Digital arteries are ligated using 3 zero polyglactic acid or cauterised using bipolar cautery. Tendons are drawn distally to divide and later to retract proximally. Condyles should be trimmed when amputation is done through joints. In amputation of distal phalanx distal interphalangeal joint is preserved so that tendon functions are retained; in middle phalanx proximal interphalangeal joint is preserved. In middle and ring fingers amputations of proximal phalanx

Fig. 10-35: Anterior and posterior incision in hip disarticulation procedure.

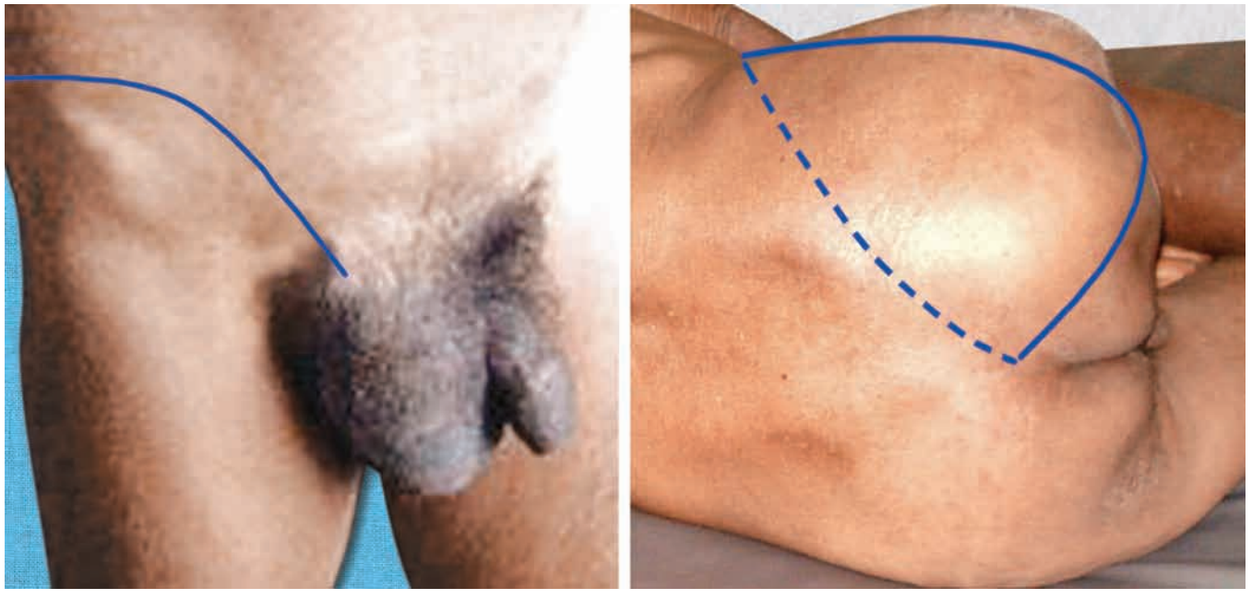


Fig. 10-36: Incision for hindquarter amputation.

are done so that stump retained in proximal phalanx can be used for power grip of hand using active flexion by intrinsic muscles. In index and little fingers proximal phalanx amputation is waste and such stump prevents the proper pinch by thumb and fingers. So amputation through respective metacarpals is done **(Fig. 10-38)**.

Amputation of Index Finger

Here proximal phalanx is never retained. Second metacarpal is divided at its distal part proximal to metacarpophalangeal joint. Volar flap incision is placed. Dissection is started from dorsal aspect. Dorsal digital nerve and digital vessels are divided. Extensor digitorum and extensor indices tendons of index finger are divided. Dorsal and palmar interossei of 2nd metacarpal is divided; distal transverse metacarpal ligament is cut; 2nd metacarpal bone is divided obliquely 2 cm from the end (one should not disarticulate the metacarpophalangeal joint). Flexor tendons, palmar digital nerve and vessels are divided. Dorsal interossei tendon is anchored to base of 3rd proximal phalanx (of middle finger). It should not be attached to severe extensor tendon. Other muscles are sutured each other and skin is closed.

Middle and Ring Finger Amputations

Here proximal phalanges should be preserved to maintain the grip of fingers and hand. 3rd and 4th metacarpals heads are important as they provide attachment to metacarpal arch. Here transverse volar flap is used. Digital neurovascular bundles are cut. Extensor tendon/hood, flexor tendons are divided. Bone is cut near the base. Muscles/tendons

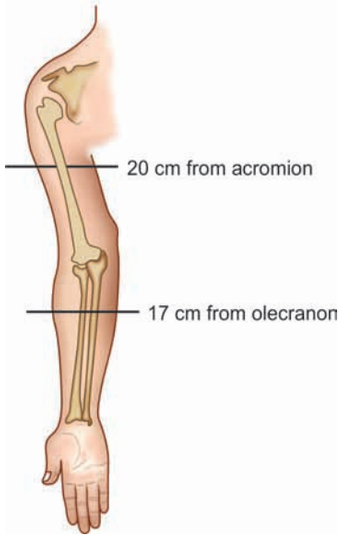


Fig. 10-37: Level of bone transaction in upper limb amputations.

are sutured. Flap should not have any tension as if tension develops it interferes with functioning of adjacent fingers also.

Wrist Amputations

Wrist amputation is preferred to forearm amputation as retained distal radioulnar joint facilitates pronation and supination.

Transcarpal amputation – It is the amputation – disarticulation between proximal and distal rows of the carpal bone complex. Long palmar and short dorsal flap with 2:1 ratio is used. Once incision is deepened all flexors and extensors are divided. Radial and ulnar arteries are ligated. Median, ulnar and radial nerves are cut. Small muscles and tendons remaining are divided. Open the transcarpal joint space and complete the amputation. Skin flap is sutured. Flexor and extensor tendons are anchored to the proximal carpal bones.

Wrist disarticulation - Long palmar and short dorsal skin flap incision which is 1.3 cm distally curved from radial and ulnar styloid processes on the palmar aspect with a connecting straight incision on the dorsal aspect. Dorsal incision is deepened; radial and ulnar arteries are ligated; joint capsule incised to enter the wrist joint; styloid processes of the radius and ulna are resected without opening the radioulnar joint. Median, radial, ulnar nerves are cut after pulling it distally. All tendons are divided at wrist joint level circumferentially. Long palmar flap is sutured back on the posterior aspect after placing a suction drain.

Forearm Amputations

In forearm amputation length as much as possible should be preserved. Distal amputation is done at the junction of distal ⅓ and proximal ⅔ of the forearm. In proximal amputations as proximal as 3.8 cm stump is retained. Both distal and proximal amputations are done with equal flaps **(Fig. 10-39)**.

Krukenberg Amputation

It is done in upper limb following any trauma. Here forearm amputation is done in such a way that it creates a gap between radius and ulna like a claw to have a hold or grip. Krukenberg amputation does not require any prosthesis. But it is cosmetically poor.

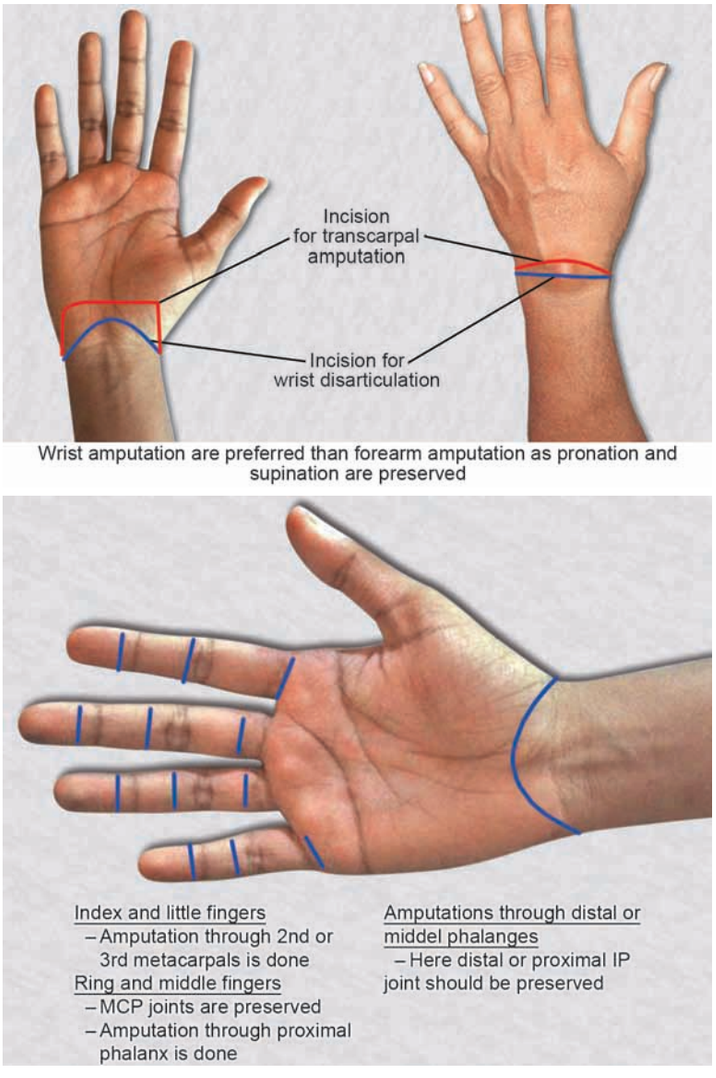

Incision for transcarpal amputation
Incision for wrist disarticulation
Wrist amputation are preferred than forearm amputation as pronation and supination are preserved
Index and little fingers
– Amputation through 2nd or 3rd metacarpals is done
Ring and middle fingers
– MCP joints are preserved
– Amputation through proximal phalanx is done
Amputations through distal or middel phalanges
– Here distal or proximal IP joint should be preserved

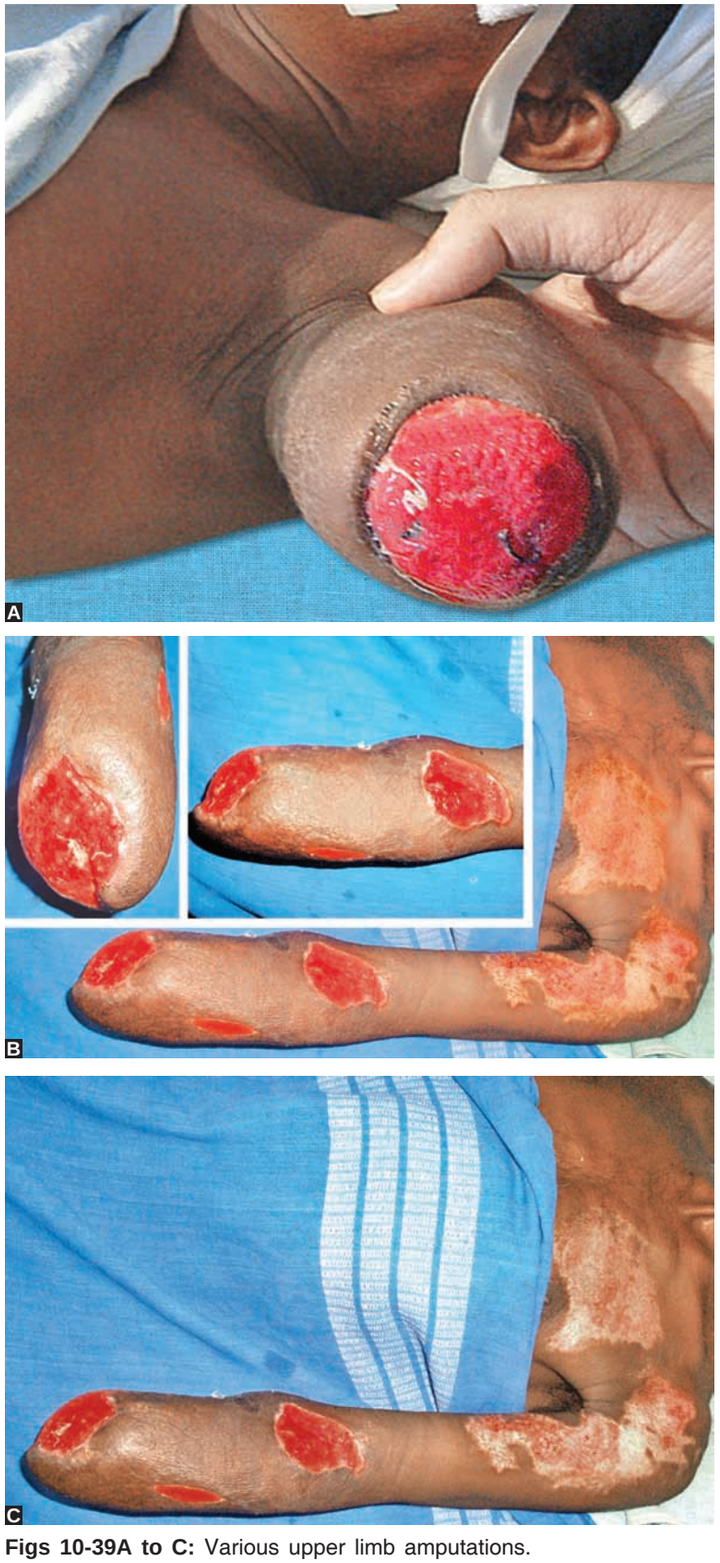
Fig. 10-38: Different amputations in the hand.

Elbow Disarticulation

It is done as equal flap at the level of humeral epicondyles. Posterior flap is 2.5 cm distal to the tip of the olecranon process. Anterior flap is just distal to the attachment of bicipital aponeurosis. Brachial artery is ligated medial to the biceps tendon. Triceps is divided near the tip of olecranon. Triceps is sutured to tendon of brachialis and biceps after disarticulation. Common extensor origin with remnants on the lateral epicondyle which is kept about 6 cm length is sutured to retained remnant of common flexor origin on the medial epicondyle.

Arm and Shoulder Amputations

Amputation in the arm can be done at any level from supracondylar region to axillary fold proximally. Usual/ideal level is 20 cm from acromion. Distal amputation close to condyles function like elbow disarticulation. Amputation proximal to axillary fold functions like shoulder disarticulation. Prosthesis placement for arm amputation should contain elbow lock mechanism to stabilise the joint in extension/flexion/varying positions; hernatable mechanism as a substitute for humeral rotation. Usually amputation is done as equal



Figs 10-39A to C: Various upper limb amputations.

flap with length of the flap 1½ times the circumference of the arm. Elbow lock mechanism of prosthesis if needed then amputation level should be 3.8 cm proximal to the elbow joint. Brachial artery, nerves and muscles are cut. Bone is divided using Giglie's saw. Triceps muscle is kept long to rotate across cut bone end to suture to anterior fascia or muscles **(Fig. 10-40)**.

Fig. 10-40: Upper limb amputations of both sides in a patient due to trauma. Right side he underwent forearm amputation; left side amputation at arm level.

Shoulder Amputation

It is amputation at the level of surgical neck of humerus. Incision is made anteriorly from coracoid process along the anterior border of the deltoid muscle to its insertion; then superiorly along the posterior border of the deltoid muscle to reach posterior axillary fold; two anterior and posterior incisions are joined by one more incision passing through axilla. Cephalic vein in deltopectoral groove is ligated. Deltoid and pectoralis major muscle is separated. Deltoid is retracted laterally. Pectoralis major muscle is divided at its insertion to lateral lip of bicipital groove of the humerus. Axillary vessels located between coracobrachialis and pectoralis minor are ligated individually (double ligation with transfixation) distal to the level of pectoral nerves. Deltoid muscle is divided at its insertion. Teres major and latissimus dorsi muscles are divided at their insertion to bicipital groove. Biceps, triceps and coracobrachialis are cut 2 cm distal to the line of bone division. Humerus is cut at its surgical neck. Biceps, triceps and coracobrachialis are sutured over the end of the cut humerus. Pectoralis major is swung laterally to suture to bone. Skin flaps are closed.

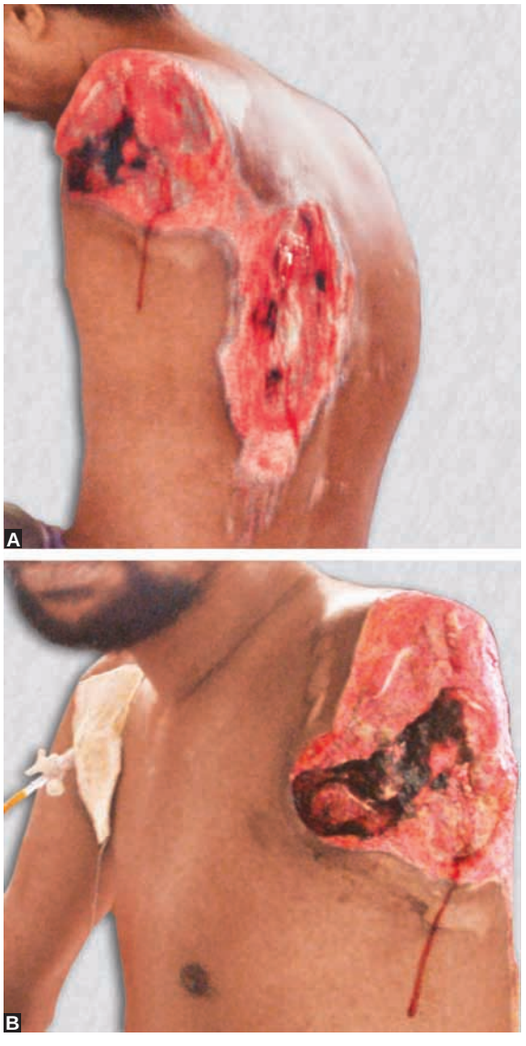
Shoulder Disarticulation

It is similar like shoulder amputation but at later period by keeping arm in internal rotation external, rotator muscles and posterior joint capsule is divided. Anterior aspect of the joint capsule and subscapularis and triceps are cut. At the end inferior part of the joint capsule is cut. Unduly prominent acromion process may be trimmed to achieve smooth rounded contour. Muscles are sutured into the glenoid cavity.

Interscapulothoracic Amputation (Forequarter Amputation) (Little Wood's Posterior Approach or Berger's Anterior Approach)

It is removal of entire upper limb with scapula and lateral ⅔ of the clavicle and muscles attached to it. It is done in malignancies involving scapula, upper part of humerus and near shoulder joint.

In posterior approach patient is kept in lateral decubitus position. Incision begins at medial end of the clavicle extending laterally along the length of the clavicle → over the acromion → posterior axillary fold → along the axillary border of the scapula → below the scapular angle. It is curved medially to end 5 cm from midline of the back. Flap is elevated medially to vertebral border of the scapula. Trapezius and latissimus dorsi muscles are identified and divided. Scapula is retracted away from the chest wall and levator scapulae and rhomboids are divided. Serratus anterior is divided along the vertebral border of the scapula. Brachial plexus cords are divided close to spine; subclavian vessels are ligated and divided individually; omohyoid muscle is divided. After completion of posterior dissection, anterior incision is made from the middle of the clavicle downwards along the lateral and parallel to deltopectoral groove across anterior axillary fold below and posteriorly to join the posterior incision at lower ⅓ of axillary border of the scapula. Pectoralis muscles are divided to complete the forequarter amputation. Flaps are sutured with a suction drain **(Figs 10-41A and B)**.



Figs 10-41A and B: Forequarter amputation.

REHABILITATION

Rehabilitation after amputation needs a team approach – surgeon, physiotherapist, occupation therapist, psychologist, social worker, etc.

Exercises should be started by physiotherapist from the 2nd or 3rd day after surgery. It is for both muscle setting and joint mobilisation.

Construction of a new organ of locomotion is essential and should be a planned one. Preservation of joint is more important then only of length. Level of amputation should eliminate pathology for which amputation was done.

Split skin grafting over the raw stump area is often done only as a temporary measure. Otherwise it should be avoided as it may repeatedly breakdown by prosthesis.

Joint movement especially adequate extension is a pre-requisite for good prosthesis. More than 30° fixed flexion at knee is contraindication for below knee amputation. Flexion contracture development after amputation is common and it should be avoided by proper rigid dressing (cast/posterior slab using plaster of Paris) and exercises (quadriceps exercises).

Proper tension free skin flap over the stump and thin linear scar are important for proper prosthesis placement **(Figs 10-42 and 10-43)**.

Fig. 10-42: Crutches used for lower limb amputation.

Prosthesis

Prosthesis is *the substitution* to a part of the body to achieve its optimum function (Orthroses are *supplement* for limb function). It can be *end bearing* or *side bearing*. Prosthesis can be suction type or non-suction type. *Suction type* is placed above the stump. It is better and well tolerated. *Non-suction type* prosthesis is placed at the ends. It requires additional support. Prosthesis can be *external* where prosthesis is placed outside; or *internal* where prosthesis is placed inside into the joint or structure related by open surgery method **(Fig. 10-44 and 10-45)**.

Fig. 10-43: Elbow crutches are used as support after lower limb joint/bone surgeries during rehabilitation.

Its functions are – cosmesis, relative achievement of the function of the part, ambulation in lower limb prosthesis. Infection, pressure ulcers, joint instability are the disadvantages.

Syme`s amputation - Elephant boot.
Below knee amputation - Patellar tendon bearing (PTB) prosthesis.
Above-knee amputation - Suction type prosthesis. It is placed above the stump. It is better and well tolerated.
Hind-quarter amputation - Tilting table prosthesis (TTP) is used here or Canadian prosthesis

Fig. 10-44: X-ray showing bilateral hip prosthesis.

Prosthesis gives structural strength to the limb. Three groups of prostheses are available: (1) *Endoskeletal/modular limb:* It has got central structural tube to which socket and joints are attached and covered with shaped form to match the contour of the contralateral limb as closely as possible. The foam is covered by skin of silicone, PVC woven material. Load bearing tube is made up of carbon graphite fibre or aluminium in conjunction with titanium for highly stressed components. (*2) Exoskeleton/conventional limb:* The outer visible skin is main structural element and such limbs are hollow. Materials used are willow, plastic laminates. Upper limb prostheses are commonly exoskeletal type. (3) *Temporary pylon type:* It is used for lower limb with two self locking jointed side struts, resembling a traditional above knee calipers.

Socket of the prosthesis transmits all loads in both swing and stance phases of walk between prosthesis and stump. Socket is the most important part of the prosthesis. Women take time to adjust to

Fig. 10-45: Below knee amputee with prosthesis. It gives good range of movements, normal walk and comfort.

prosthesis as they are having less muscle bulk and more subcutaneous fat and stump volume may fluctuate due to hormonal changes during menstrual cycle and pregnancy. Sockets have got tolerant areas for increased loading pressure like ischial tuberosity or patellar tendon and intolerant areas for reduced pressure like head of fibula or adductor tendon. Polypropylene, fibre glass, aluminium alloy, plastic are different materials used for sockets. Socket is worn over a stump sock of cotton or wool. Thickness of sock for proper fitting of the socket is important. Sock is not used in suction or myoelectric sockets. Polyurethane gel layer incorporated or silicone impregnated socks are also used to reduce the skin shearing and stump sweating.

Prosthesis requires *suspension* to hold it place with a belt, cuff or sleeve. Self suspending or suction sockets are also available. Rotational alignment around the central axis of the limb, angular alignment in coronal and sagittal planes and mediolateral and anteroposterior shift must be optimised.

Prosthesis for Below Knee Amputation

Ideal below knee stump is 15-18 cm. Longer stump causes alignment problem. Minimum length is 9 cm. If after flexing the knee joint to right angle, residual tibial length more than three fingerbreadth beyond the hamstring insertion, means stump is adequate for use. Robinson skew flap is better for fitting early definitive prosthesis. Bone bridge between tibial and fibular cut ends is better for prosthesis. Excess bulbous soft tissue on the end of the stump is not good for prosthesis. Stable mobile knee joint is essential for proper prosthesis.

Patellar tendon bearing prosthesis (PTB prosthesis): Here all the weight bearing is done below knee; movement is controlled by his own knee joint. Patellar tendon is the main key weight bearing area within the socket; stump posteriorly up to the popliteal fossa is also important to provide counter pressure so that patellar tendon is kept in place. Medial and lateral paratibial areas and medial condylar flare also bear significant weight. Head of the fibula, tibial tubercle, cut ends of tibia and fibula are pressure intolerant areas. Socket should have proper relief areas to these intolerant parts.

Computer assisted designing and computer assisted manufacturing (CAD – CAM) socket is an automated processing method which fulfills all above criteria accurately with modifications. It is more comfortable and is made up of thermoplastic or laminated plastic with closed cell polyethylene foam.

Suspension for below knee amputation prosthesis is leather cuff strap above femoral condyles. Exoskeleton or endoskeleton is used. For athletics endoskeleton is preferable.

SACH (Solid Ankle Cushion Heel) foot: It is multiaxial, optimizes gait, and facilitates walking on rough ground. It needs minimal maintenance. It is preferred in old people. Energy storing foot is often used wherein ankle joint is replaced by a plastic spring **(Fig. 10-46)**.

Below knee prosthesis with a thigh corset is used in patients who cannot bear full weight below knee may be due to extensive scarring, presence of skin graft, loss of sensation, damaged knee. Leather thigh corset is joined to lower part of the prosthesis by side steel incorporating joints at knee level to transmit body weight above knee; but retaining entire knee movement and control. Ischial tuberosity is also used often additionally to high corset to minimise below knee weight bearing **(Fig. 10-47)**.

Prosthesis for Above Knee Amputation

Above knee prosthesis is heavier and bulkier and needs more energy for walk (50% more than normal). Minimum length of the above knee stump needed for prosthesis placing is 8 cm measured from the origin of the adductor longus on pubis to the cut end of the femur. *Ischial tuberosity* is the key weight bearing part for above knee amputation prosthesis. Anterior wall of the socket must extend more proximal than ischial tuberosity to prevent slipping. Rigid plastic or Ireland Sweden Newyork (ISNY) socket is used. ISNY socket contains a flexible plastic liner in a rigid carbon fibre reinforced frame. It controls the shape of the socket brim extending down the medial side of the socket as narrow strut to provide strength and attachment to knee mechanism. Contoured adducted trochanteric controlled alignment method socket

Fig. 10-46: Prosthesis used for lower limb amputation.

Fig. 10-47: Below knee amputation – prosthesis.

(CAT – CAM) has main weight bearing in ischial tuberosity but the stability of the stump is in coronal plane with a bone lock between medial aspect of the ischial tuberosity and greater trochanter.

Knee joint mechanism system is added to all above knee prosthesis. Locked prosthesis knee which flexes on sitting is used in elderly. Simple friction system with a spring or pneumatic unit to assist extension may be used. Self retaining suction socket or soft neoprene leather belt or rigid pelvic band or shoulder brace is used for suspension system for above knee amputation prosthesis.

Prosthesis for other Lower Limb Amputations

Lisfranc's and Chopart's amputations have tendency to develop equinovarus deformity. So they need ankle joint fixation/obliteration.

In Syme's amputation, person can walk for short distances without prosthesis. Heel pad fat preservation is very important. Projections of malleoli should be preserved to act as suspension. Compliant linear closely fitting polyethylene foam prosthesis is used. Sockets are end weight bearing but extends proximally to patellar tendon level. SACH foot variant is used.

Through knee disarticulation is cosmetically poor. Endoskeletal prosthesis is longer than the natural side and causes limp. Exoskeletal prosthesis with hinge knee joint shows poorer knee control. Rigid plastic socket with compliant linear inside which suspends condyles is used.

In Grittistokes amputation lateral/side weight bearing prosthesis over ischial tuberosity is used.

In through hip amputation endoskeletal prosthesis is used with ischial tuberosity as weight bearing. Socket wrap around both iliac crests in through hips and self suspending is used.

In hind quarter amputation endoskeleton prosthesis with contralateral ischial tuberosity as weight bearing point is used. Socket wrap around with shoulder brace is needed.

Prosthesis for Upper Limb Amputations

Upper limb prosthesis provides grip. But sensation and movements are limited. It is very difficult to achieve complex movements of the natural hand. Every part of the upper limb should be tried to preserve. More the preservation betters the rehabilitation outcome. Pinch grip is totally lost if there is loss of thumb. Opposition prosthesis is helpful. Even when all digits are lost wrist should be preserved for prosthesis plate suitable for pinch and oppose.

In forearm/below elbow amputation ulna length should be at least 8 cm from tip of the olecranon. This gives 4 cm flexor stump beyond the insertion of the biceps tendon. There is not much problem if radius is not preserved. Junction of middle and distal third level is the ideal level of amputation in the forearm to achieve proper function. Laminated prosthesis and socket with cotton sock is used. Prosthesis may be – body powered split look operated; or mechanical hand with active three point grip between thumb, middle and index finger; or myoelectric hand wherein electrical signals are picked up by skin electrodes placed over common flexor or extensor origin; powered wrist rotation.

Above elbow amputation should have stump length of 3 finger width below the anterior axillary fold measured with arm by side. Clearance from stump end to the tip of olecranon should not be less than 9 cm. Prosthesis for above elbow is heavier and bulkier with poor and variable functional outcome. Plastic exoskeleton functional prosthesis with plastic/leather socket over the top of the shoulder is used.

Chapter

11

Surgeries in Arterial Diseases

Surgery for arterial diseases is a complicated one. Artery is always surgically mobilised deep to the adventitia. Tunica adventitia contains fibrous and elastic tissue with periarterial sympathetic nerves. It is attached loosely to the tunica media. Tunica media contains smooth muscle and elastic tissue. Elastic tissue is more in large vessels. Tunica intima is inner thin endothelial layer that lies on an elastic tissue basement membrane which comes in contact with tunica media.

Alexis Carrel in 1912 got Nobel Prize for establishing principles of vascular suturing. Arterial repair is needed in trauma, aneurysm, and block surgery for malignancy in many anatomical places like neck, axilla, abdomen; limbs may need vascular reconstruction while doing radical surgery. All general surgeons should know the technique of vascular suturing which will be handy while operating.

PRINCIPLES IN VASCULAR SURGERY

Gentle handling of all vessels using non-toothed fine forceps is essential. Intima can get damaged without adventitial injury which may lead to thrombosis.

Artery should be mobilised adequately including proximal branches to have adequate control.

In emergency situation like bleeding speed of surgery is very important especially in major arterial injury. Rapid access, quick proximal control is essential to save the life.

Blind clamping of bleeding area in a hurry due to stress should be avoided. It may damage more or injure adjacent structures.

Resuscitation should be undertaken simultaneously by a critical care team with adequate venous accesses including a central line in major vascular bleeding.

Precision and gentle handling is essential in vascular surgery.

Vascular clamps or tapes are used at the site of an arteriotomy. While applying clamps, adjacent vein should be taken care off as thin walled vein may get injured. Vascular clamps available occlude lumen to control bleeding without injuring the vessel wall; but diseased atheromatous vessel may develop breakage of the plaque often causing embolus. Injury to the plaque itself may precipitate the thrombosis of the vessel. Clamp should be held properly or should be fixed to the drape as twisting or traction of the instrument may injure the vessel. Side clamp is also used often in major vessels like in aorta, and inferior vena cava. Prelaparotomy thoracotomy for aortic clamping or intraabdominal per laparotomy aortic clamping in torrential bleeding is often advocated as life saving procedure (Refer Chapter 8 - Principles of Surgical Management in Trauma).

Slings or tapes of different colours are used to control haemorrhage in elective vascular surgical procedure **(Figs 11-1 and 11-2)**.

Severe ischaemia with muscle death is contraindication of arterial repair. It is also better avoided in presence of sepsis.

Atraumatic but firm vascular clamps should be used. Size and type of clamps should be selected depending on need, site, size of the vessels **(Figs 11-3 and 11-5)**.

Needle holder for arterial suturing should be of high quality material like tungsten with fine points. Monofilament non-absorbable synthetic suture material is used. 3 zero to as fine as 7 zero suture materials are used. For aorta 3 zero or 4 zero is used; for iliac arteries 4 zero; for femoral artery 5 zero; for popliteal and brachial arteries 6 zero; for distal vessels 7 zero is used. Always atraumatic needle is used. Polypropylene suture material is ideally used. It is very smooth, slips through tissues easily. Brittleness, memory, knot slipping should be taken care of. Minimum 5 knots should be placed. Polytetrafluoroethylene (PTFE) sutures are very strong but knot slips easily.

Usually continuous sutures are placed as it is haemostatic. But often interrupted sutures are also placed safely especially in medium sized and small sized arteries. Single needled suture material is used for closure of longitudinal arteriotomy; double needled suture material (double armed suture with needle at both ends) is used for end-to-end closure or patch closure.

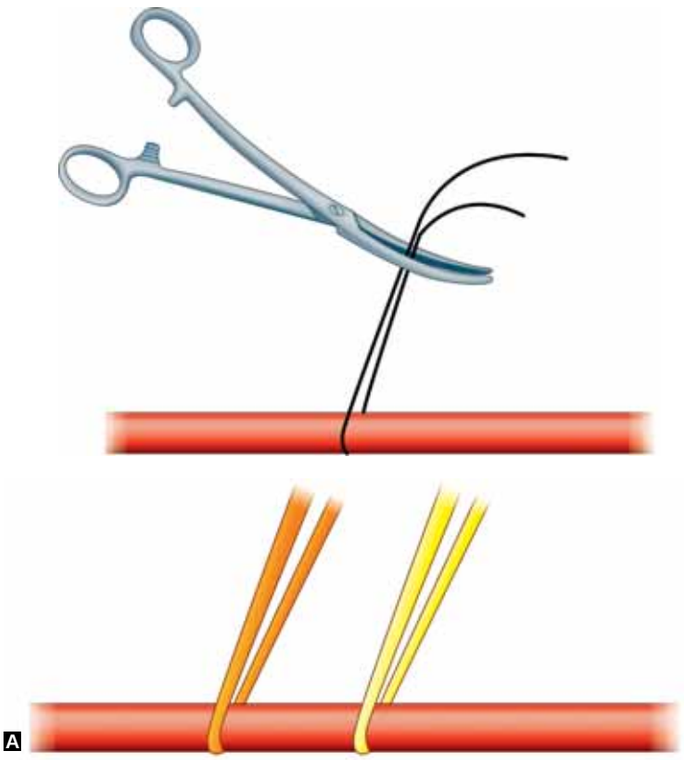
Use of magnifying loops may be necessary for fine suturing. But once habituated it is difficult to do suturing in the absence of loops.

In suturing of diseased vessels thicker suture material is used (3 zero/4 zero). Needle should be passed from within outside of the artery.

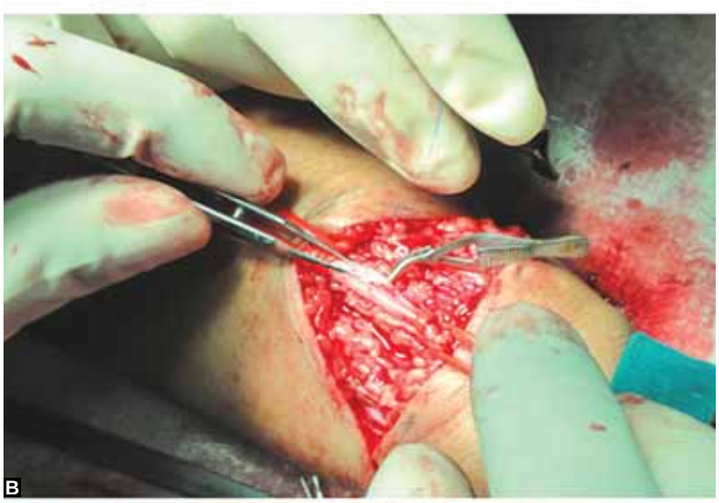
During arterial suturing, interposition of the adventitia should be avoided as it may initiate thrombosis.

End of the suture material should not be held directly by fine haemostat but with jaws protected by fine rubber or plastic tubes. Unprotected metal instruments should never be used to hold the end of fine suture.

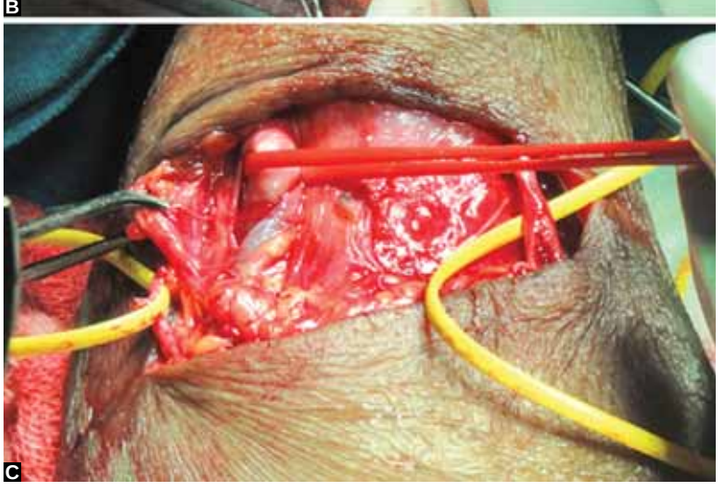
Before application of clamps 5000 IU of heparin is given intravenously. Often half the dose is reversed using protamine sulphate but not necessarily always. Heparinised saline solution should be used for irrigation of opened vessels. 5000 IU of heparin is mixed with 500 ml of normal saline to prepare such solution.



A



B



C

Figs 11-1A to C: Silk slings or fine coloured rubber or synthetic slings/ loops can be used to control haemorrhage.

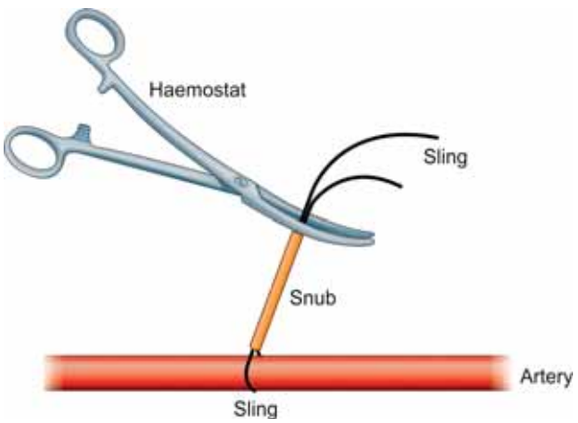
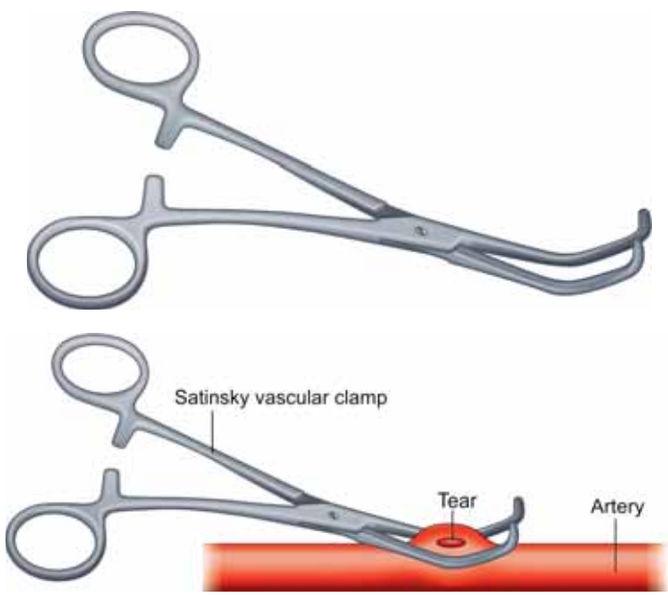


Fig. 11-2: Sling with snub also can be used to control the haemorrhage.



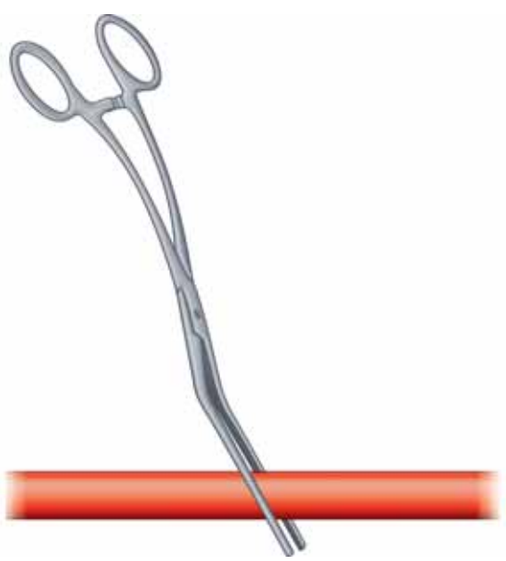
Figs 11-3: Satinsky vascular clamp and its use in vessel tear.

A

Fig. 11-4A

B

C

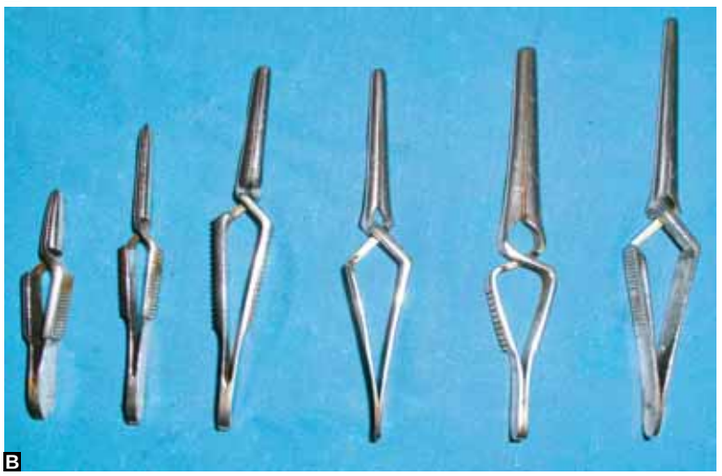


D

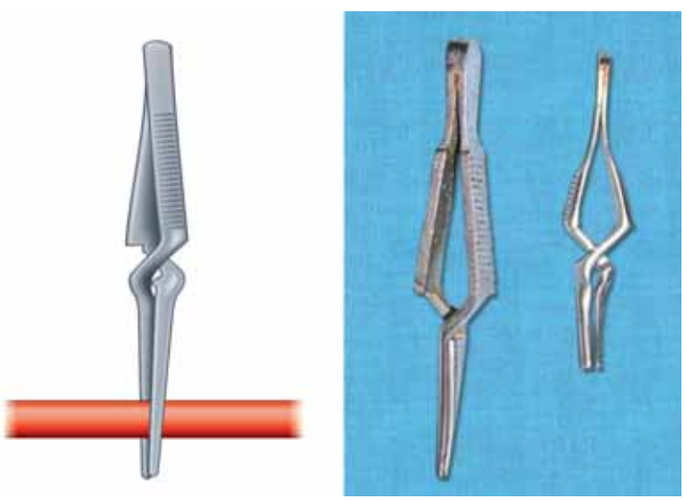
Figs 11-4B to D

Figs 11-4A to D: Different vascular clamps – Soft jaw Fogarty clamp; Satinsky vascular clamp.

A



B



C

Figs 11-5A to C: Bull dog clamp and its application. It temporarily occludes vessel firmly and completely. Different sized and type of clamps-straight and curved types are available.

Arteriotomy

Artery is opened (*arteriotomy*) longitudinally. *Longitudinal arteriotomy* is easier to close. Thrombus formed in suture line will be thin and longitudinal and so will not block the lumen. Longitudinal arteriotomy is easy to extend as needed. It is commonly used in thrombectomy and endarterectomy. *Transverse arteriotomy* is difficult to appose. Circular suture line thrombus formed at one place may block the lumen. Intima retracts much more than deeper layers so that often it is difficult to take suture bite. Intima may get dissected in transverse arteriotomy. But in many situations like in trauma, in surgeries of malignancies end-to-end anastomosis is needed. Often it is done using interrupted sutures especially in medium sized vessel of less than 4 mm size **(Fig. 11-6)**.

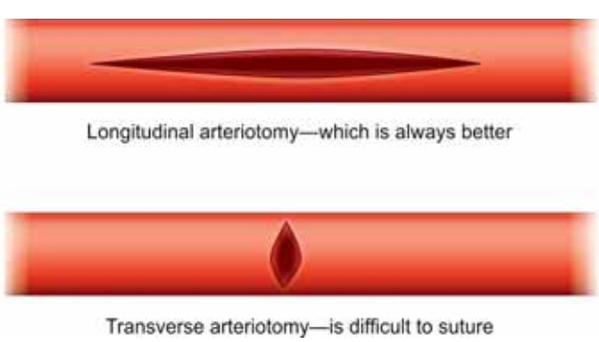


Fig. 11-6: Arteriotomy is opening of artery surgically. Longitudinal arteriotomy is better than transverse one.

Sterile field, good retraction, light and access, control of bleeding are essential parts of vascular surgery. Non-absorbable monofilament polypropylene is used as a suture material. Round body needle is used for arterial anastomosis. Tapercut needle can be used if suturing is done through a thick graft.

Intima should be included in all bites during sutures except in endarterectomy. Needle should be passed from within out across the vessel to prevent intimal flap formation and dissection. When bite is taken from without in towards intima, intima should be supported firmly using fine instrument to prevent intimal separation.

Arterial ligation is done in different methods: (1) Direct ligature of the vessel using nonabsorbable or delayed absorbable sutures. Silk/polyglactic acid/thread may be used. (2) Transfixation sutures across the vessel using polypropylene or polyglactic acid sutures. (3) Over sew technique is continuous running sutures over a large vessel to have a firm safe/secure closure of the vessel **(Fig. 11-7)**.

DIFFERENT METHODS OF ARTERIAL SUTURING

All layer simple lateral sutures are used for closure of longitudinal arteriotomy. Turning intima outwards, firm uniform tension on suture line, proper spacing of the bite and optimum width of the bite are essential.

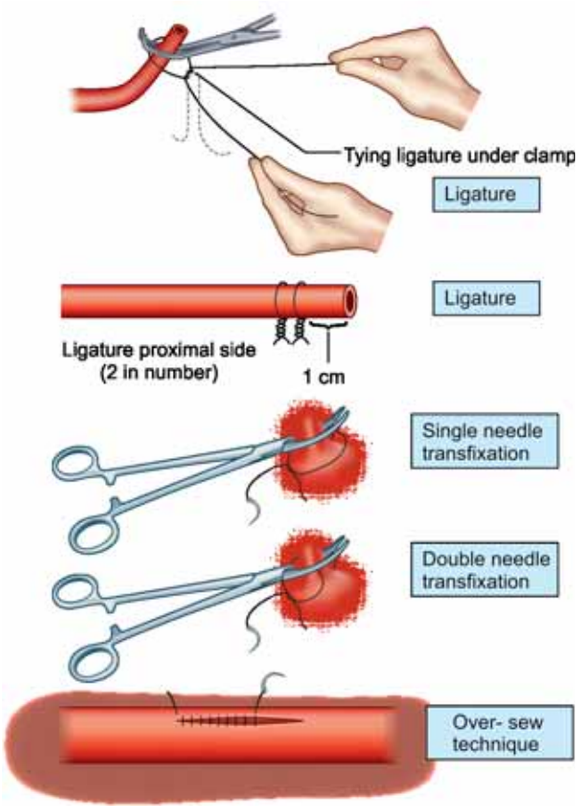


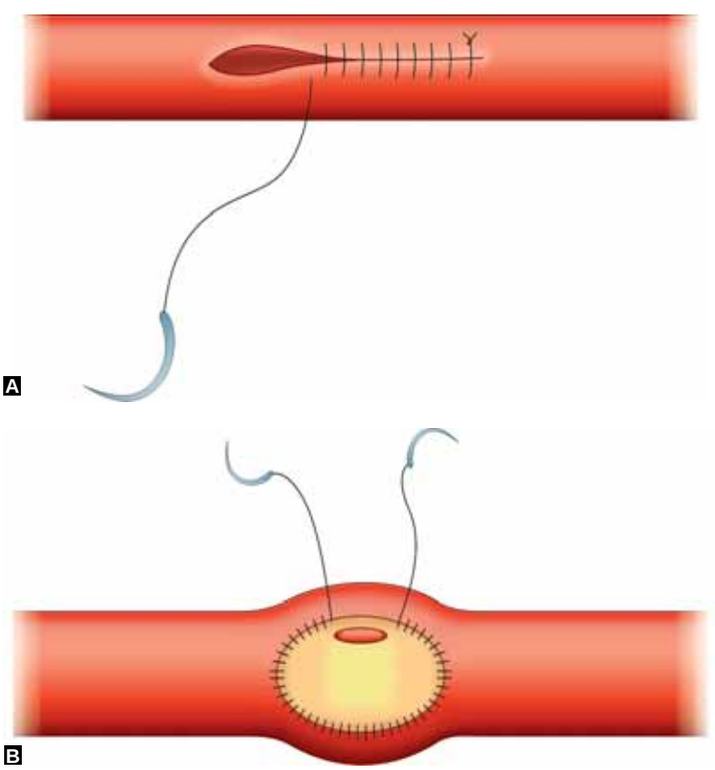
Fig. 11-7: Different methods of arterial ligation. Secure ligation is important. Type of ligation is used individually in each surgery. For definitive arteries like uterine or cystic or gastric, proper 2 or 3 ligatures should be placed. Transfixation suture also can be placed. In bulky tissues bleeding is controlled by double transfixation or over sewing method.

Closure using a venous (autologous) or prosthetic (Dacron or PTFE) patch is used in smaller arteries like brachial artery or deep femoral artery (profundaplasty). Oval or rectangular patch should be used; not elliptical one with sharp point which may narrow the artery at the corners **(Fig. 11-8)**.

End-to-end suturing of the cut ends of artery is done by Carrel's triangulation technique. Three sutures are placed; one on the posterior deeper part; one on each at equidistant on the corners. Continuous sutures are placed keeping these three stay sutures as guiding points. Everting mattress sutures also can be placed. Deepest parts of the triangulation should be sutured first. Larger arteries are sutured with continuous sutures; medium and small arteries are sutured with interrupted sutures. Whether continuous or interrupted sutures are used, triangulation should be done at the beginning **(Figs 11-9 and 11-10)**.

Single stitch, end-to-end suturing of large artery can be done by placing continuous sutures beginning from the nearest cut end progressing posteriorly towards other cut end and commencing later on anterior aspect to complete the end-to-end suturing. Double needle suture may be used which is started at midpoint posteriorly proceeding on either sides towards in front to complete the end-to-end suturing.

Inlay method of suturing is usually practiced in reconstruction of abdominal aorta using graft wherein horizontal mattress sutures are placed with needle passing from graft to aorta. Parachute technique is a method where double end sutures are placed without initial tying of the knot.



Figs 11-8A and B: Simple suturing of the vessel; often venous or prosthetic patch may be required in smaller arteries.

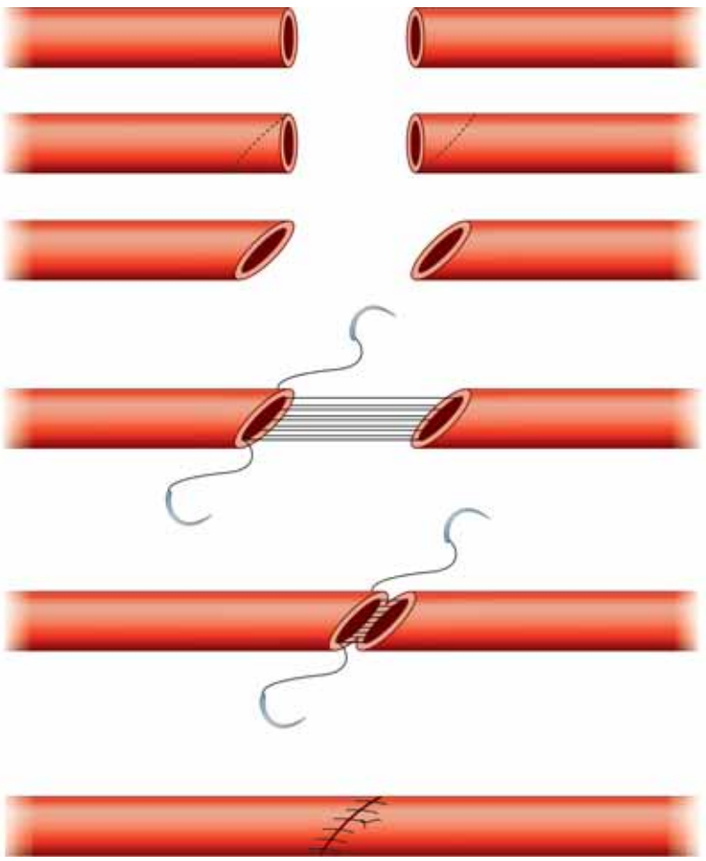


Fig. 11-9: Technique of end-to-end suturing.

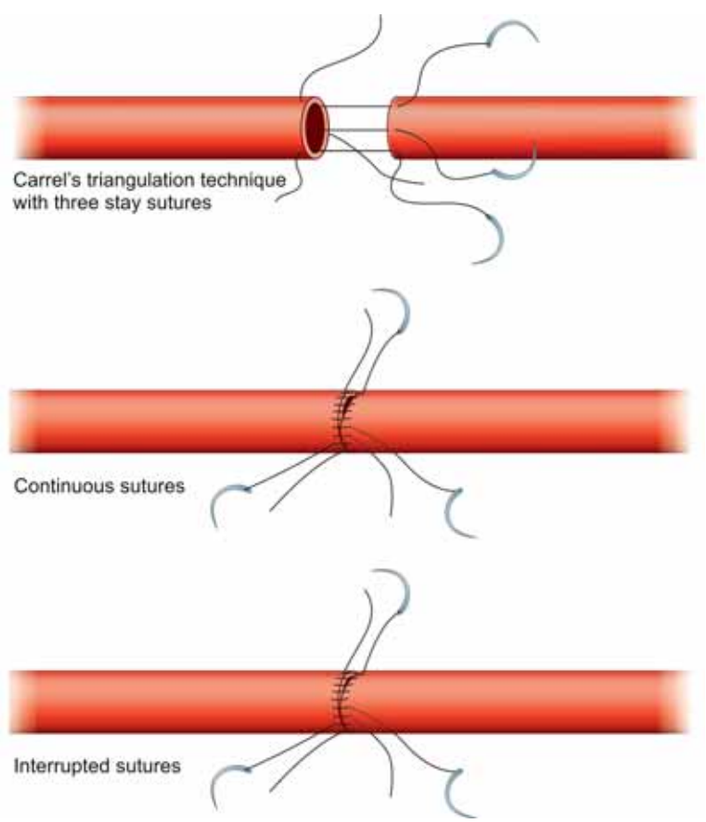
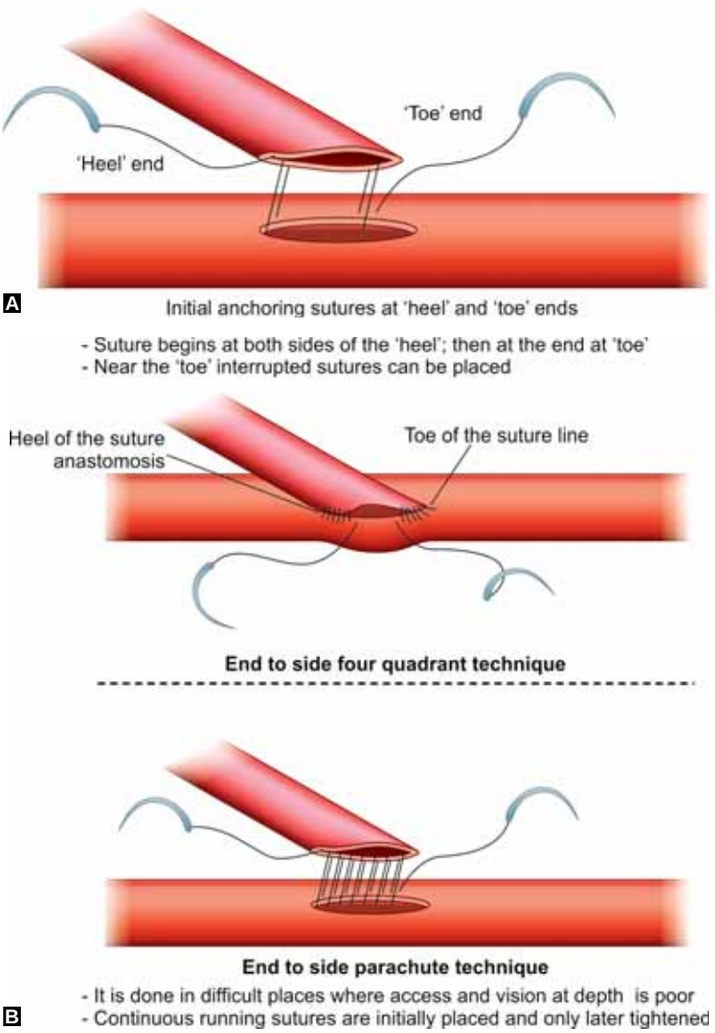


Fig. 11-10: Carrel's triangulation technique in arterial suturing.

End-to-side suturing of the arteries is done in arterial bypass procedures with oblique stoma which is twice the diameter of the artery/graft to have a spatula end with cobra head look.

Four quadrant technique with double ended suture at the heel of the anastomosis; the end with acute angle of the anastomosis is called as *heel* and the end with obtuse angle is called *as toe* of the anastomosis.

Parachute end-to-side suturing is also done whenever there is poor access or poor visualisation; is done using double ended vascular running stitches continuously which later is pulled tight for approximation of the vessel/graft parts **(Fig. 11-11)**.


'Toe' end
'Heel' end
A
Initial anchoring sutures at 'heel' and 'toe' ends
- Suture begins at both sides of the 'heel'; then at the end at 'toe'
- Near the 'toe' interrupted sutures can be placed
Heel of the suture
anastomosis
Toe of the suture line
End to side four quadrant technique
End to side parachute technique
- It is done in difficult places where access and vision at depth is poor
- Continuous running sutures are initially placed and only later tightened
B

Figs 11-11A and B: Different end-to-side suturing technique. Note the *heel and toe end* of the arterial suturing.

In an endarterectomy special ***Kunlin suture*** is inserted to prevent intimal dissection. Suture initially passed from outside to inside through endarterectomised part then from inside out through atheromatous part to tie outside. It fixes the intima properly **(Fig. 11-12)**.

In calcified artery often additional fine adventitious sutures may be required. In a friable artery suture holding may be inadequate; so to hold sutures and to prevent haemorrhage, additional *buttressing under the sutures* can be done using Dacron in larger artery or muscle piece in small artery **(Fig. 11-13)**.

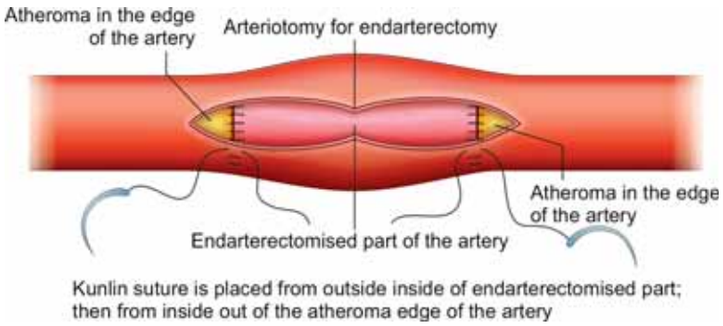

Atheroma in the edge of the artery
Arteriotomy for endarterectomy
Atheroma in the edge of the artery
Endarterectomised part of the artery
Kunlin suture is placed from outside inside of endarterectomised part; then from inside out of the atheroma edge of the artery

Fig. 11-12: Kunlin suture.

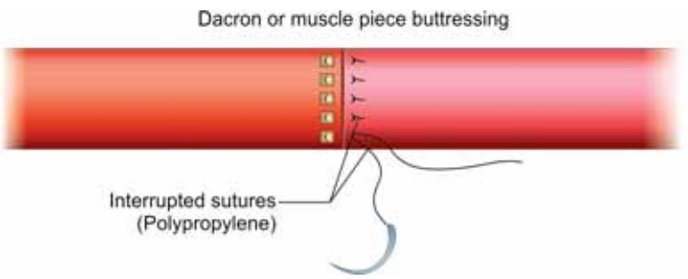
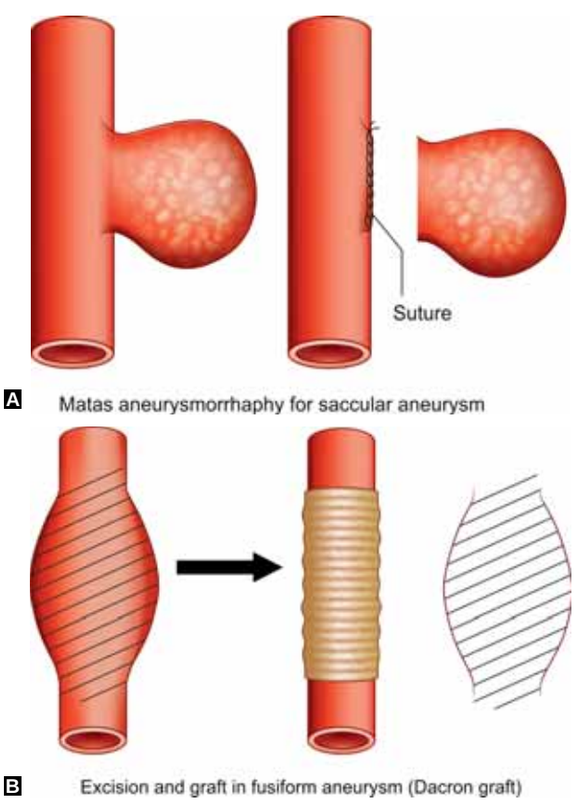


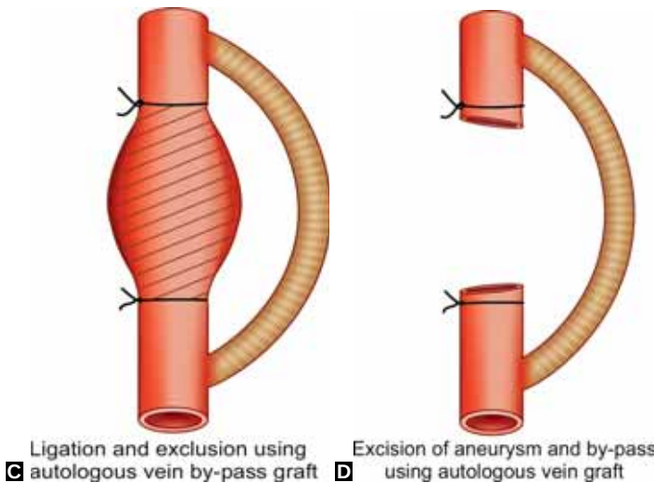
Fig. 11-13: Buttressing under suture is done using Dacron or muscle piece.

Nonsutured anastomosis is a new method used in aorta during surgical treatment of aneurysm to keep in place of the synthetic graft. A rigid Dacron covered polypropylene ring is passed using an applicator within the lumen. Tapes are ligated outside the aorta also.

Peripheral aneurysms are approached by different methods – Matas aneurysmorrhaphy; excision of aneurysm and Dacron graft; ligation and exclusion using vein; excision of aneurysm and bypass using autologous vein **(Figs 11-14 and 11-15)**.



Figs 11-14A and B


C Ligation and exclusion using autologous vein by-pass graft
D Excision of aneurysm and by-pass using autologous vein graft

Figs 11-14C and D

Figs 11-14A to D: Different surgical approaches for managing peripheral aneurysm. Basic principles are similar – meticulous dissection proximally and distally; heparinization on table; proper clamping of artery on either ends; right selection of the technique; avoidance of sepsis; synthetic (Dacron or PTFE) or venous graft placement; proper postoperative positioning; prevention of postoperative sepsis and thrombosis.

ENDARTERECTOMY

It is a procedure where diseased atheromatous plaque with intima is excised through an adequate arteriotomy. It is often called as *reboring/disobliteration*.

It is done in short stenotic lesion commonly; often it is done in long arterial blocks where graft is contraindicated. It is done commonly in *carotid artery*.

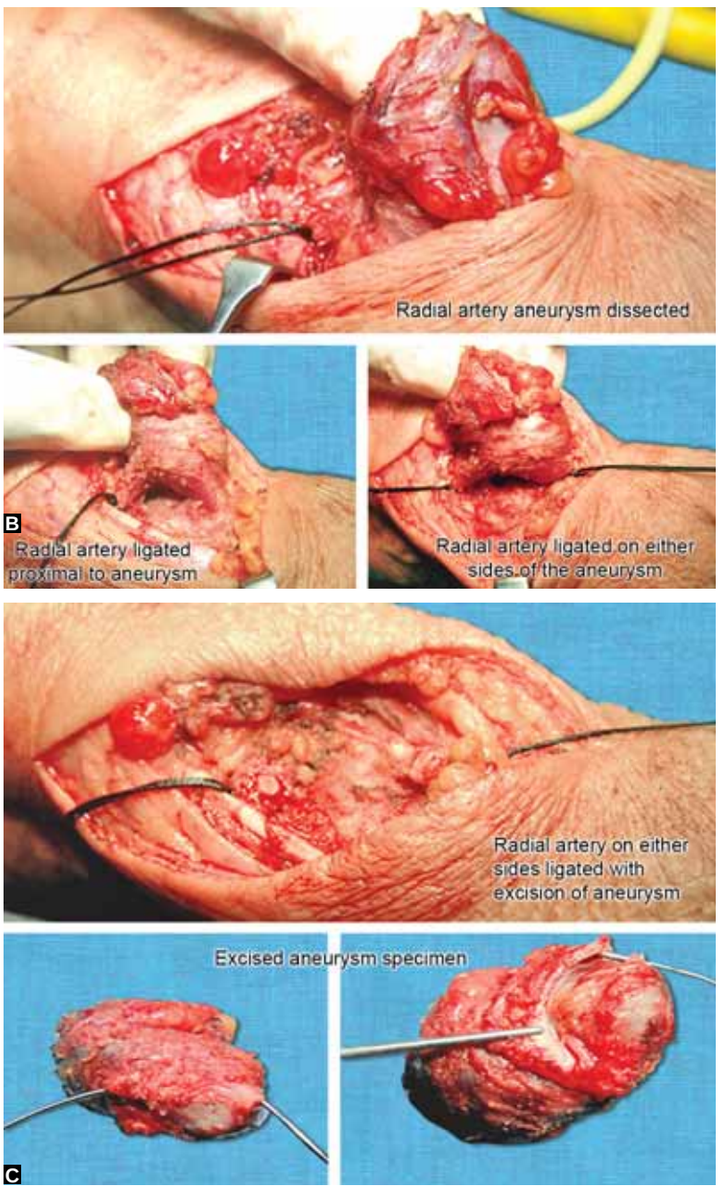
Preoperative *angiogram* is a must to evaluate exact site, extent and nature of the arterial stenosis.

Procedure

Artery is exposed with proper incision. Patient is heparinised. Arterial clamps are applied on both ends. Longitudinal incision is made over the artery using No. 15 blade. Incision deepened with same blade until fresh blood oozes out. Incision is further extended on either ends using *Pott's* scissor.

Arteriotomy edges are held and lifted using fine instruments by surgeon and assistant. A plane between arterial wall and diseased intima with plaque is created.

Fig. 11-15A


Radial artery aneurysm dissected
B
Radial artery ligated proximal to aneurysm
Radial artery ligated on either sides of the aneurysm
Radial artery on either sides ligated with excision of aneurysm
Excised aneurysm specimen
C

Figs 11-15A to C: Radial artery aneurysm. It is excised with ligation of the artery proximally and distally. Usually there is no need to repair as collateral circulation through ulnar artery and palmar arch will maintain the distal circulation.

Dissector is passed at distal end around the plaque which is then continued proximally. Proximal end of the plaque is cut circumferentially. Proximal to this point of cut, intima should never be lifted off and if done it will cause flap dissection as complication. Then distal end of the plaque is cut taking similar care like done for proximal part. In the distal part often it is necessary to place few interrupted anchoring sutures from endarterectomised part to nonendarterectomised part. Usually removal of the plaque is done from proximal to distal part of the artery. Only in difficult situations like in carotid endarterectomy (often), it is done from distal to proximal part **(Fig. 11-16)**.

Each clamp is released once and reapplied to check the forward flow and backflow.

Arteriotomy is closed using 3 zero polypropylene in large artery, 5 zero polypropylene in small arteries. Artery lesser than 5 mm is closed with a venous or synthetic graft patch to prevent re-stenosis at the site. A holding single interrupted suture is placed first at proximal site. Then closure of arteriotomy is done using continuous sutures from *distal to proximally*.

Always proximal vascular clamp is first released to empty the air from the arteriotomy segment. Then distal clamp is released. Artery distal to the arteriotomy is palpated for adequate pulsation. Distal part of the arterial wall is inspected for few minutes for possible formation of bluish discoloration as an evident of intimal flap lift distally. Here distal pulse is absent but pulsation may be well felt over dissected intimal flap part.

Postoperative Management

Closed suction drain is placed. Blood pressure monitoring to prevent/control hypertension is needed so that to reduce hyperperfusion syndrome. Heparin should be given for 5–10 days. Later warfarin may be needed. Infection should be prevented. If infection develops proper antibiotics should be given. One should watch the area for haematoma. Distal pulse warmness should be checked at regular intervals. Postoperative Doppler should be done for assessment. Immobilisation of the part and positioning is required for 2 weeks.

Problems and Complications

Intimal flap dissection is an on table problem. Procedure may be insufficient and on table decision may be taken to change over to graft interposition.

Haematoma, torrential bleeding, infection, reblock, thrombosis formation and suture breakdown are the complications.

Semiclosed Endarterectomy (Fig. 11-17)

It is used in lengthy occlusions of the artery. Initial heparinisation → clamps on either sides →arteriotomy distal to distal part of the occluded part → extension of the incision towards distal occluded part → dissection and cutting of the distal part of the plaque → passing of the loop endarterectomy stripper around the plaque towards proximal part (often arc stripper is also used) → plaque is broken gently using artery forceps or using thumb and fingers → care must be taken that outer wall of artery is not damaged → plaque is gently removed using loop. If fragments of plaque are left in the wall, which can be confirmed by feeling, can be removed using Martin's thrombectomy forceps. Undue traction or more should not be executed as it may injure the vessel wall. In such difficulties another arteriotomy may be made over the proximal end of the occluded artery. Arteriotomy is closed from distal end to proximal end. When two arteriotomies are present, proximal one is closed first, then the distal one.

Wiley's Eversion Endarterectomy (Fig. 11-18)

Here artery is transected completely (transversely) so that right plane between diseased intimal plaque and media is created

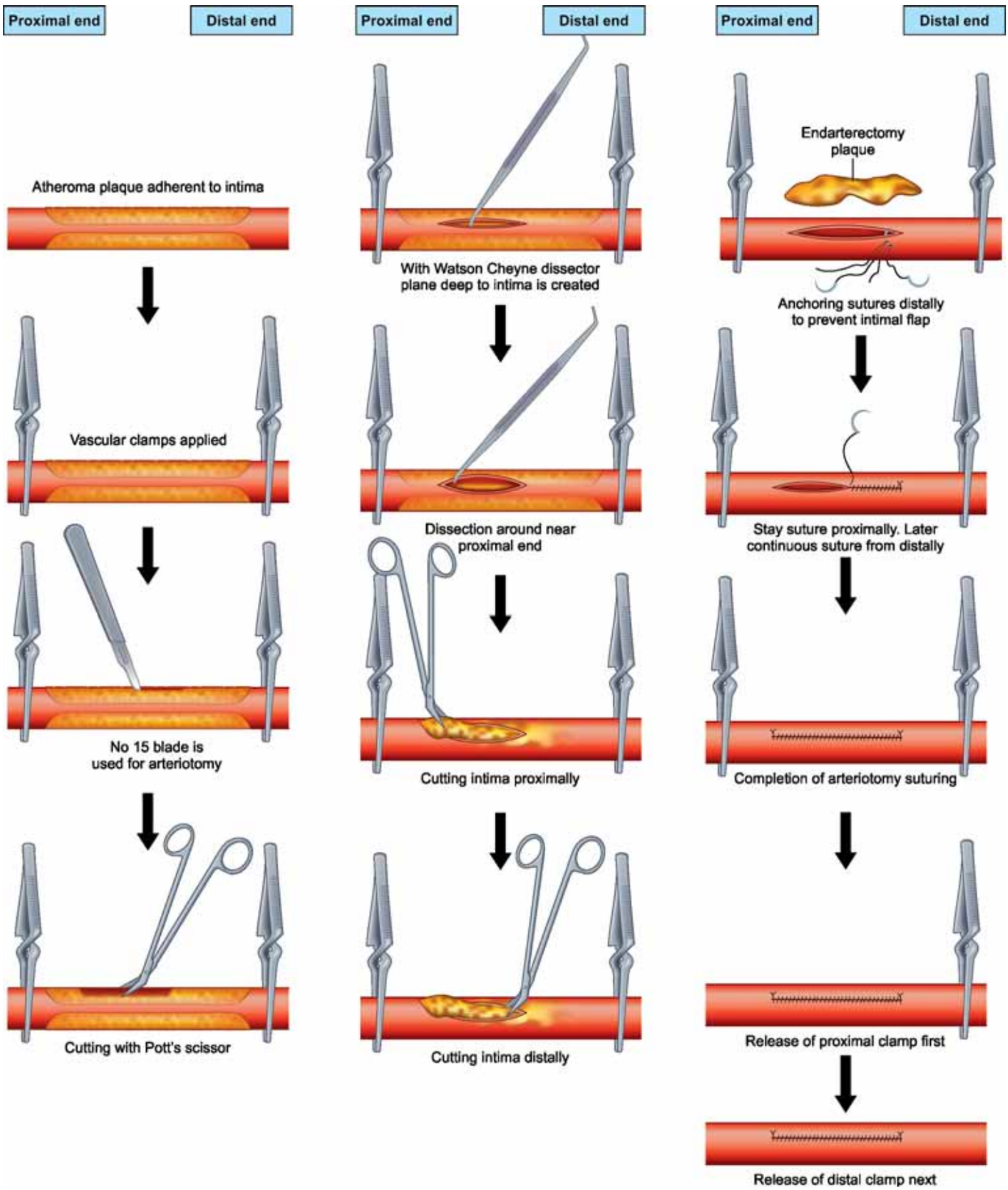

Proximal end
Distal end
Atheroma plaque adherent to intima
Vascular clamps applied
No 15 blade is used for arteriotomy
Cutting with Pott's scissor
Proximal end
Distal end
With Watson Cheyne dissector plane deep to intima is created
Dissection around near proximal end
Cutting intima proximally
Cutting intima distally
Proximal end
Distal end
Endarterectomy plaque
Anchoring sutures distally to prevent intimal flap
Stay suture proximally. Later continuous suture from distally
Completion of arteriotomy suturing
Release of proximal clamp first
Release of distal clamp next

Fig. 11-16: Open endarterectomy technique.

circumferentially. Once plane is created all around arterial wall is everted to exteriorise the plaque completely. Everted artery is reduced later. Cut ends of the artery is sutured using polypropylene interrupted sutures with bite taking from outside-in of the endarterectomised segment to inside out of the unendarterectomised segment.

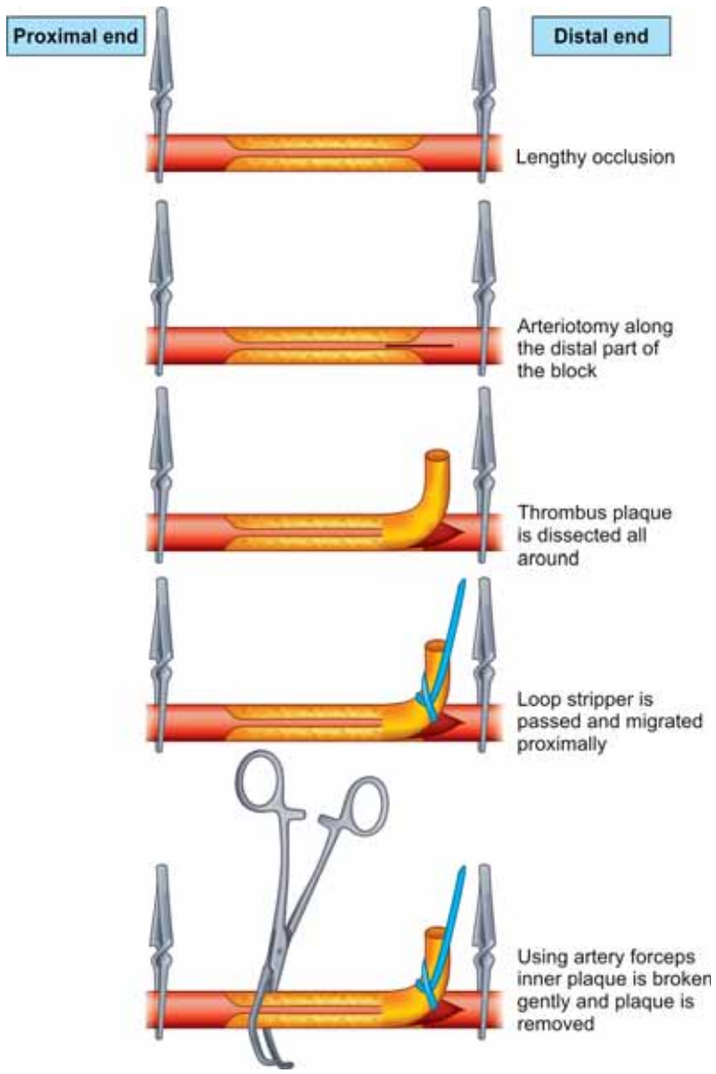

Proximal end
Distal end
Lengthy occlusion
Arteriotomy along the distal part of the block
Thrombus plaque is dissected all around
Loop stripper is passed and migrated proximally
Using artery forceps inner plaque is broken gently and plaque is removed

Fig. 11-17: Semiclosed/semiopen endarterectomy.

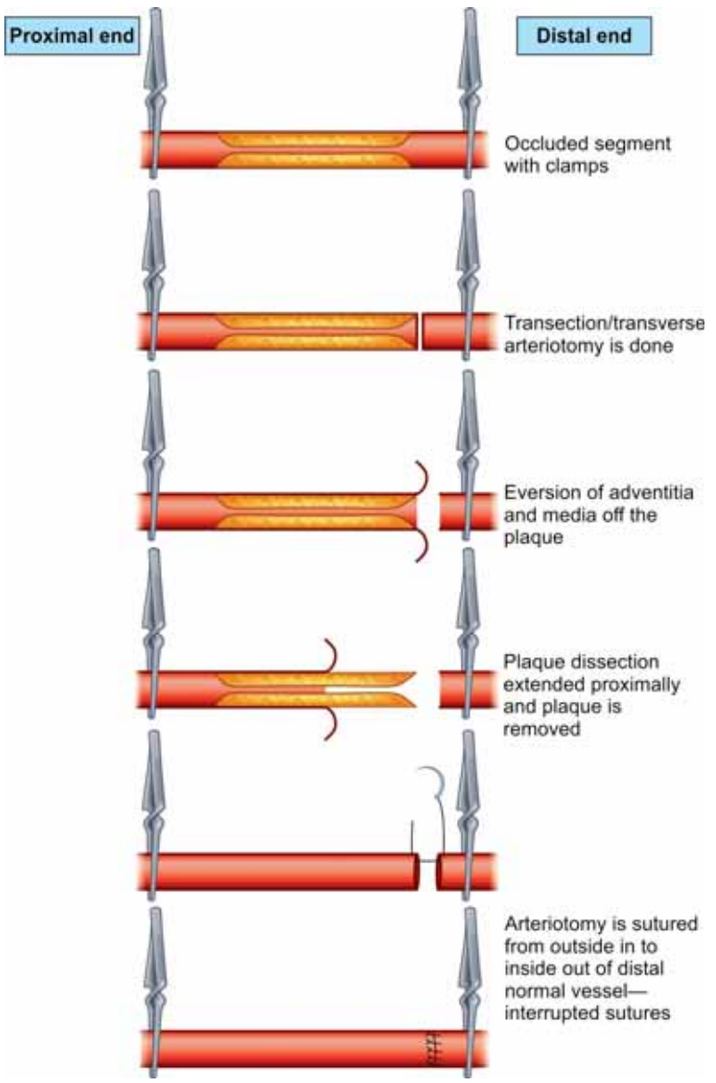

Proximal end
Distal end
Occluded segment with clamps
Transection/transverse arteriotomy is done
Eversion of adventitia and media off the plaque
Plaque dissection extended proximally and plaque is removed
Arteriotomy is sutured from outside in to inside out of distal normal vessel—interrupted sutures

Fig. 11-18: Eversion endarterectomy technique.

CAROTID ENDARTERECTOMY

Indications

- Asymptomatic carotid stenosis more than 60% by angiography or more than 70% on Duplex ultrasound.
- Symptomatic carotid stenosis with cerebrovascular accident/transient ischaemic attacks/amaurosis fugax with > 50% block.

Carotid endarterectomy *prevents development of stroke* for significantly long period.

Evaluation

Blood parameters, lipid profile, duplex ultrasound are the usual needed investigations. Duplex ultrasound is sensitive method of assessing the carotid artery. Angiogram is done only in selected patients with re-stenosis, neck irradiation, earlier neck lymph node block dissection, and atypical cases.

Procedure

Patient is placed in semi-sitting position with round pillow under shoulder to extend the neck. Head is rotated towards opposite side. Arm on the same side is tucked over the chest or side of the table. Ear lobe, mastoid, mandible, sternal notch and clavicle area should be prepared and exposed as landmarks.

Procedure is done under general anaesthesia with routine or selective shunting as needed. Intraoperative EEG monitoring is essential. Regional anaesthesia is often used.

Incision is oblique one along the anterior margin of the sternocleidomastoid muscle. Transverse incision is also often used. But it is not useful in higher lesions. Platysma once divided; medial margin of the sternomastoid muscle is dissected from its upper tendon part to the level of the omohyoid. Internal jugular vein is dissected by sharp dissection along its medial edge. Common facial vein, middle thyroid vein and hypoglossal veins are ligated carefully. Sternomastoid and IJV are retracted laterally. Ansa cervicalis is cut near its origin. Superior thyroid artery is dissected near its origin. Common, external and internal carotid arteries are dissected all

round circumferentially at the confluence. Each artery is held with vascular tape (sling with snub). Superior thyroid artery is held with a loop of silk suture. Hypoglossal nerve is identified by tracing the ansa hypoglossal part above. It is further mobilised after ligating the occipital and sternomastoid arteries. Digastric muscle is divided only when there is a need to expose distal part of the internal carotid artery. Internal carotid artery *should be exposed adequately when needed prior to arteriotomy*. It is difficult to expose internal carotid artery distally once arteriotomy is already done.

Internal carotid artery distally is occluded with a vascular clamp/clip. Routine or selective shunting of the carotid (internal) artery is done. Longitudinal arteriotomy is done → plaque is dissected off the media → proximal portion is first dissected circumferentially → extended towards distal part of the internal carotid artery → eversion endarterectomy is done in external carotid artery plaque → heparinised saline irrigation of the bed of the opened artery is done → with fine forceps small pieces of plaques are removed → Dacron or bovine pericardium patch graft is placed over the defect → sutured to vessel using polypropylene suture material 4 zero or 5 zero. Prior to completion of suturing near the end shunt is removed and back bleed is allowed. First blood flow is allowed to external carotid artery then only internal carotid artery.

Nasotracheal intubation and mandibular subluxation may be needed in difficult cases.

Risk and Problems

It is not possible to do endarterectomy for most distal part of the internal carotid artery in the neck.

Perioperative stroke risk is 1.5%.

Hypoglossal nerve injury, non-recurrent laryngeal nerve (anomaly) injury (it is mistaken for ansa cervicalis and is cut), superior laryngeal nerve injury, marginal mandibular branch (facial nerve) injury, glossopharyngeal nerve injury and spinal accessory nerve injury are neurological complications in relation to cranial nerves.

Distal end of the stenosis should be assessed properly as distal exposure is often difficult. It is quite difficult to expose unusual high bifurcation of the carotid.

Postoperative bleeding, myocardial infarction and carotid re-stenosis are other complications.

Eversion Carotid Endarterectomy

It is done in well localised severe lesions. Type I transection is done as oblique near vertical cut when main block is in the internal carotid artery. Type II transection is done as oblique near transverse cut when main block is in common carotid artery. Shunt is needed during the procedure. After endarterectomy end to end anastomosis is done often with a synthetic patch.

AORTOILIAC THROMBOENDARTERECTOMY

Open (Dos Santos), semi-closed, eversion methods are used. Often aortofemoral bypass has replaced this procedure. Even though commonly performed procedure is bypass graft in cases with localised disease at distal aorta and iliac arteries, thromboendarterectomy is also done. In a *contaminated field* endarterectomy is *better* than graft.

Evaluation is done with duplex ultrasound, angiography of entire abdominal aorta, visceral and renal branches. Both anteroposterior and lateral views are essential as origin of the celiac and superior mesenteric arteries and posterior aortic plaques are well identified by lateral views. To assess the extent of the disease oblique films are taken. Distal tibial films are taken to check distal run off. Pull back pressure gradient more than 10 mm Hg after injection of vasodilator like papaverine suggests significant block. Transfemoral Seldinger method is used for both angiogram and pressure gradient assessment. If there is complete block, transbrachial or lumbar transaortic approach may be used. Arterial digital subtraction angiography can be used. Venous DSA is less informative. Systemic assessment like of renal, cardiac and respiratory should be done.

Prophylactic antibiotic is given intravenously one hour before surgery.

General anaesthesia with epidural supplements is used.

Approach: Retroperitoneal standard or transabdominal approach is used.

Procedure

Left side 45° elevated position is used. Break table (reverse flexion/jack knife) position will give additional access.

↓

Incision is from a point just medial to the lateral margin of the left rectus muscle just below the umbilicus level extending laterally to the tip of the 12th rib. Incision is deepened to superficial fascia and fat.

↓

Anterior rectus sheath is incised to expose rectus muscle. Rectus muscle is either transected or retracted medially. Care should be taken not to open the peritoneum.

↓

External oblique, internal oblique and transverse abdominis muscles are cut in the line of incision. Glistening peritoneum is visualised. It is swept/pushed using gauze or finger and retracted medially. Psoas major muscle and genitofemoral nerve is identified **(Fig. 11-19)**.

↓

Fig. 11-19: Extraperitoneal approach for aortoiliac segment.

Inferior mesenteric artery is identified, ligated and divided. Aorta and iliac arteries are mobilised properly along full/adequate length. 3 cm proximal and 3 cm distal to the level of occlusion should be isolated.

↓

Common, external and internal iliac arteries are dissected; middle sacral and lumbar arteries are identified.

↓

Vascular clamps are placed at all ends.

↓

Arteriotomy incisions are made in the aorta and iliac arteries in different methods. (A) Here two incisions are used – (1) From right of the inferior mesenteric artery extending down along the origin of right common iliac artery. (2) Second incision is separately along the left common iliac artery. This is done to avoid injury to preaortic autonomic plexus which is located to the left side of aortic bifurcation. (B) In this type three separate arteriotomies are made in the aorta and both common iliac arteries. Arteriotomy incisions in iliac arteries should extend beyond their bifurcations.

↓

Endarterectomy is begun at proximal part using a spatula circumferentially; then extending distally along the diseased segment of the artery.

↓

Initially it is cut transversely at proximal point; later at distal point using Pott's scissor.

↓

Endarterectomised part of the vessel is inspected, loose debris and thrombus are removed, and part is irrigated with heparinised saline solution.

↓

Often intima at distal cut margin should be anchored to the artery using non-absorbable polypropylene interrupted mattress sutures which are tied outside. It is done to prevent *intimal flap* dissection.

↓

Repeated irrigation using heparinised solution is needed.

↓

Arteriotomies are closed using continuous 4 zero polypropylene sutures from proximal to distal. Vascular clamps are released just prior to last suture bite; first distal clamp is released then proximal clamp is released.

↓

Arteriotomy often is closed using Dacron or PTFE (Polytetrafluoroethylene) graft as a patch.

↓

Once after release of vascular clamps if bleeding points are found over the sutured arteriotomy, then it is controlled by interrupted 6 zero sutures/liquid thrombin/collagen/light pack and pressure **(Figs 11-20A to I)**.

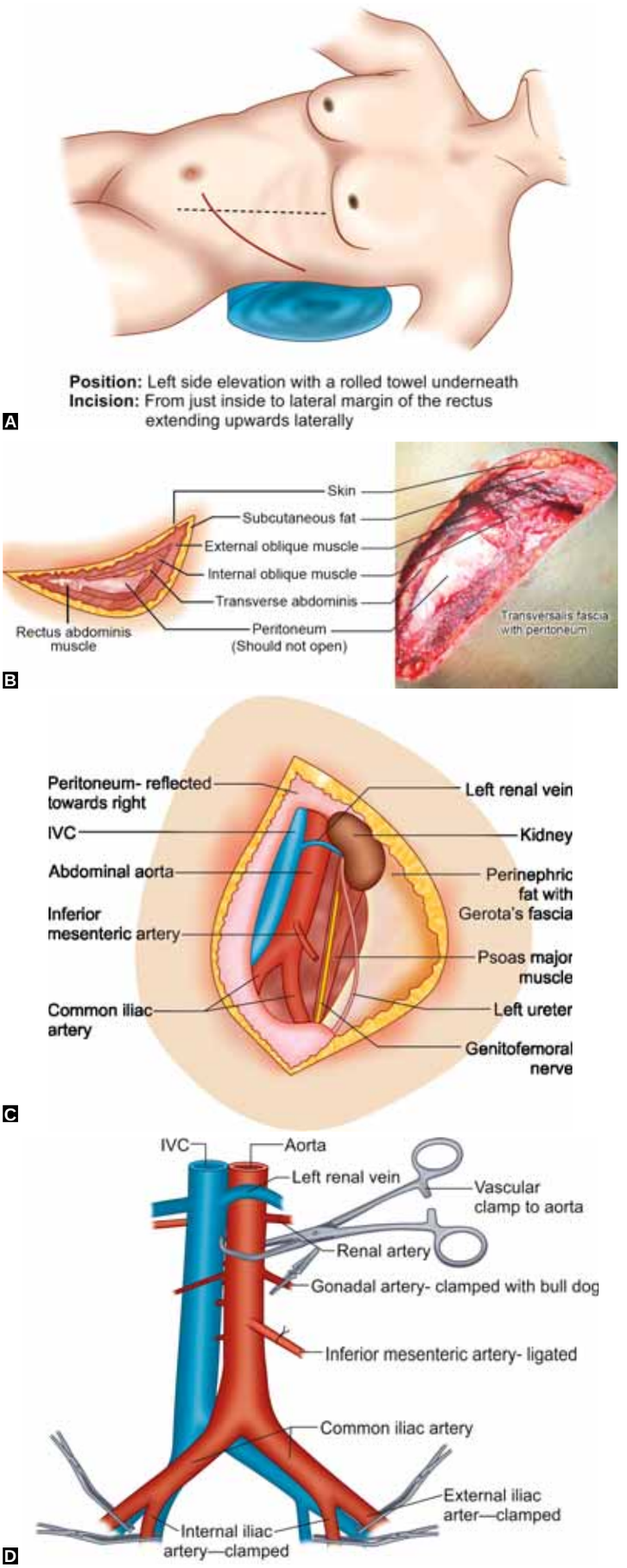
Anticoagulant effect is reversed using protamine sulfate.

Postoperative Care

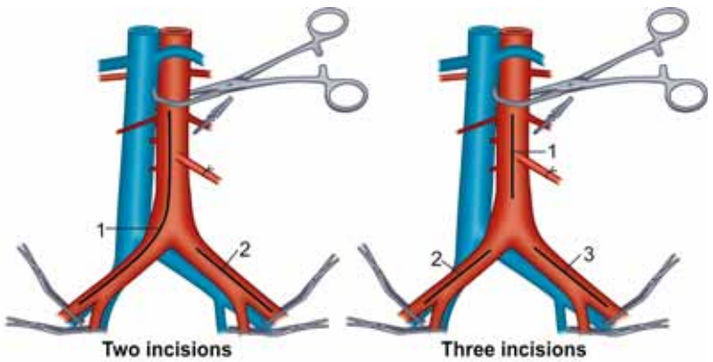
ICU monitoring for 2 days. CVP line, pulmonary artery catheter line, radial artery line, urinary catheter is a must.

Complications

- It is technically more demanding. It is done in only selected localised disease.
- Bleeding can occur which occasionally requires re-exploration. Hypovolemia is common.



Figs 11-20A to D



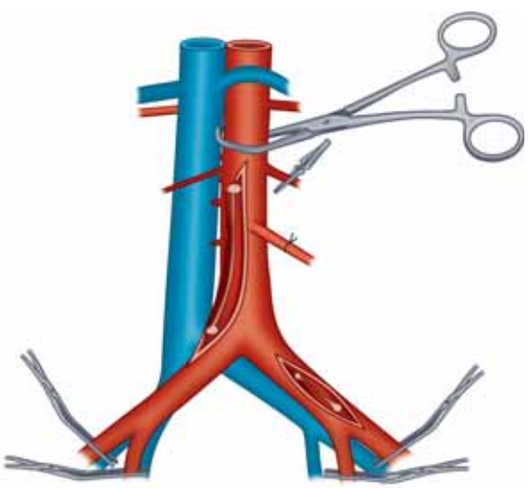
Two incisions

1. First incision is on the aorta along the right of origin of the inferior mesenteric artery extending along the right common iliac upto external iliac artery
2. Second arteriotomy incision along left common iliac artery

Three incisions

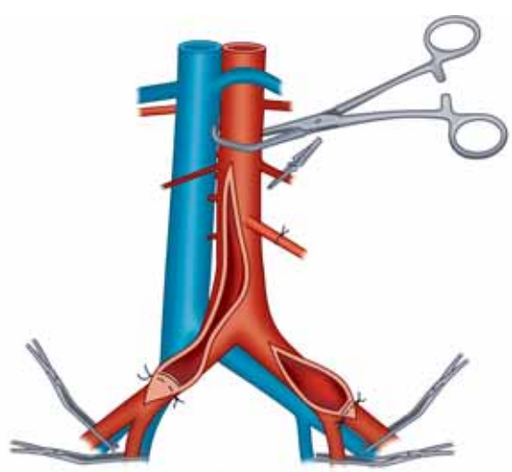
Here three separate incisions—one in the aorta and one each in common iliac arteries upto external iliac artery—1, 2 and 3

E



Intima with thrombus (endarterectomy) is separated from media throughout the length of the arteriotomy incisions both proximally and distally and cut across on both ends.

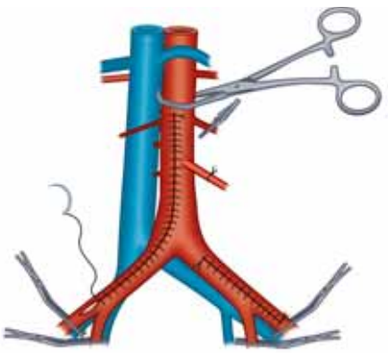
F



After extraction of endarterectomy specimen, mattress anchoring sutures at the distal end intima with knots outside—are placed to prevent intimal flap.

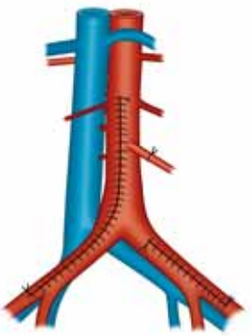
G

Figs 11-20E to G

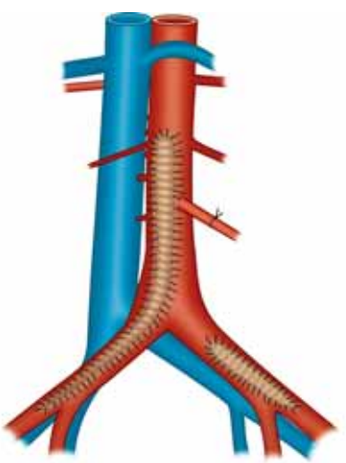


Closing the arteriotomy using continuous polypropylene 4 zero sutures.

H



Completed closure of arteriotomy with release of clamps.



When the lumen is narrow arteriotomy can be closed with PTFE/Dacron vascular graft patch to widen the lumen.

I

Figs 11-20H and I

Figs 11-20A to I: Technique of aortoiliac endarterectomy.

- Rethrombosis and failure is also a known complication.
- Distal ischaemia and gangrene can occur. Doppler study of limbs is done to assess the distal perfusion.
- Embolism due to atheroma dislodged when it occurs with intact pulse needs embolectomy.
- Injury to aortic nerve plexus may cause impotence but it is less common.
- Wound infection, haematoma and abscess formation are other complications. Progressive haematoma needs re-exploration.
- *Colonic ischaemia* mainly left sided (sigmoid) can occur. Only mucosal ischaemia is treated by nasogastric aspiration; deeper level ischaemia needs laparotomy and resection.

ARTERIAL SUBSTITUTES

Ideal arterial substitute is not yet developed. Ideal arterial substitute should be strong, durable for patient's life, biocompatible, non-thrombogenic, should have resistant for infection, easily available, should have a long-term patency rate and elastic property of normal artery.

Features of ideal graft	
Strong	Should be leakproof on restoration of blood flow
Durable for patient's life	Should not chemically or physically degenerate
Non-thrombogenic	Should not cause any abnormal reaction to surrounding tissues
Biocompatible	Should not occlude when flexed
Resistant to infection	Should not damage blood contents
Flexible	
Should maintain long-term patency	
Should have elastic property of normal artery	

Carrel and Guthrie first did venous autograft into arteries of dogs. They did extensive histological study of viable and non-viable grafts. Lexer in 1907 used saphenous vein for axillary artery repair. Murray started to use intraoperative heparin. Enaz Moniz and dos Santos originated technique of arteriography. Gross and his colleagues in 1948 started to use viable arterial allografts. Later it was found that as far as graft is considered tissue viability is not essential for success of graft take up.

Classification of Arterial Substitutes

1. Arterial allograft – Not used.
2. Arterial autograft – Internal mammary artery (common), internal iliac artery.
3. Arterial xenograft – Bovine carotid artery graft – not used.
4. Venous autograft – Long saphenous vein (common), small saphenous vein, basilic vein, cephalic vein.
5. Venous allograft – Umbilical vein graft.
6. Prosthetic grafts:
   a. Textile grafts -
      - Dacron graft – Knitted or woven or crimping or velour types.
      - Teflon graft – Knitted or woven or crimping or velour types.
   b. Non-textile semi-inert polymer graft -
      - ePTFE graft – Expanded polytetrafluoroethylene graft.

Arterial Allograft

As aorta contains more collagen and elastin long-term graft function is more than in femoral artery which contains more smooth muscle. Arterial allograft loose endothelium rapidly with formation of platelet fibrin coagulum. Over the years graft becomes less cellular with thinning of the wall. Late thrombosis, calcification, aneurysm formation and rupture can occur. Arterial allografts are not used now.

Arterial Autografts

Arterial autografts has the *advantages of* intact blood supply, resistance for infection, maintenance of flexibility, absence of degeneration, growth potential when used in pediatric age group. Wylie in 1965 first used arterial autograft. There is very less incidence of intimal thromobsis in autograft. Small initial thrombus formed around suture line will get absorbed in 20 days.

Inner most 500 µ thickness of arterial wall gets its nutrition directly from luminal blood through diffusion. Thickness outer to this level gets its blood supply through vasa vasora, a complex system derived from arterial side branches. So in arterial autograft few side branches should be retained.

Arterial autografts are used in *coronary artery bypass*, renal artery bypass (in pediatric age group), in places where graft is needed in infected field.

Internal mammary artery is the commonest and *preferred autograft* used. Internal iliac artery can be used in pediatric age group and in adults if it is not atherosclerosed.

Internal mammary artery is commonly used for CABG (coronary artery bypass graft). It shows superior long-term patency (95%) and is very suitable in emergency situation. Both internal mammary arteries are used commonly. They are dissected from chest wall retaining wide pedicle. *Distal internal mammary artery anastomosis* is done as end-to-side into the coronary artery using 8 zero polypropylene interrupted sutures. *Sequential internal mammary artery grafting* is also done when more than two anastomoses are needed. Free internal mammary arterial graft also can be used wherein internal mammary artery is cut at its origin and is sutured to proximal part of the aorta if extra length is needed. A combination of bilateral internal mammary artery graft with sequential and free mammary graft is called as *complex mammary grafting.*

Internal mammary artery (internal intercostal) arises from inferior aspect of the first part of the subclavian artery 2 cm above the sternal end of clavicle. It runs downwards, forward and medially behind sternal end of clavicle, internal jugular vein, brachiocephalic vein, first costal cartilage and phrenic nerve. Below and behind the first costal cartilage artery runs vertically downwards upto 6th intercostal space. Here it is related in front to pectoralis major, upper six costal cartilages, external intercostal membrane, internal intercosatl muscles and upper six intercostal nerves. Behind it is related to endothoracic fascia and pleura upto 3rd costal cartilage; further it is separated from pleura by sternocostalis muscle. At 6th intercostal space it divides into two terminal branches as superior epigastric artery and musculophrenic artery. Below 3rd intercostal space artery is accompanied by two venae commitantes which join together to form internal mammary vein which runs on the medial side of the artery to join brachiocephalic vein. Internal mammary lymph nodes are located along the artery. Its branches are – pericardiophrenic artery, mediastinal arteries, and two anterior intercostal arteries (upper and lower) for each upper six spaces, perforating branches and terminal branches **(Figs 11-21 and 11-22)**.

Arterial Xenograft

Xenograft from other species causes immense immunologic reactions leading to graft rejection. A modified xenograft (*Rosenberg*) is derived from *bovine carotid artery* which is treated by proteolytic enzyme ficin. Ficin removes smooth muscle and elastic tissue retaining collagen tube which has got equal tensile strength and is nonantigenic. This collagen tube is tanned with dialdehyde starch. But this graft has got high rate of aneurysm formation (6%) and high infection rate (6%) and patency rate is 40% after 6 years. So this type is also inferior to autograft and synthetic grafts.

Venous Autograft

Saphenous vein autograft is commonly used autograft as arterial substitute successfully. Normal ***long saphenous vein*** in adult is 60 cm in length and thigh part is a single trunk. 8-12 valves of LSV is mainly located at below knee level. Its average diameter is 5.5 mm after gentle distension in thigh. Minimum diameter required for grafting is 4 mm. In 10% of individuals LSV is too small for grafting; in another 20% patients it cannot be used due to phlebitis, varicosity, and prior surgery. So only in 70% of people it is available for grafting. In 30%

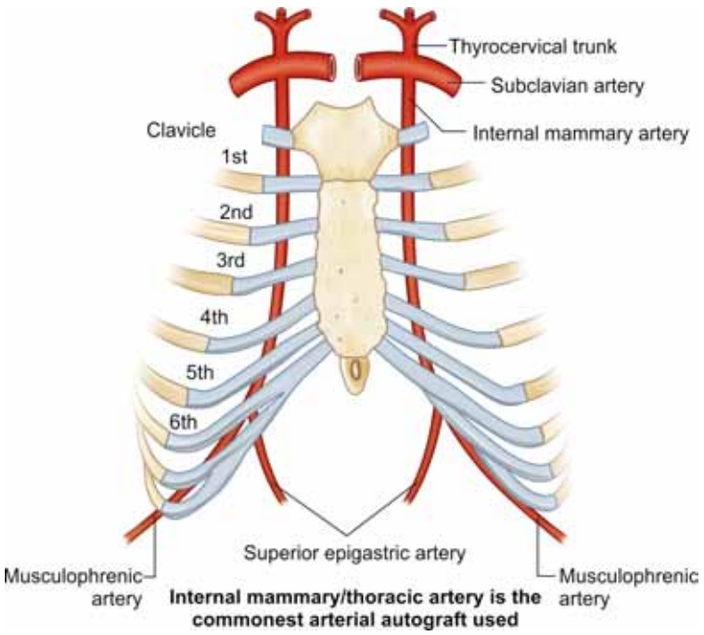


Fig. 11-21: Arterial autograft. Internal mammary artery is commonly used.

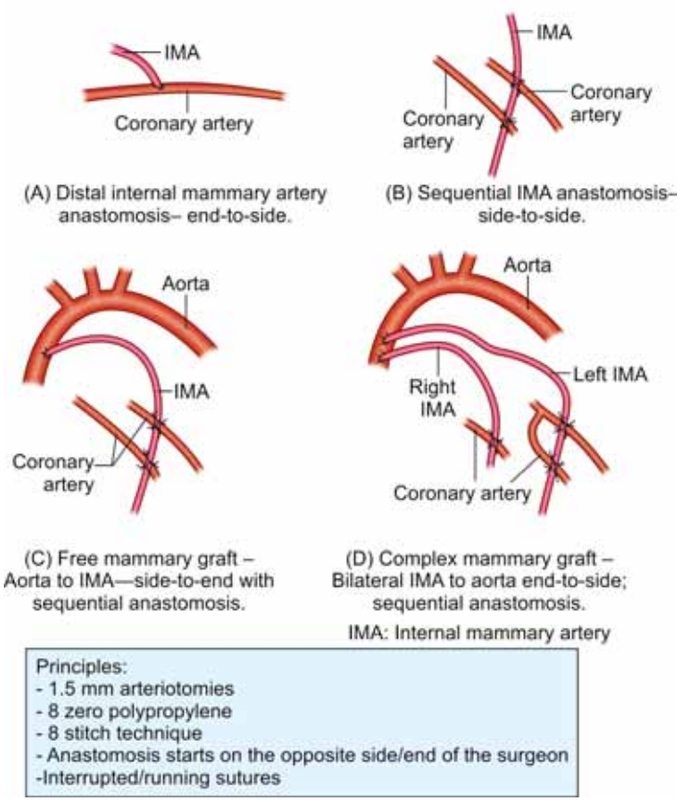


Fig. 11-22: Technique of internal mammary artery graft to coronary artery.

of non-available LSV category, small saphenous vein, basilic vein or cephalic vein can be used as a graft. But these alternate veins are not as good as LSV. Saphenous vein graft is used for small and medium sized arterial replacement – mainly in coronary artery bypass and lower limb bypass surgeries (superficial femoral and popliteal). *Standard reversed saphenous vein graft or modified in situ saphenous* vein grafts may be used. It is excellent for coronary and femoropopliteal artery bypass.

Carrel observed that after vein graft there will be marked subintimal and medial hyperplasia of the venous graft called as 'arterialisation' of vein graft.

Venous Allograft

Saphenous vein allograft was not successful. ***Umbilical vein allograft*** is successful after glutaraldehyde tanning of the graft which increased collagen wall strength and also made graft nonantigenic. Complications are aneurysm formation, separation and infolding of inner lining causing luminal narrowing. Its only advantage over prosthetic graft is availability and cost.

Prosthetic Grafts

Voorhees in 1952 developed nylon related porous textile graft Vinyon N and used as arterial replacement in animals.

Later Dacron and Teflon synthetic grafts were evoluted. Dacron looses up to 10% of its tensile strength. Teflon does not lose its tensile strength **(Figs 11-23 and 11-24A and B)**.

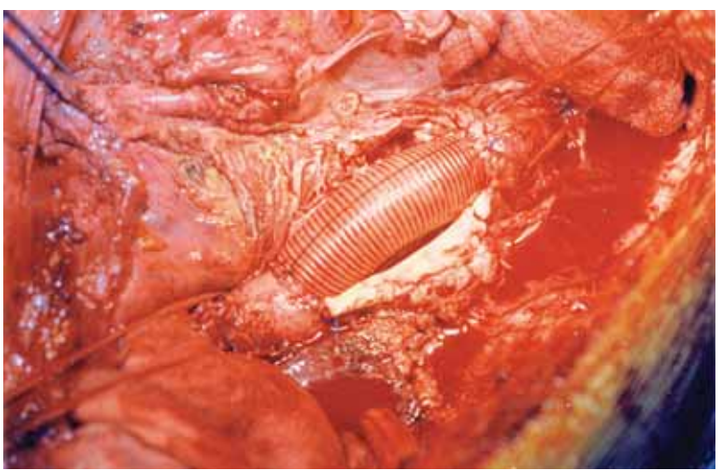


Fig. 11-23: Arterial prosthetic Dacron graft placed to aorta.

Prosthetic grafts are manufactured by weaving or knitting multifilament yarns of Dacron or Teflon.

Woven type is compact one with small interstices and low porosity. Woven graft has difficult in handling **(Fig. 11-25)**.

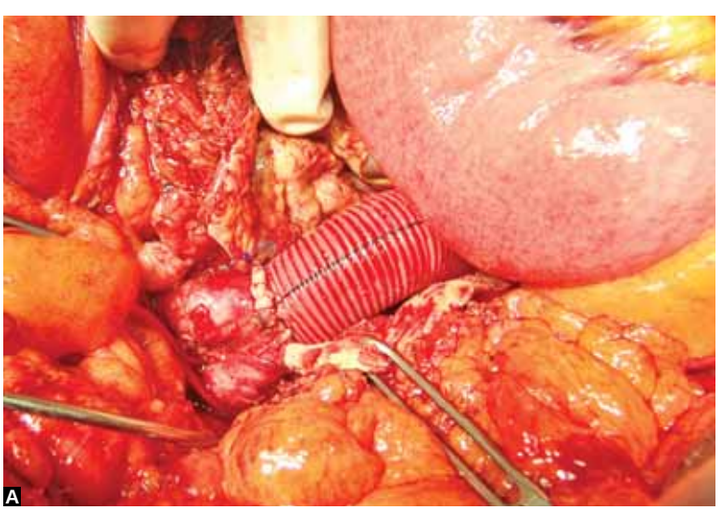


Fig. 11-24A

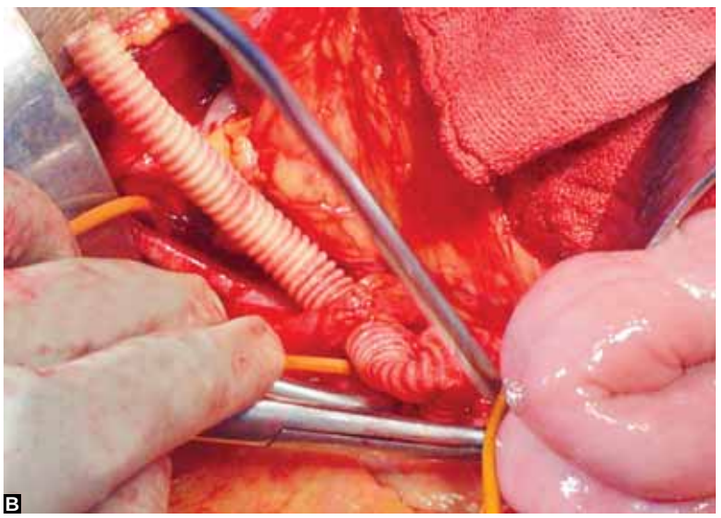


Fig. 11-24B

Figs 11-24A and B: Dacron arterial graft placement.

Fig. 11-25: Woven Dacron graft.

Fig. 11-26: Knitted Dacron graft.

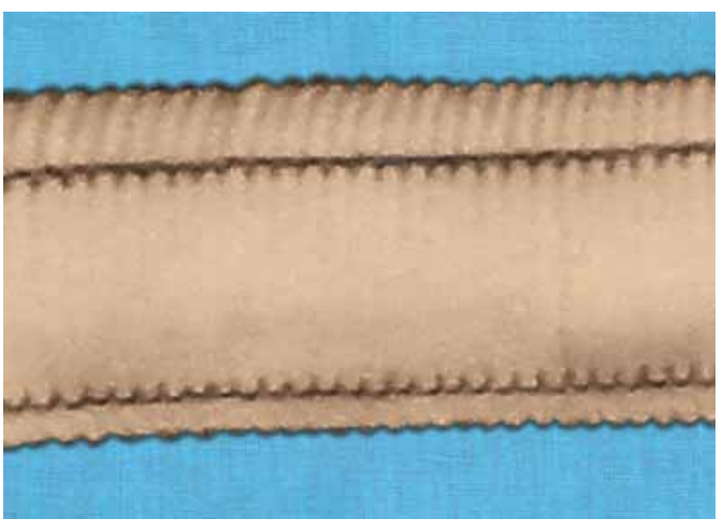


Fig. 11-27: Dacron crimping graft.

Fig. 11-28: Velour graft.

Knitted graft is more porous and needs preclotting prior to use. It *should not be used* in patients with platelet and coagulation defects, hepatic disease, and ruptured aortic aneurysm. Knitted graft has got better handling ability due to its softness and it does not fray while cutting **(Fig. 11-26)**.

Crimping textile grafts (1955) are available now which shows greater flexibility without kinking. But it may reduce the graft diameter and may be thrombogenic **(Fig. 11-27)**.

Velour surface graft (1960) was evoluted later with loops of yarn extending perpendicular to graft surface. It provides a better preclotting and gives scaffold for fibroblast proliferation and so makes graft firmly adherent to surrounding tissues **(Fig. 11-28)**.

Both knitted and woven grafts are commonly used. Surgeons prefer to preclot both grafts.

Preclotting the ***non-coated knitted*** or woven Dacron graft is done to seal the graft and to prevent leak and to create a smooth lining at graft - blood interface. This step is not necessary for PTFE or newer grafts. Preclotting is done by collecting 100 ml of patients' blood prior

to heparinisation from aorta or IVC using a syringe which is collected in a bowl. Selected graft is clamped at one end; from other end fresh blood collected in the bowl is forced into the graft using a fine catheter or syringe until leakage from the pores stops. Later graft is flushed using heparinised saline. Deposited platelet fibrin layer in the interstices on inner part of the graft after implantation is slowly replaced by fibrous in growth. Cooley described a *modified version of pre-clotting of* the prosthetic graft. Knitted Dacron graft is soaked with patient's own platelet rich plasma and which is steam autoclaved for 5 minutes to produce a blood impervious graft in which denatured protein is slowly resorbed.

Expanded Polytetrafluoroethylene Graft (ePTFE)

Soyer (1972) first used ePTFE as arterial graft. PTFE is a fluorocarbon polymer manufactured by paste extrusion method containing solid nodules with interconnecting small fibrils. Standard pore size presently in use is 17 μ. Fluorine gives high electronegative surface charge to the polymer to prevent thrombosis. It is mainly used in lower limb arterial disease **(Fig. 11-29)**.

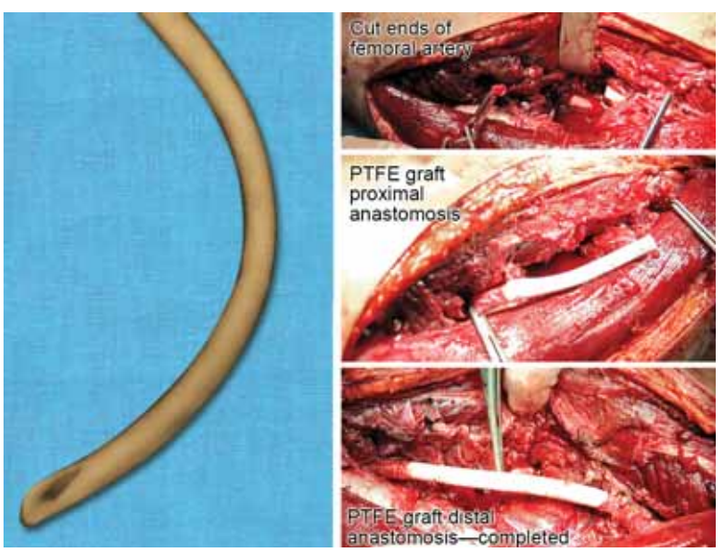


Fig. 11-29: PTFE graft. PTFE graft used in the lower limb in a patient.

Complications of Graft

Neointimal fibrous hyperplasia at suture lines of the graft is due to surgical trauma, PDFG, arterial smooth muscle proliferation.

Graft infection incidence is 2%. It is more in lower limb graft than abdominal graft. Peroperative cephalosporin administration reduces the rate of graft infection. If infection occurs graft should be removed and revascularisation is achieved using a saphenous vein graft.

Graft failure is rare but can occur. It is due to fibre degeneration, manufacturing defect, diffuse dilatation of graft (is due to expansion of the knit in knitted Dacron).

Anastomotic false aneurysm (3%) occurs just adjacent to suture line towards host artery. It is tearing of the artery adjacent to suture line due to mismatched graft artery compliance, improper suture placement, and arterial degeneration. There will be partial or total separation of the graft from the host with blood collection in a covering of the fibrous capsule. It eventually will rupture/may cause thrombosis and embolism. Treatment is graft–artery re-anastomosis with insertion of additional piece of graft **(Fig. 11-30)**.

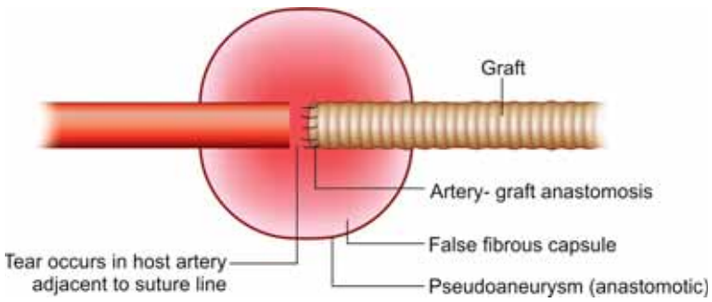


Fig. 11-30: Anastomotic pseudoaneurysm can occur at disrupted suture line.

Basic Principles in Arterial Graft Surgery

Type of surgery should be selected properly based on site, extent and severity of block.

Site for inflow anastomosis should be having adequate inflow of blood. Site of outflow anastomosis is also important to accommodate the graft blood flow. If it is too diseased graft failure can occur.

Type of graft selected is also important. Size, quality, length, preclotting should be proper.

Adequate imaging in the form of Duplex scan, angiogram, CT angiogram and MR angiogram (contrast or non-contrast) are needed. In critical limb with extensive arterial involvement contrast may precipitate total block and gangrene and in such situation non-contrast MR angiogram is ideal to delineate the site. However, much hope cannot be given to the patient as far as limb salvage is considered.

AORTOFEMORAL BYPASS GRAFT

It is commonly used technique at present. Aortofemoral bypass is preferred as often block extends to distal iliac arteries. Dacron or PTFE is commonly used. Knitted/woven Dacron when used needs preclotting before use. Collagen impregnated Dacron/PTFE does not require preclotting.

Transperitoneal approach: Transabdominal/transperitoneal approach is ideal for graft placement. Lengthy midline incision from xiphisternum to pubic symphysis is needed. Femoral arteries are exposed from above the level of the inguinal ligament down, below and beyond the level of the common femoral bifurcation. When there is a need to expose the external iliac artery additionally, it is achieved by extending the femoral incision above, laterally curving parallel to inguinal ligament with or without cutting the inguinal ligament.

↓

Omentum and transverse colon are pushed upwards; small intestine is shifted towards right; duodenojejunal junction is exposed properly. Retroperitoneum is incised adjacent to duodenum lateral to fourth part of the duodenum. Duodenum is mobilised to expose the aorta. Lymphatic vessels are ligated. Proximal aortic clamp is placed here *from left side* after heparinisation and after clamping distally at femoral vessels.

↓

Proximal dissection is done up to the level of renal vein. It is identified by left renal vein crossing the aorta *in front* to reach IVC. Occasionally as a variation left renal vein may be retroaortic. Left renal vein should be mobilised adequately without division by ligating left gonadal and

left adrenal veins. Rarely in high lesions left renal vein may need to be divided at its entry into the IVC. In such occasion ligation of left gonadal and left adrenal veins should be avoided as these two veins are essential to drain left kidney.

↓

Inferior mesenteric vein is mobilised and retraced away from the field.

↓

Infrarenal aortic dissection is done up to 3 cm beyond the block or level of graft anastomosis. During dissection care should be taken not to injure IVC and lumbar veins. Lumbar arteries can be ligated if needed.

↓

Preclotting the noncoated knitted or woven Dacron graft is done to seal the graft and to prevent leak and to create a smooth lining at graft - blood interface. This step is not necessary for PTFE or newer grafts. Preclotting is done by collecting 100 ml of patient's blood prior to heparinisation from aorta or IVC using a syringe which is collected in a bowl. Selected graft is clamped at one end; from other end fresh blood collected in the bowl is forced into the graft using a fine catheter or syringe until leakage from the pores stops. Later graft is flushed using heparinised saline.

↓

Retroperitoneal *tunnel* is made by blunt finger dissection extending down into the femoral incision. This tunneling should pass *behind ureter* and *in front* of iliac artery. Umbilical tape on each side is placed along the length of the tunnel.

↓

Intravenous heparin is injected 150 units/kg body weight to anticoagulate the patient. First distal part of the artery is clamped to prevent embolism; then proximal part.

↓

Proximal anastomosis: End-to-end or end-to-side anastomosis can be done. *End to end is preferred* as it causes uniform blood flow with less turbulence and stable accurate suturing is possible. It also allows proper inspection of the proximal part with limited endarterectomy at proximal site which gives more stable suture line. Aorta is transected between two vascular clamps at the site of anastomosis; distal cut end of the aorta is sutured with double layer 4 zero polypropylene continuous sutures – first like a sewing machine method; second as a oversewing/over and over sutures at cut edge (like closure of duodenal stump in gastrectomy).

↓

Graft should be of *same size or smaller than the size* of the aorta. Ideally it should not be larger. 4 zero polypropylene continuous sutures are placed posteriorly and anteriorly. Needle bites should be smooth, single stroke, precise with needle piercing the aorta *from intimal side towards adventitia*; in the graft *from outside towards inside.* Interrupted mattress sutures are often used but it is not popular.

↓

Once proximal anastomosis is completed, graft is filled with blood by releasing the proximal clamp and later clamp is reapplied to the aorta proximal to suture line. Another vascular clamp is applied on the graft distal to suture line and proximal clamp over aorta is again released for short period to check the bleeding at the site suture line. Small bleeders can be controlled by pressure; persistent or large leaks are controlled by additional interrupted sutures. Proximal aortic clamp is reapplied and clamp over the graft just distal to proximal suture line is also released. Repeated clamping of the graft is not advisable. Often a cuff of graft additionally placed over the graft to prevent aortoenteric fistula as complication.

↓

Distal anastomosis: It is done over *common femoral artery commonly*; near the origin of the deep femoral artery to improve the long-term patency rate. Allowing an area of flexion along the length of the graft at groin is small but less significant drawback. (In aortoiliac graft such flexion problem is not present).

↓

Tunneling is completed by passing long vascular clamp from thigh wound below towards abdominal wound above. It is done on both sides. An index finger is passed gently in front of common femoral artery; gentle finger dissection upwards is done to create a tunnel. Deep circumflex iliac vein runs over external iliac artery which should be taken care of as injury to it can cause torrential bleeding. Tunnel usually of two fingerbreadth size is created deep to inguinal ligament. Peritoneum is pushed upwards from upper wound; ureter is also pushed aside. A long Robert clamp is passed from thigh wound across groin to abdominal wound. Often umbilical tape is kept in place on the tunnel till graft is passed down.

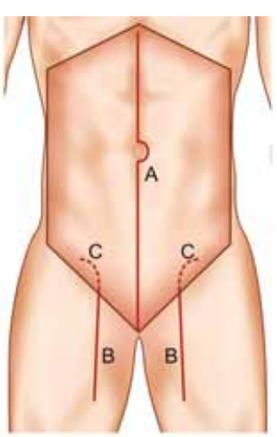
↓

Through the vascular clamp each side limb of the aortofemoral graft is pulled gently downwards towards thigh (femoral) wound on respective sides avoiding any twist or undue pull **(Figs 11-31A to L)**.

↓

Distal anastomosis is *end-to-side* one. Distal end of the graft is bevelled like 'S' using heavy scissor and sutured to the arteriotomy made at the junction of common femoral artery. Both superficial and deep femoral arteries should be dissected adequately. Vascular clamps are placed on the two branches distally. Arteriotomy done at the junction can be extended towards deep femoral artery, if needed. Orifices of branches should be exposed and any block at the orifices can be cleared. Continuous 6 zero polypropylene sutures are placed either tied running or as parachute technique. Suturing should be done from inside out at arterial side and from out to inside at graft side. Usually four corner sutures are placed; two in middle and two at angles. Then running sutures are proceeded towards angle posteriorly then towards anteriorly. Initial mattress suture may be placed at the heel of the graft for proper alignment of the graft over the artery.

↓



Incision:
(A) Lengthy midline incision from xiphisternum to pubic symphysis.
(B) Femoral exposure is vertical incisions on both sides from inguinal ligament along mid-inguinal point in on thigh.
(C) If external iliac artery need to be exposed then lateral upward extension is needed.

Fig. 11-31A

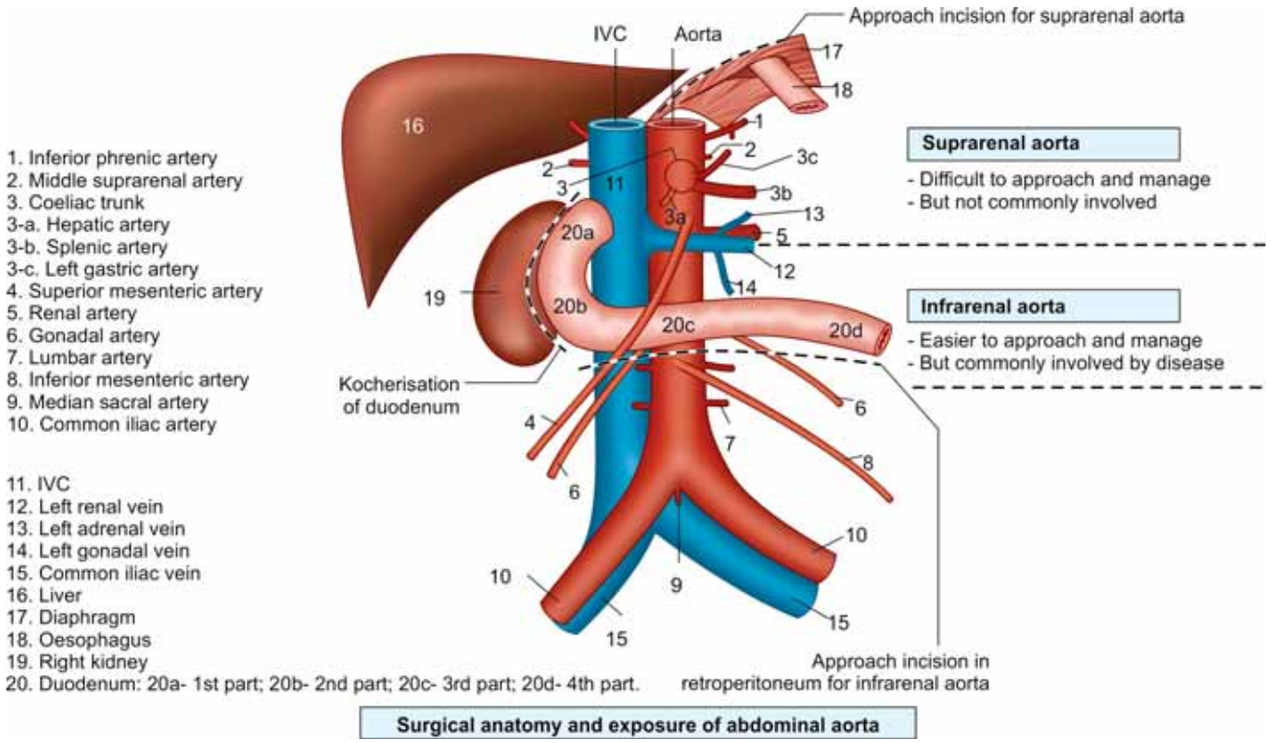


Fig. 11-31B

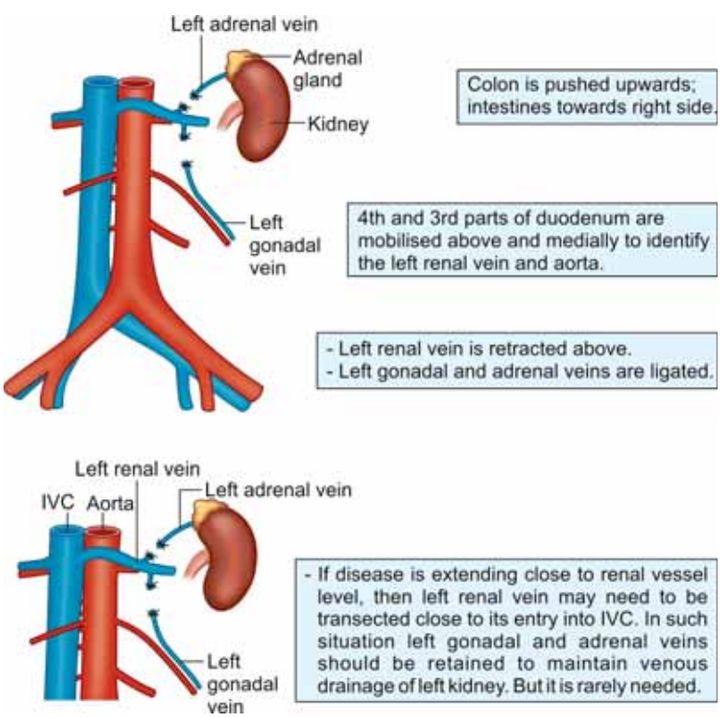

Left adrenal vein
Adrenal gland
Kidney
Left gonadal vein
Colon is pushed upwards; intestines towards right side.
4th and 3rd parts of duodenum are mobilised above and medially to identify the left renal vein and aorta.
- Left renal vein is retracted above.
- Left gonadal and adrenal veins are ligated.
Left renal vein
IVC
Aorta
Left adrenal vein
Left gonadal vein
- If disease is extending close to renal vessel level, then left renal vein may need to be transected close to its entry into IVC. In such situation left gonadal and adrenal veins should be retained to maintain venous drainage of left kidney. But it is rarely needed.

Fig. 11-31C

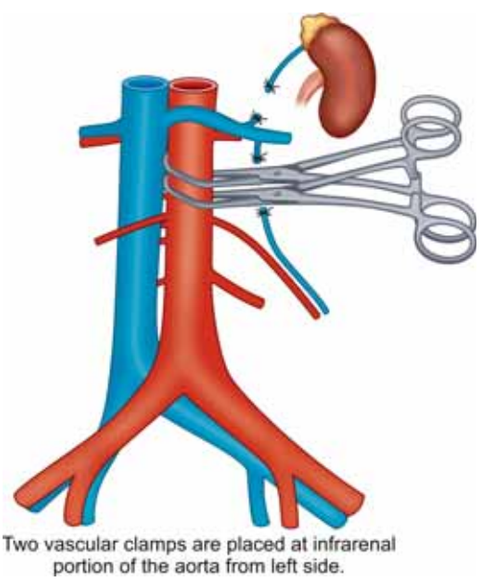
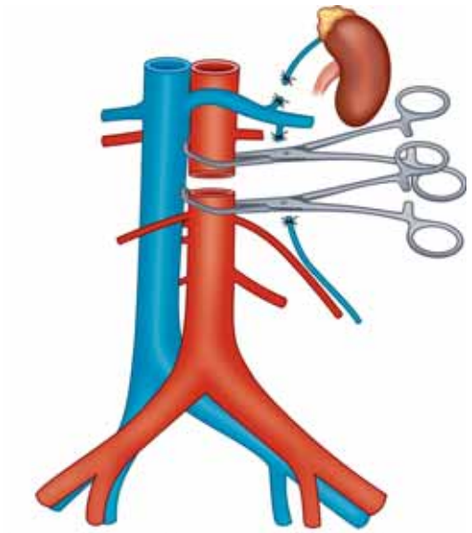


Fig. 11-31D



Aorta is transected between two vascular clamps.

Fig. 11-31E

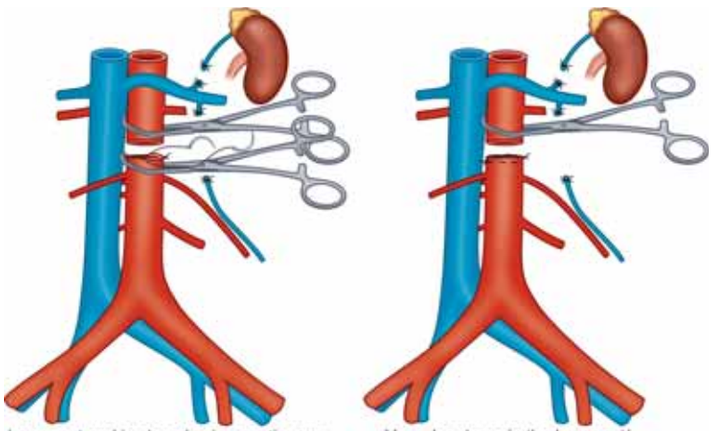

Lower cut end is closed using continuous polypropylene 4 zero sutures—initially sewing machine method then over and over sutures are placed.
Vascular clamp in the lower cut/ sutured part is released.

Fig. 11-31F

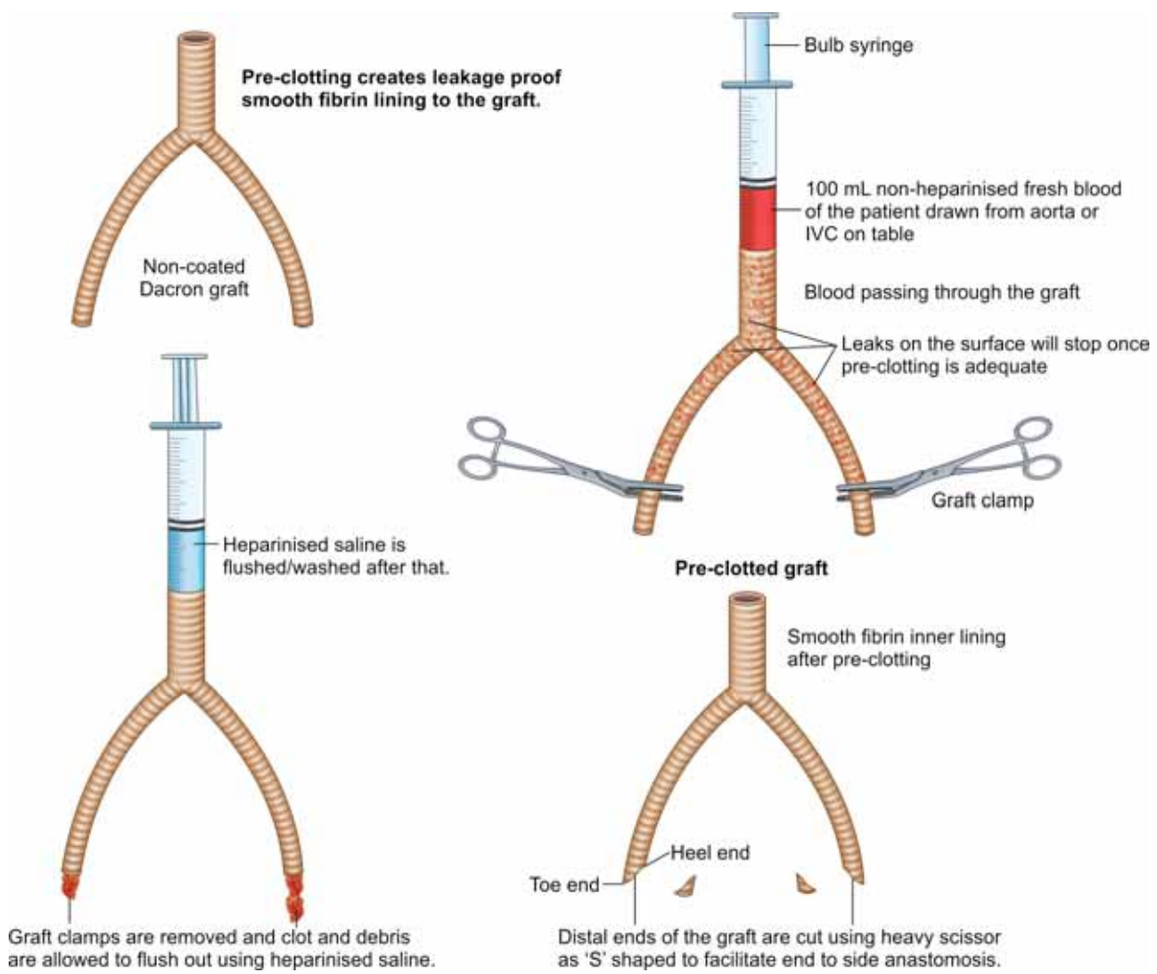
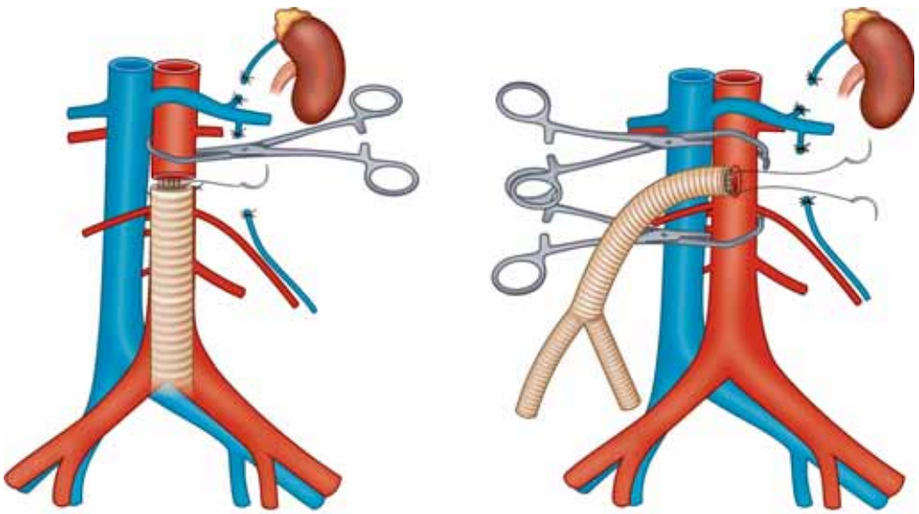

Pre-clotting creates leakage proof smooth fibrin lining to the graft.
Non-coated Dacron graft
Heparinised saline is flushed/washed after that.
Graft clamps are removed and clot and debris are allowed to flush out using heparinised saline.
Bulb syringe
100 mL non-heparinised fresh blood of the patient drawn from aorta or IVC on table
Blood passing through the graft
Leaks on the surface will stop once pre-clotting is adequate
Graft clamp
Pre-clotted graft
Smooth fibrin inner lining after pre-clotting
Heel end
Toe end
Distal ends of the graft are cut using heavy scissor as 'S' shaped to facilitate end to side anastomosis.

Fig. 11-31G



End-to-end anastomosis using 4 zero polypropylene sutures.

End to side anastomosis (End of graft to side of aorta).

Fig. 11-31H

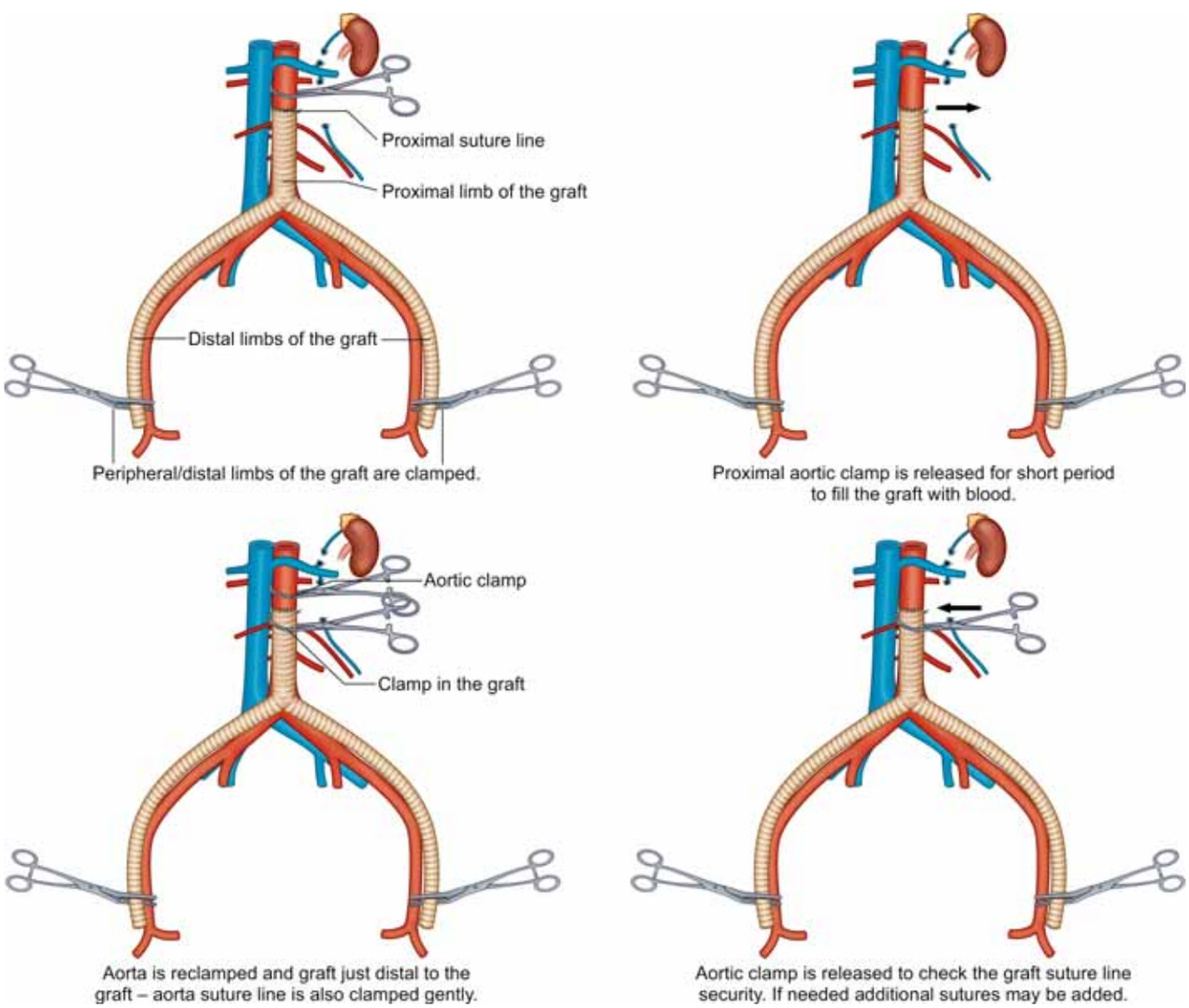
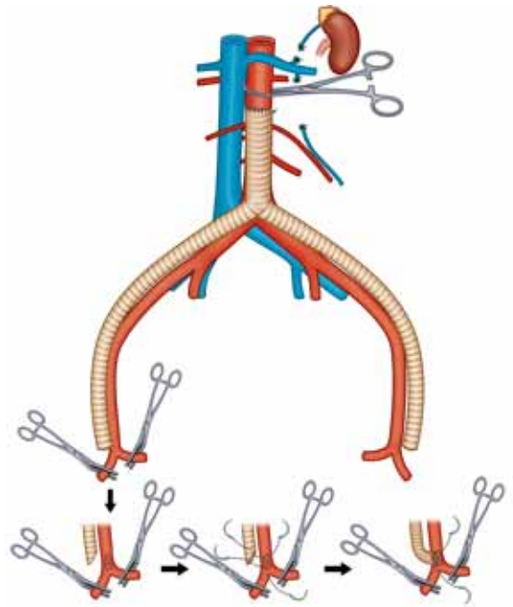
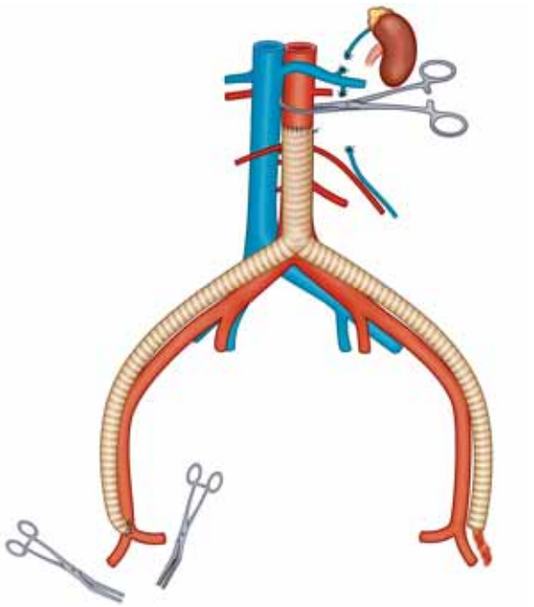

Proximal suture line
Proximal limb of the graft
Distal limbs of the graft
Peripheral/distal limbs of the graft are clamped.
Proximal aortic clamp is released for short period to fill the graft with blood.
Aortic clamp
Clamp in the graft
Aorta is reclamped and graft just distal to the graft – aorta suture line is also clamped gently.
Aortic clamp is released to check the graft suture line security. If needed additional sutures may be added.

Fig. 11-31I

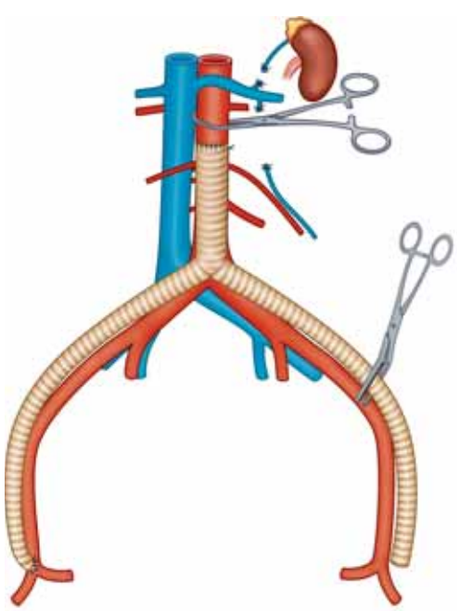


Vascular clamps are applied to both branches of femoral artery of one side. Aortic clamp is kept in place. End to side anastomosis is done.

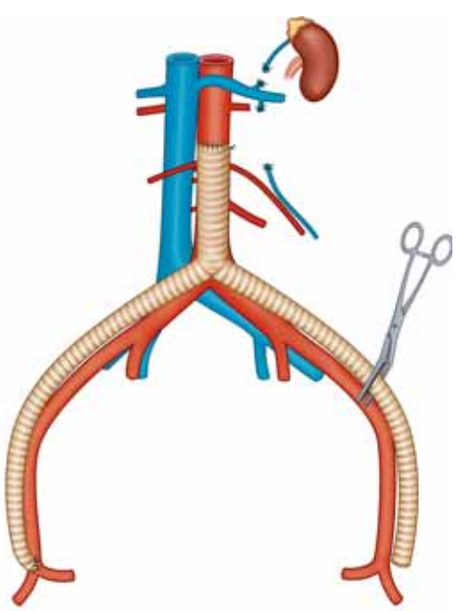


Clamps over the femoral branches are released to allow retrograde flow of blood to opposite limb of the graft to remove clots and debris. Aortic clamp should be in situ.

Fig. 11-31J



Clamp applied over to the opposite limb of the graft.



Aortic clamp is released to allow blood flow to sutured limb.

Fig. 11-31K

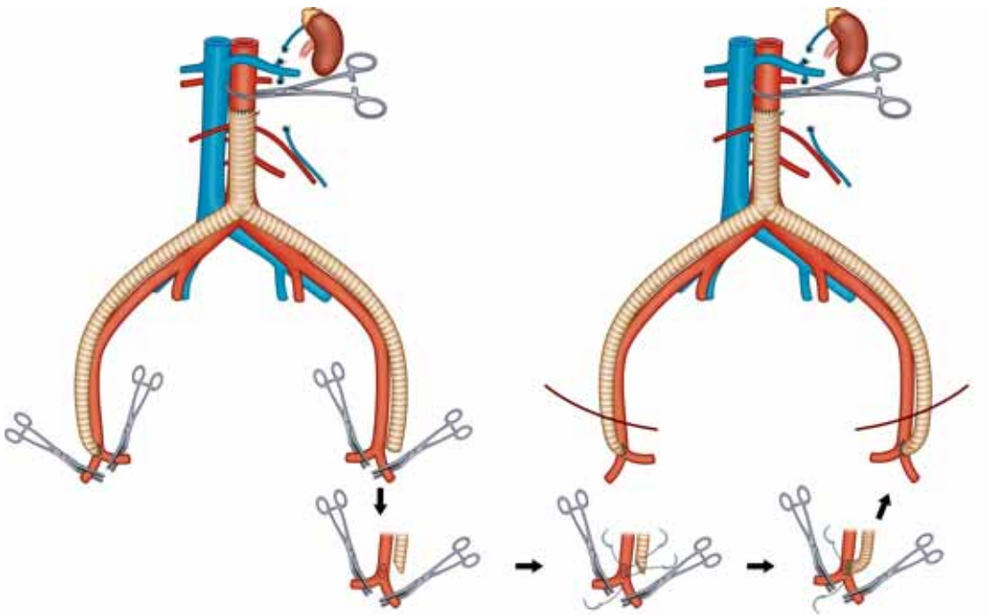

With aortic clamp in place, clamps are applied on superficial and deep femorals on both sides. Arteriotomy is done on left side femoral near origin of deep femoral. End to side anastomosis is done using 5 zero or 6 zero polpropylene.
Distal clamps on the side (left) is released. then proximal aortic clamp and later opposite (right) side femoral clamps are removed. Any bleeding points are tackled by further few sutures.

Fig. 11-31L

Figs 11-31A to L: Aortofemoral bypass graft.

Distal clamps of the superficial and deep femoral arteries are released to allow retrograde flow of blood along the limb of the same side of the graft; towards the limb on the opposite side of the graft to clear clots and debris.

↓

Now opposite limb of the graft is clamped near its bifurcation/origin of the branching. Proximal aortic clamp is slowly released so as to avoid sudden fall in blood pressure beyond 20 mm Hg.

↓

Opposite side superficial and deep femorals are clamped; arteriotomy is done near its origin; opposite graft limb is trimmed as 'S.' Anastomosis is done similarly. Femoral clamps are released just before last sutures. Proximal clamp at the graft limb is slowly released to perfuse across the graft. Any leak is dealt with similarly.

↓

Inferior mesenteric artery, if needed, should be reimplanted into the proximal limb of the graft. Large artery, artery with less back bleeding after transection, and when there are poor collaterals need reimplantation of inferior mesenteric artery. Colour of the bowel wall and Doppler study by placing the probe on the antimesenteric part of the bowel after clamping the artery will decide the need for reimplantation.

↓

Retroperitoneum is *closed over the graft*. It prevents the contact of the graft into intestines or duodenum to prevent aortoduodenal or aorto-intestinal fistula. Omental pedicle may be placed between aorta and intestines. Meticulous haemostasis in all layers is important **(Fig. 11-32)**.

Complications

Bleeding can occur which occasionally requires re-exploration. Hypovolaemia is common.

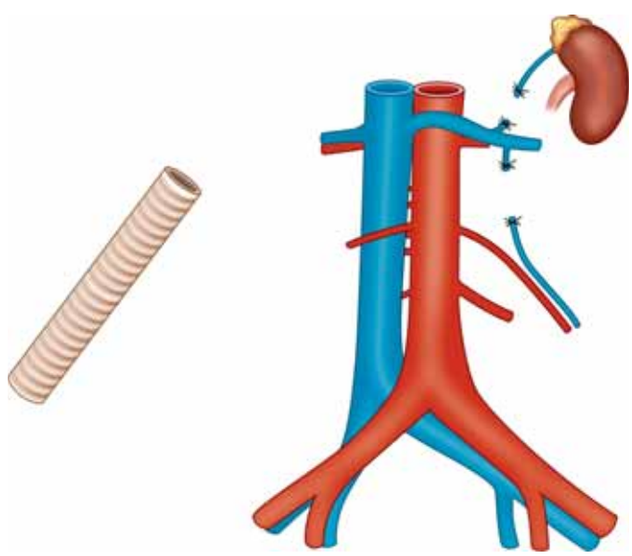


Fig. 11-32: End-to-side aortic graft. It is not commonly used; but it maintains the spinal cord blood supply to reduce the chance of spinal cord ischaemia.

Re-thrombosis and graft failure are also known complications.

Distal ischaemia and gangrene can occur. Doppler study of limbs is done to assess the distal perfusion.

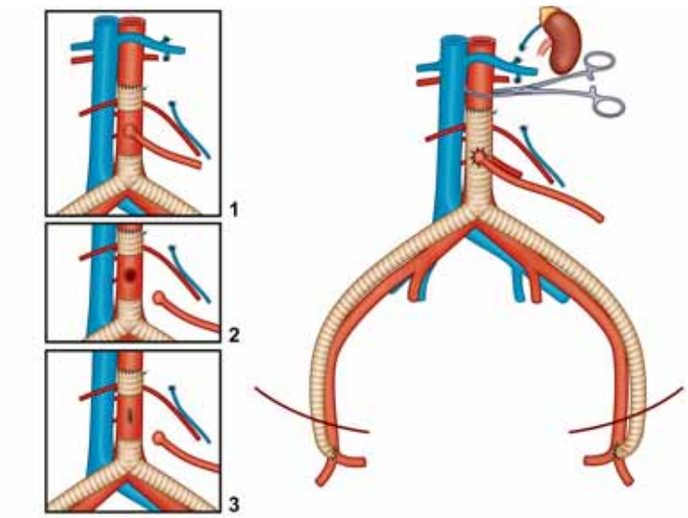
Embolism due to dislodged atheroma when occurs, with intact pulse needs embolectomy.

Injury to aortic nerve plexus may cause impotence but it is less common.

Wound infection, haematoma and abscess formation are other complications. Progressive haematoma needs re-exploration.

Colonic ischaemia mainly left sided (sigmoid) can occur. Only mucosal ischaemia is treated by nasogastric aspiration; deeper

level ischaemia needs laparotomy and resection. If preoperatively suspected by wider diameter of inferior mesenteric artery or artery with poor back bleeding then *reimplantation of inferior mesenteric artery is done.* Inferior mesenteric artery at its origin is cut with cuff/button of adjacent aorta. Corresponding graft at the site is opened like a buttonhole to which inferior mesenteric artery origin cuff is sutured using polypropylene to achieve reimplantation **(Fig. 11-33)**.

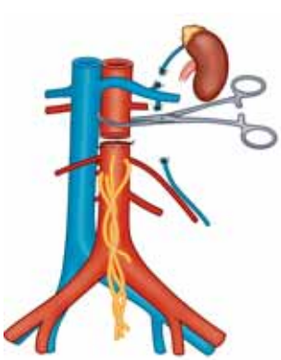


Inset showing distal cut end of the aorta deeper to sutured graft with origin of inferior mesenteric artery. This origin with a cuff of the aortic wall is excised and aortic wall is sutured. This excised cuff is sutured into the similar button created in the front of the sutured graft. Confirmation of perfusion is done using Doppler study on the left side colon.

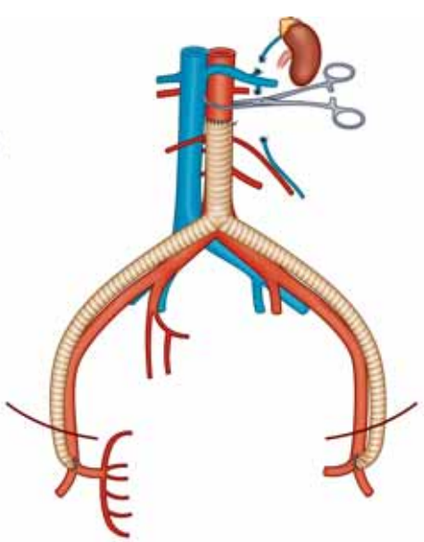
Fig. 11-33: Inferior mesenteric artery origin can be reimplanted into the aortic graft in case if colonic ischaemia possibility suspected.

Graft failure and leak when occurs, needs re-exploration and regrafting. Sepsis is the major cause for graft failure.

Disruption of the parasympathetic nerves near aortic bifurcation leads into impotence or retrograde ejaculation. Care is taken during the dissection around bifurcation so as not to injure the nerve plexus **(Fig. 11-34)**.



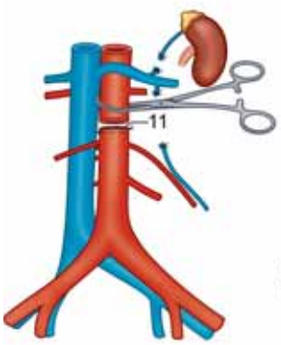
Parasympathetic nerves around aortic bifurcation.



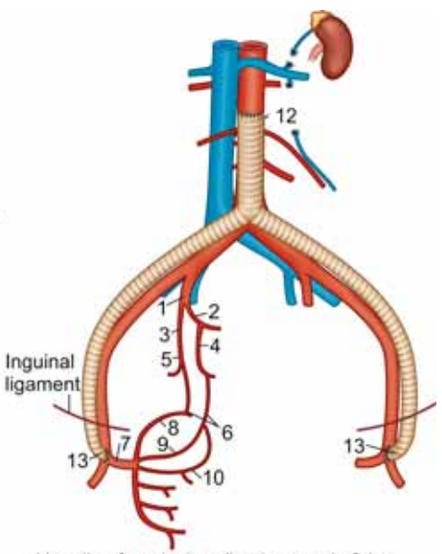
Disruption of this parasympathetic nerve around aortic bifurcation can cause impotence.

Fig. 11-34: Impotence can occur after aortofemoral grafting due to parasympathetic disruption.

Spinal cord ischaemia can occur due to severe arterial insufficiency. It leads into paraplegia. It is more common in end-to-end anastomosis of the proximal part of the graft into aorta. In *proximal end-to-end anastomosis,* distal to distal cut end of the aorta gets its perfusion through retrograde blood flow along hypogastric arteries. But in severe bilateral iliac disease, such retrograde perfusion is not adequate as it leads to poor perfusion of the lower spinal arteries causing spinal cord ischaemia. It can be identified prior to surgery by preoperative angiogram; if detected it is better to add on revascularisation procedure of the hypogastric artery. In *end-to-side proximal graft – aorta anastomosis* incidence of spinal cord ischaemia is less **(Fig. 11-35)**.



End-to-end anastomosis more commonly causes spinal cord ischaemia than end to side anastomosis.



Usually after closing distal cut end of the aorta perfusion is maintained through cruciate anastomosis between branches of internal iliac artery and deep femoral artery.

1. Internal iliac artery (Hypogastric).
2. Posterior division of IIA.
3. Anterior division of IIA.
4. Superior gluteal artery.
5. Inferior gluteal artery.
6. Anastomotic branches.
7. Deep femoral artery (profunda femoris).
8. Medial circumflex iliac artery.
9. Lateral circumflex iliac artery.
10. First perforating branch.
11. Closed end/distal aorta.
12. Graft-proximal suture line.
13. Graft distal suture line.

Fig. 11-35: Diagrammatic representation of collaterals and possibility of developing spinal cord ischaemia.

Aortoduodenal/aortointestinal/aortovenacaval fistula can occur which is often life threatening. It is treated by immediate surgery, redoing of graft, resection, etc., but it is technically demanding with high mortality.

OTHER GRAFT PROCEDURES

Other grafts in the lower limb/aortoiliac femoral segments can be done using same principles. Bypass grafts are classified as anatomical bypass graft and extra-anatomical bypass graft.

Anatomical bypass graft is the one which is along the normal course of the artery. Examples are aortobifemoral, aortoiliac, ileofemoral, femoropopliteal grafts.

Extra-anatomical bypass graft is the one which traverses through different than normal arterial pathways. Examples are cross over femoral graft, axillofemoral bypass graft.

Duplex ultrasound scanning, segmental limb pressures and segmental limb plethysmography are needed investigations to assess

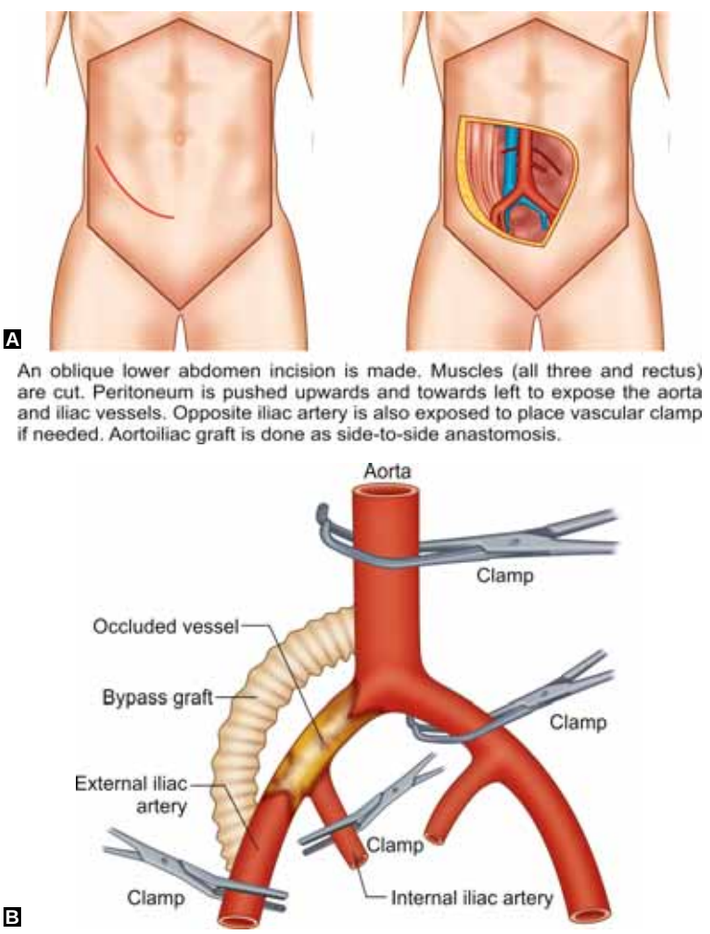
accurate physiological status of the vessel. Cardiac assessment is essential in all these patients.

Prophylactic antibiotics are started 24 hours prior to surgery; entire abdomen both lower limbs and chest below nipples should be prepared.

AORTOILIAC BYPASS GRAFT

Aortoiliac bypass graft can be done if there is unilateral common iliac artery block. Often unilateral aortofemoral graft is preferred although graft has to pass across groin crease.

Aorta and iliac artery is exposed *through retroperitoneal* (occasionally transperitoneal) approach using oblique groin muscle cutting incision (peritoneum is not opened, instead is pushed above towards left). Lower end of aorta with bifurcation and common, external and internal iliac arteries on that side are exposed and dissected. Vascular clamps are applied over aorta above the level of aortic anastomosis, on to opposite common iliac artery to prevent retrograde flow, and distal part of the external iliac artery distal to the line of anastomosis **(Figs 11-36A and B)**.


A
An oblique lower abdomen incision is made. Muscles (all three and rectus) are cut. Peritoneum is pushed upwards and towards left to expose the aorta and iliac vessels. Opposite iliac artery is also exposed to place vascular clamp if needed. Aortoiliac graft is done as side-to-side anastomosis.
Aorta
Clamp
Occluded vessel
Bypass graft
Clamp
External iliac artery
Clamp
Clamp
Internal iliac artery
B

Figs 11-36A and B: Aortoiliac graft.

Pre-clotting of the selected graft is done. Aorta is opened longitudinally and side-to-side graft to aorta anastomosis is done. Its integrity is confirmed by once releasing aortic clamp for a short period and later reapplied. External iliac artery just proximal to distal clamp is opened and side-to-side anastomosis is done between lower end of graft and external iliac artery. Just prior to completion of last suture distal clamp is released to remove clot and debris. Proximal clamp and clamp on the opposite common iliac artery is released. Suction drain is placed and kept for 72 hours. Complications are similar to other graft procedure.

ILEOFEMORAL GRAFT

It is done when disease is limited to one common iliac artery. Common iliac artery near its origin should be patent and free of disease to do ileofemoral graft. Aortic bifurcation also should be normal. It is often preferred method than cross femoral graft as opposite limb dissection is avoided here.

Incisions may be suprainguinal (*retroperitoneal commonly*, transperitoneal occasionally) to expose the aorta and common, external and internal iliac arteries; or vertical thigh incision along midinguinal point across inguinal ligament. External and internal oblique and transversus abdominis muscles are split to reach retroperitoneal area; by blunt finger dissection, vessel is dissected adequately; common iliac or external iliac artery is used for proximal graft placement **(Figs 11-37 to 11-39A to C)**.

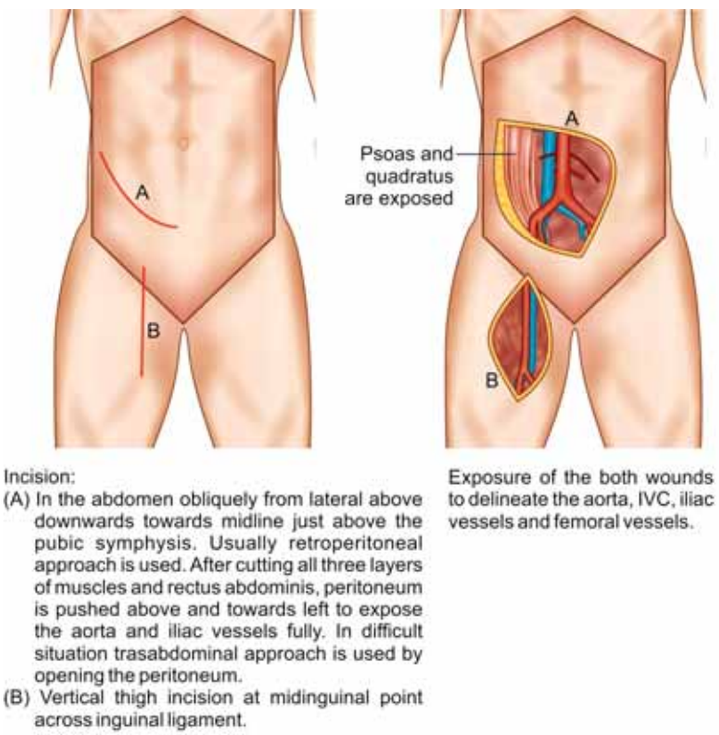

A
B
Psoas and quadratus are exposed
A
B
Incision:
(A) In the abdomen obliquely from lateral above downwards towards midline just above the pubic symphysis. Usually retroperitoneal approach is used. After cutting all three layers of muscles and rectus abdominis, peritoneum is pushed above and towards left to expose the aorta and iliac vessels fully. In difficult situation trasabdominal approach is used by opening the peritoneum.
(B) Vertical thigh incision at midinguinal point across inguinal ligament.
Exposure of the both wounds to delineate the aorta, IVC, iliac vessels and femoral vessels.

Fig. 11-37: Incision and exposure for ileofemoral graft.

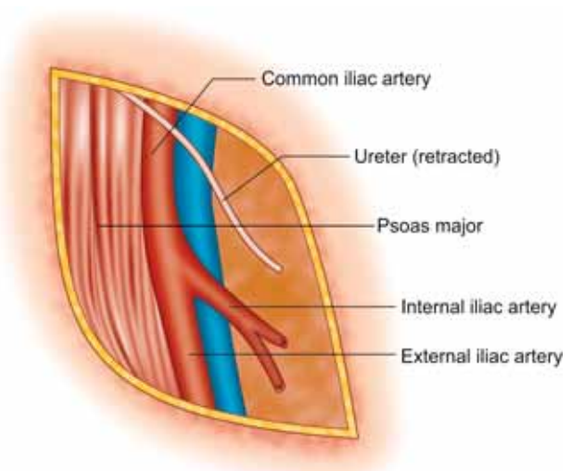
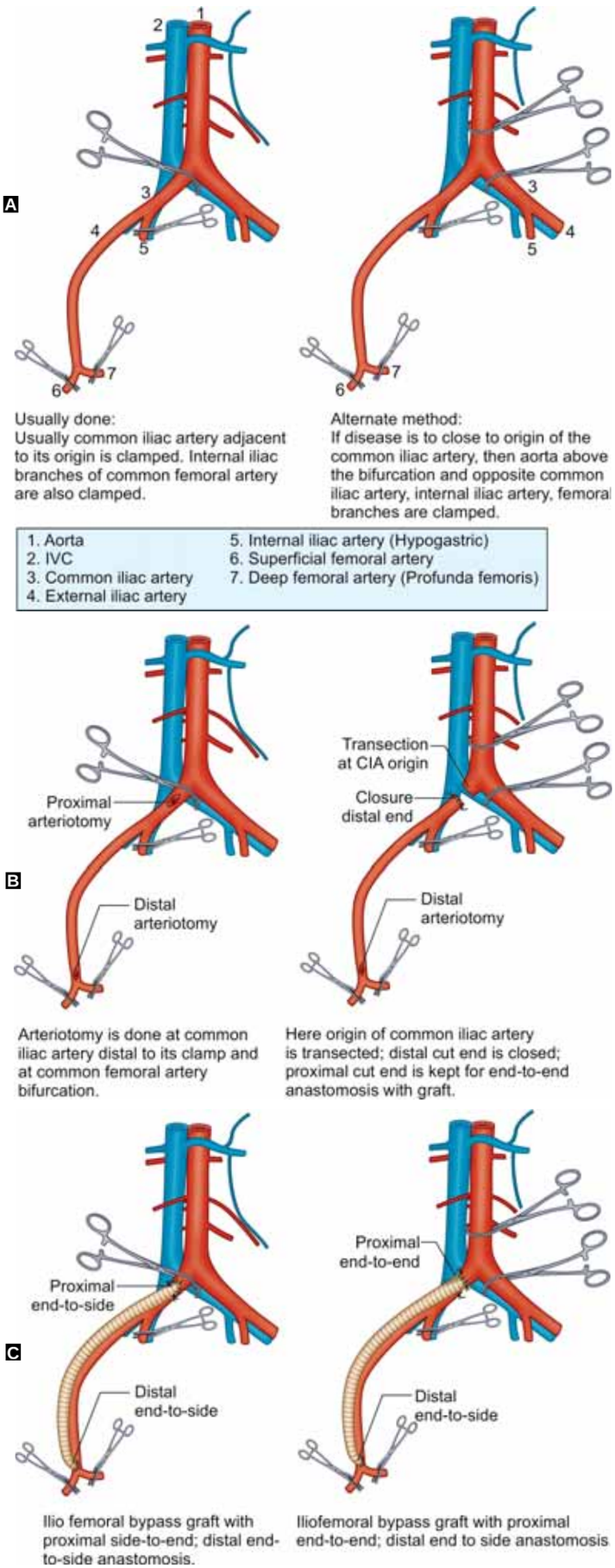


Fig. 11-38: Iliac artery exposure.


A
1
2
3
4
5
6
7
Usually done:
Usually common iliac artery adjacent to its origin is clamped. Internal iliac branches of common femoral artery are also clamped.
Alternate method:
If disease is to close to origin of the common iliac artery, then aorta above the bifurcation and opposite common iliac artery, internal iliac artery, femoral branches are clamped.
1. Aorta
2. IVC
3. Common iliac artery
4. External iliac artery
5. Internal iliac artery (Hypogastric)
6. Superficial femoral artery
7. Deep femoral artery (Profunda femoris)
B
Proximal arteriotomy
Distal arteriotomy
Transection at CIA origin
Closure distal end
Distal arteriotomy
Arteriotomy is done at common iliac artery distal to its clamp and at common femoral artery bifurcation.
Here origin of common iliac artery is transected; distal cut end is closed; proximal cut end is kept for end-to-end anastomosis with graft.
C
Proximal end-to-side
Distal end-to-side
Proximal end-to-end
Distal end-to-side
Ilio femoral bypass graft with proximal side-to-end; distal end-to-side anastomosis.
Iliofemoral bypass graft with proximal end-to-end; distal end to side anastomosis

Figs 11-39A to C: Ileofemoral graft—technique.

Initial heparinisation is done. Vascular clamps are applied on the origin of the common iliac artery, internal iliac artery and femoral branches. If the origin of iliac artery is diseased then clamps are placed on aorta above the bifurcation and on opposite common iliac artery to prevent retrograde blood flow from opposite common iliac artery. Cut end of its origin is sutured using 4 zero polypropylene sutures (If end-to-side anastomosis is proposed method, transection of artery is not done). Usually 10 mm graft is used. Internal iliac, superficial and deep femoral arteries are also clamped beyond their origin.

Proximal anastomosis can be done as end-to-side or end-to-end if common iliac artery is transected. Continuous 4 zero polypropylene sutures are placed. Distal part of the graft is tunneled deep to inguinal ligament across femoral triangle into common femoral artery near its division towards deep femoral artery. Distal anastomosis is done as end-to-side using 4 zero polypropylene continuous sutures.

Wounds are closed with a suction drain. *Complications* are bleeding, graft leak, haematoma, thrombosis of graft, intimal dissection, infection and impotence.

Ileofemoral cross over graft is used from one side common or external iliac to opposite side femoral artery wherein graft is passed usually in front of (or underneath) the opposite inguinal ligament **(Fig. 11-40)**.

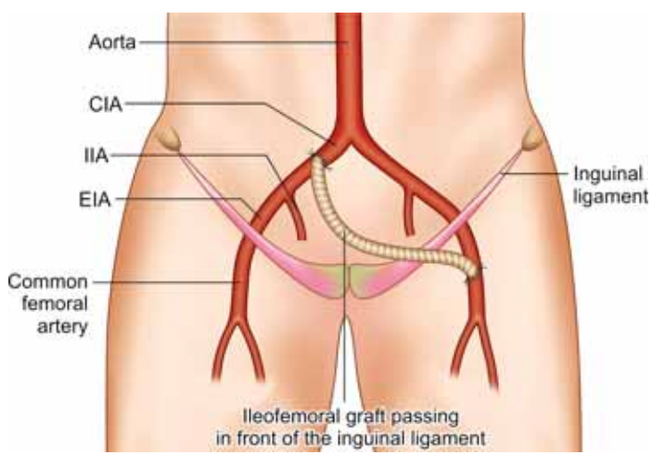


Fig. 11-40: Ileofemoral cross over graft.

FEMOROPOPLITEAL BYPASS GRAFT

It is done in lower limb ischaemia as a limb saving procedure if disease segment is in superficial femoral artery from its origin to below knee popliteal segment. There should be adequate good blood flow in iliac arteries to do femoropopliteal bypass. *Adequate distal run off* is also needed. If there is associated localised profunda femoris (deep femoral) artery block, then profundaplasty with a vein or graft patch should also be added to improve collateral circulation. Vein graft is always better than prosthetic graft in below knee segment revascularisation. Main artery is left in situ to retain whatever existing functions as it is. Side-to-end femoro graft anastomosis proximally and end-to-side graft to popliteal anastomosis is done **(Fig. 11-41)**.

Procedure

Under regional/general anaesthesia preparation of entire limb from umbilicus up to ankle is done.

First *recipient popliteal segment* is dissected. *Medial approach* is commonly used. Initially *proximal segment of artery* is exposed.

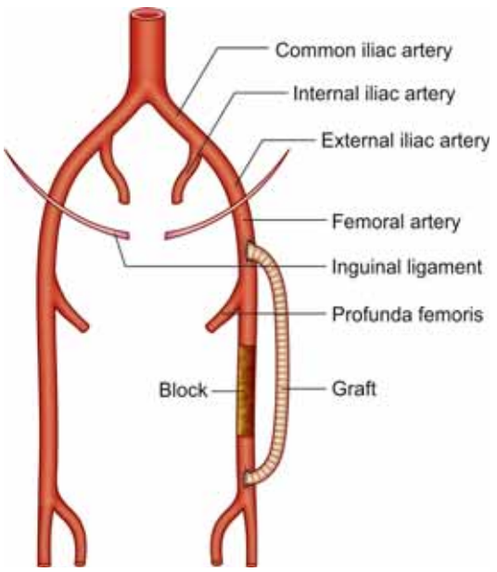


Fig. 11-41: Femoropopliteal bypass graft.

Incision is on the medial aspect from upper part of femoral condyle proximally for 10 cm. Dissection is deepened between vastus medialis and hamstring muscles (semitendinosus, semimembranosus). Sartorius, gracilis, vastus medialis are retracted in front. Artery passing through the adductor hiatus under femur is found. In popliteal fossa artery is found in a fatty area. It is separated from popliteal vein. Genicular branches are identified and safeguarded **(Fig. 11-42)**.

Distal segment of artery is dissected next by medial approach through an incision which is vertical and 1 cm posterior to medial subcutaneous border of the tibia. Often flexion and abduction of hip joint and flexion of knee joint at 90^0 is needed. As long saphenous vein is very close to this incision it should not be injured as it is needed to use as a graft for bypass. After skin incision, long saphenous vein is fully mobilised. Medial head of the gastrocnemius is retracted posteriorly. Dense fascia connecting it to tibia is divided to expose the lower part of the popliteal fossa **(Fig. 11-43)**.

Division of guy ropes (semitendinosus, semimembranosus and gracilis) is only occasionally needed; retraction only suffices. Anterior tibial vein is ligated; artery is dissected carefully including its divisions – anterior tibial artery and tibioperoneal trunk. Popliteal artery is medial to posterior tibial nerve and popliteal vein. Small tributaries are ligated using double loop silk sutures *(Pott's sutures/ties)*. Both branches are isolated and occlusion slings are placed. Fascia anterior to sartorius is incised and using blunt finger dissection tunnel is created to pass the graft **(Fig. 11-44)**.

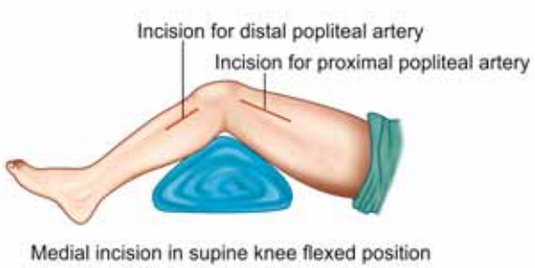
Adductor canal is an intermuscular space (*Hunter's canal*, John Hunter – 1793) situated on the medial side of middle ⅓ of the thigh extending from apex of femoral triangle to tendinous opening (adductor magnus hiatus) in the adductor magnus below. It is formed anteriorly by vastus medialis; posteriorly (floor) by adductor longus above and adductor magnus below; medially (roof) is formed by strong fibrous membrane joining anterior and posterior walls, which is covered by sartorius. Canal contains femoral artery and vein, saphenous nerve, nerve to vastus medialis, two divisions of obturator nerve. Descending genicular artery originates in the canal from femoral artery which divides into saphenous artery which accompanies the saphenous nerve and muscular branch to vastus medialis **(Fig. 11-45)**.

Proximal dissection at femoral artery level is done through a vertical incision with convexity laterally at midinguinal point. Convexity towards lateral side prevents damage to lymphatic vessels. Lymphatic vessel disruption can cause lymphorrhoea, lymphocele, lymph fistula and wound infection. If lymph vessels are injured, it should be ligated with fine silk suture. LSV can be dissected through same incision on its medial margin. Long saphenous vein may be dissected through a separate vertical incision 1 cm below and lateral to the pubic tubercle directly on LSV. Skin flaps should not be raised as much as possible to prevent development of skin necrosis.

Usually vein graft is used. Long saphenous vein is commonly used. If it is not available by disease or previous surgery, then small saphenous vein or cephalic vein is used. Vein graft is better than prosthetic graft in relation to graft take up and long-term efficacy in femoropopliteal bypass. However technical precision and availability of good graft makes prosthetic graft also equally effective **(Figs 11-46A to F)**.

SAPHENOUS VEIN GRAFT

Both in situ and reversed vein graft is used. LSV is divided in the wall of the common femoral vein to achieve maximum width at the LSV opening. Junction is clamped using Satinsky vascular clamp. All tributaries are ligated at 1 mm distance. It should not be less nor more than 1 mm; if less, it may narrow the graft or block; if more, it may precipitate the thrombus at the stump of the tributary. Care should be taken not to injure the adventitia of the vein **(Figs 11-47 to 11-51)**.



A Medial incision in supine knee flexed position

Distal incision/incisions for recipient artery site—Popliteal artery is made first. Supine semiflexed knee with medial incision is preferred. Incision for proximal popliteal artery is vertical just above the femoral epicondyle two fingerbreadths behind the femur along the anterior margin of sartorius. Incision for distal popliteal artery is vertical, medial and just behind the tibial margin of 15 cm length.

B

Proximal incision to expose femoral artery—It is vertical incision in the thigh at midinguinal point with lateral convexity to avoid disruption of lymphatics. LSV can be dissected through same incision on medial flap or through separate vertical incision below and lateral to pubic tubercle.

C

Donor LSV may be taken from opposite side if same side LSV is not amenable for graft.

Figs 11-42A to C: Incisions and approaches for femoropopliteal bypass graft.

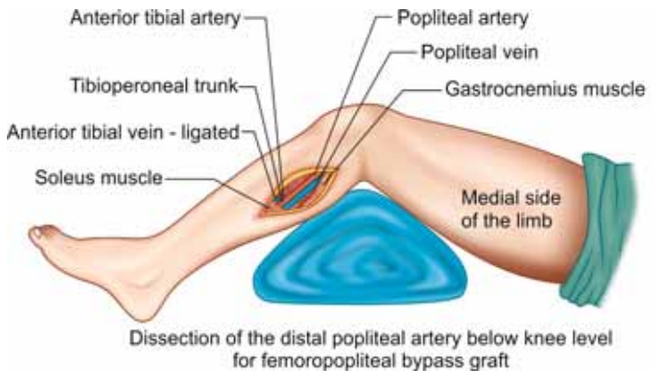

Anterior tibial artery
Popliteal artery
Popliteal vein
Tibioperoneal trunk
Gastrocnemius muscle
Anterior tibial vein - ligated
Soleus muscle
Medial side of the limb
Dissection of the distal popliteal artery below knee level for femoropopliteal bypass graft

Fig. 11-43: Dissection of the distal artery for femoropopliteal artery bypass.

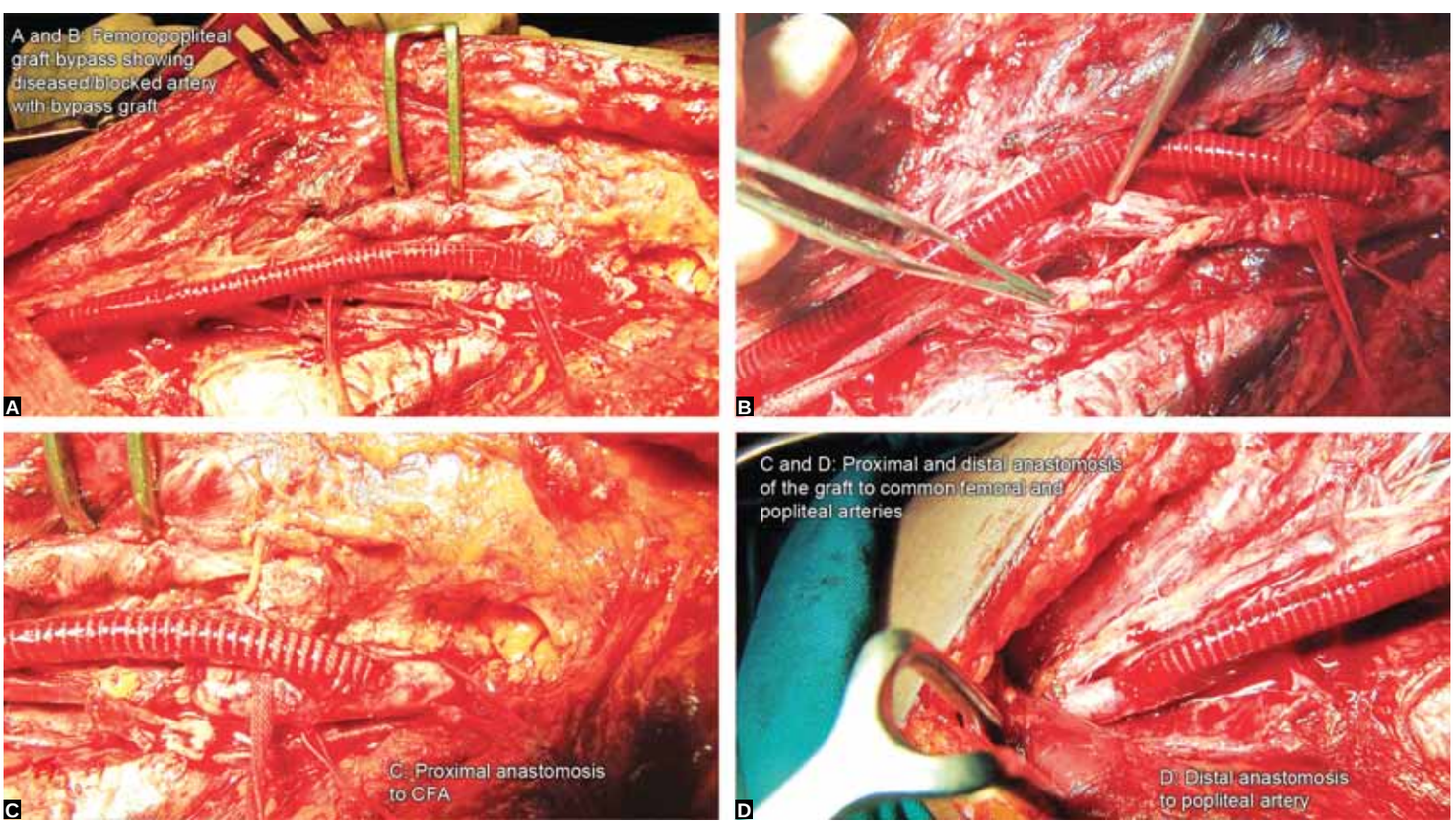
In Situ Saphenous Vein Graft

Here proximal part of the graft is anastomosed to the femoral artery above the level of the block without disturbing the LSV graft anatomical location. But as LSV junction is often at lower level than site of anastomosis to artery, proximal part of the LSV often needs to be mobilized.

Since valves are present in the LSV graft, they need to be destroyed using valvulotome. First valve is usually at 1 cm from SFJ. Its translucent central part is excised under direct vision using Pott's scissor. Second valve is 3-5 cm from SFJ. If saphenous vein is 3 mm or more in diameter *valve cutter method* can be used to destroy the valves. A guide catheter is passed from ankle level of the saphenous vein upwards towards proximal cut end of the LSV. Proximal pulled out catheter is connected to a heparinised saline delivery system which inflates up to the next proximal valve and valve cutter should float in the lumen freely. Vascular loop kept around proximal part of the saphenous vein is snugged. Valve cutter is rotated 90° to cut the valve leaflets using cutting edge. Once valve is cut, distal next level valve will become prominent due to saline distension and cutter is gently pulled down distally to feel the resistance by the valve. Valves are cut to feel a popping sensation with vein getting distended below up to the next valve level **(Figs 11-52A and B)**.

During valvulotomy, intima of the vessel may be damaged. Retained tributary of in situ saphenous graft is a potential anatomical area of *arterio venous fistula* formation.

Vascular clamps are applied on proximal part of the femoral artery and proximal cut end of saphenous vein. Distal part of the popliteal artery is also clamped. *Side-to-end proximal anastomosis* is done between side of the femoral artery and proximal cut end of saphenous vein (cobra head) using 6 zero polypropylene sutures first 'heel' of the graft is sutured; then sides and at the end 'toe' of the graft. Often parachute technique is used. Arterial vessel loops/slings/clamps are released to allow blood flow through saphenous vein up to proximal valve. It is confirmed by pulsation which stops at first valve level. Venotomy is done at the side branch of distal end of the vein. *Valvulotomy* instrument (*Le Maitre's valvulotome* – blunt tipped) is passed carefully through it with 90° rotations without traumatizing the intima. Proximal graft anastomosis is pinched by assistant's finger to prevent valvulotome entering into the anastomotic site. If it enters anastomotic site, it will snag the sutures and cut. Valve with distended proximal vein segment is identified; valve is cut carefully by rotating the valvulotome 90°. Blood now flows towards next level of valve which is cut again and is repeated until all valves are cut. *All tributaries should be identified carefully and ligated.* Full length of the


A and B: Femoropopliteal graft bypass showing diseased/blocked artery with bypass graft
A
B
C: Proximal anastomosis to CFA
C
C and D: Proximal and distal anastomosis of the graft to common femoral and popliteal arteries
D: Distal anastomosis to popliteal artery
D

Figs 11-44A to D: Femoropopliteal bypass graft.

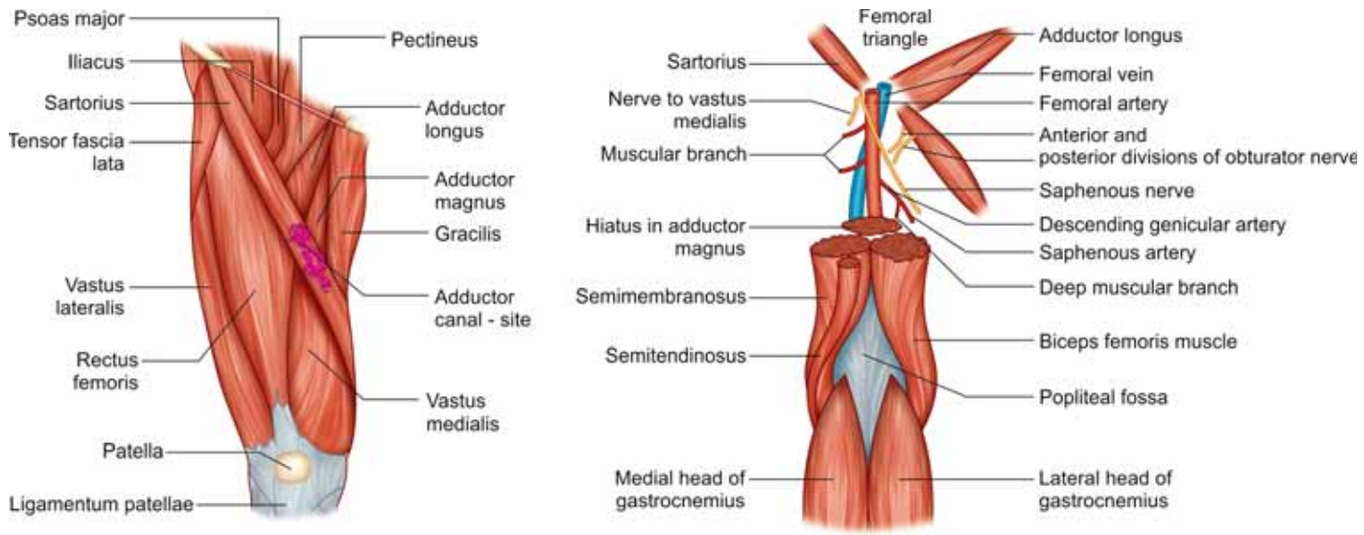


Fig. 11-45: Anatomy of femoral triangle and adductor canal in relation to femoropopliteal bypass graft.

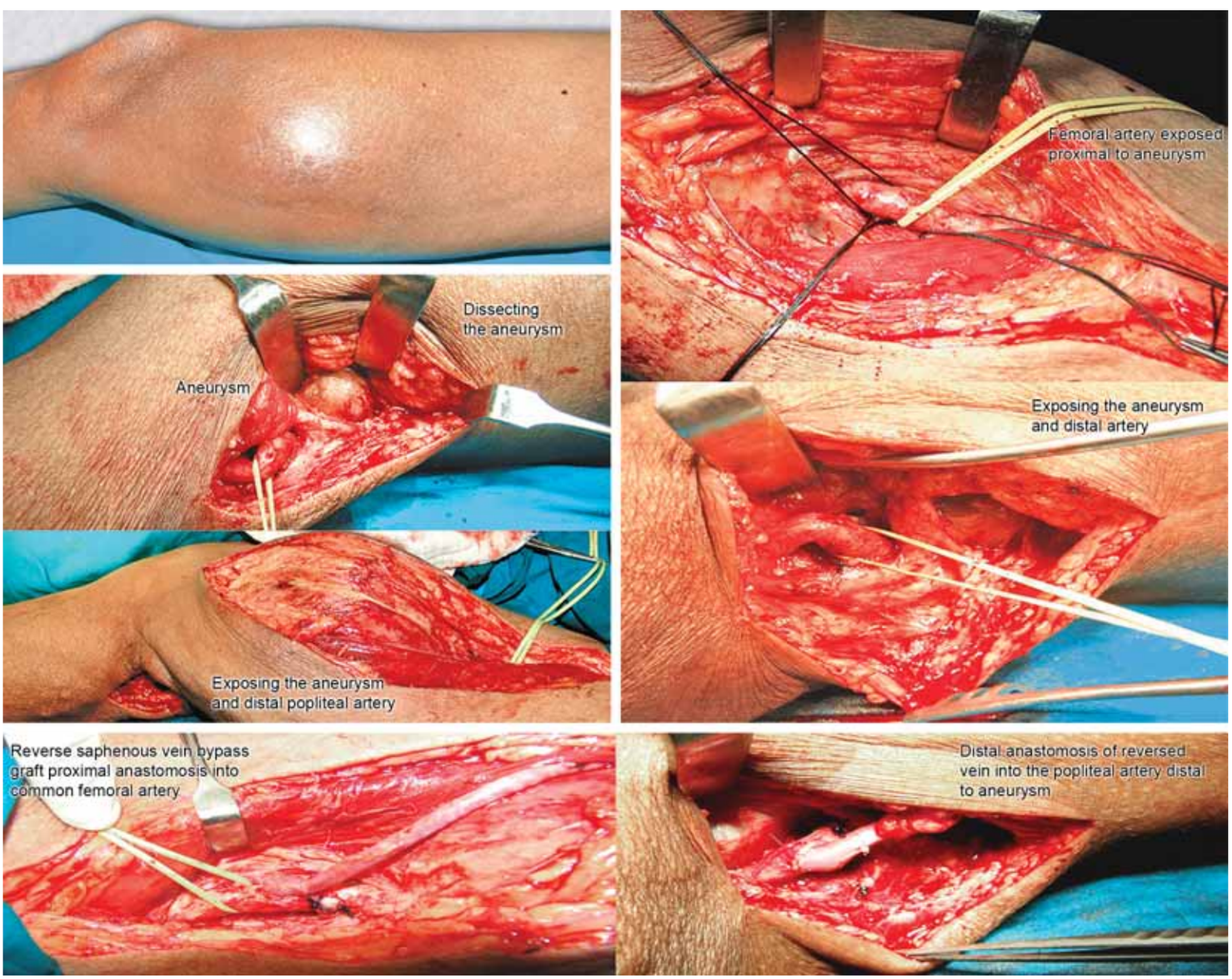

Dissecting the aneurysm
Aneurysm
Exposing the aneurysm and distal popliteal artery
Femoral artery exposed proximal to aneurysm
Exposing the aneurysm and distal artery
Reverse saphenous vein bypass graft proximal anastomosis into common femoral artery
Distal anastomosis of reversed vein into the popliteal artery distal to aneurysm

Fig. 11-46(1)

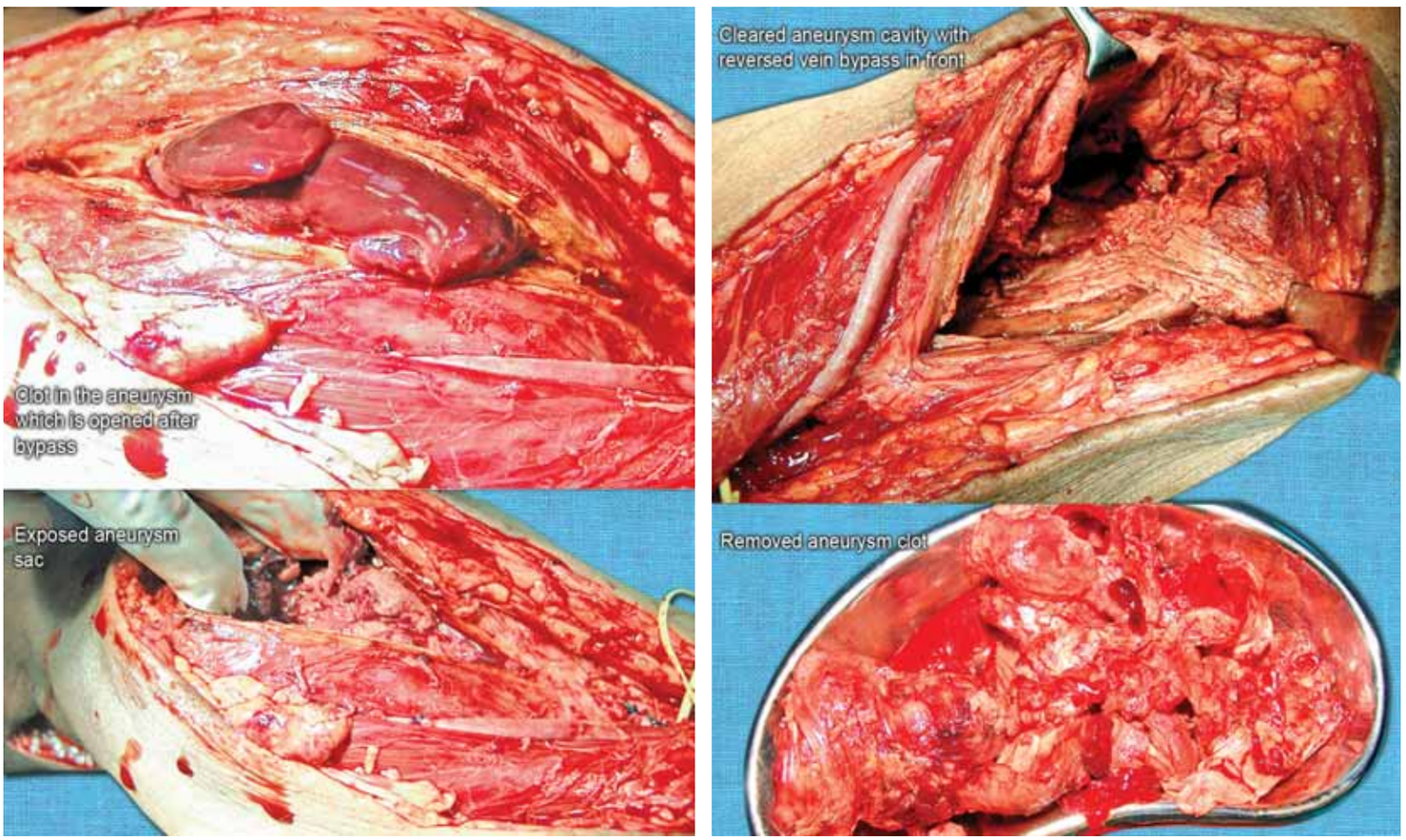

Clot in the aneurysm which is opened after bypass
Cleared aneurysm cavity with reversed vein bypass in front
Exposed aneurysm sac
Removed aneurysm clot

Fig. 11-46(2)

Figs 11-46(1 and 2): Femoropopliteal aneurysm—clot evacuation after placing reverse saphenous vein femoropopliteal venous bypass graft.

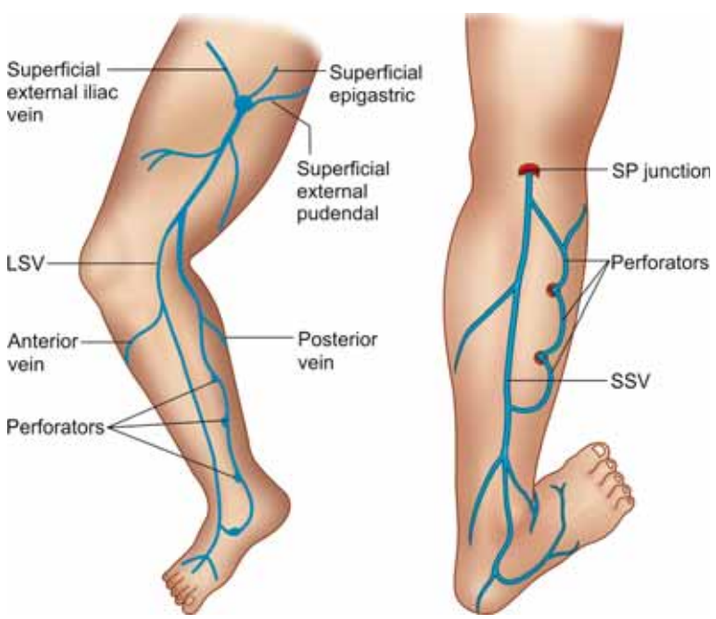


Fig. 11-47: Anatomy of long and short saphenous vein.

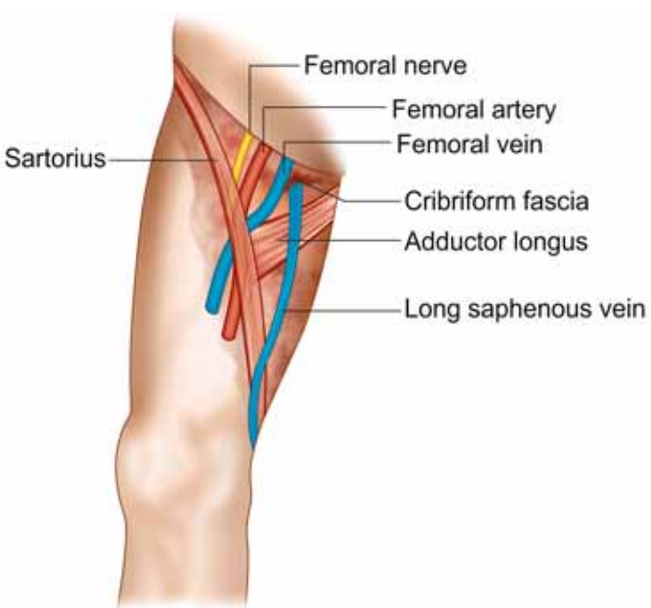
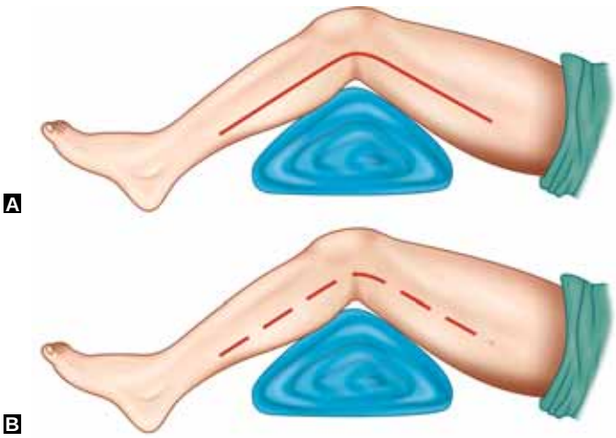


Fig. 11-48: Surgical anatomy of saphenofemoral junction and femoral triangle.



Incisions for long saphenous vein harvesting for saphenous vein femoropopliteal graft. LSV may be exposed by (A) longitudinal incision along the LSV or (B) by multiple small longitudinal incisions. It is technically easier with single lengthy incision. In situ saphenous vein graft cab be done with multiple incisions. All tributaries should be ligated at 1 mm distant from the surface of the LSV using 4 zero polypropylene sutures.

Figs 11-49A and B: Incision for exposing the long saphenous vein.

Harvesting of LSV is done by ligating the saphenofemoral junction very close to the femoral vein so that to achieve wide LSV opening for proximal (in 'in situ' graft) or distal (in reverse graft) anastomosis to artery. Satinsky clamp is applied at SFJ; LSV is cut using No. 15 blade; continuous underrunning over and over sutures on the Satinsky clamp is done using 4 zero polypropylene suture to close the SFJ.

Fig. 11-50: Saphenofemoral ligation for harvesting the LSV graft.

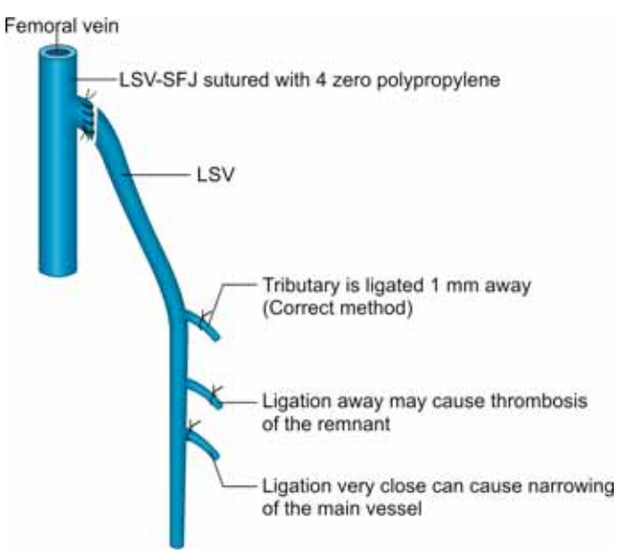
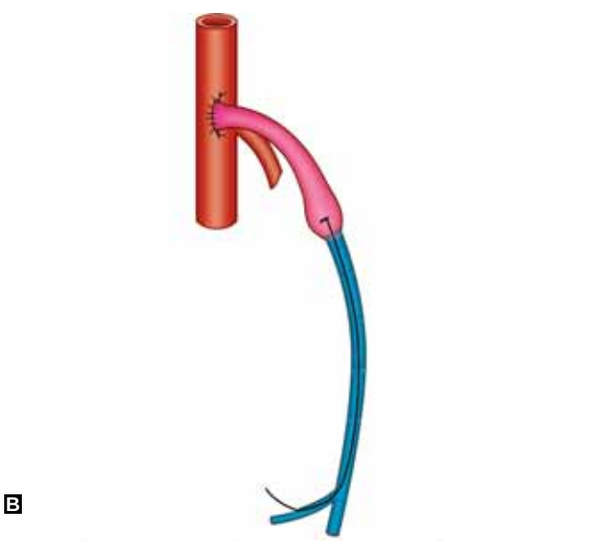


Fig. 11-51: Proper ligation of tributaries is essential in harvesting the saphenous vein.

SFJ is ligated close to the femoral vein; proximal saphenous vein is looped; through distal venotomy valvulotome is passed; next to proximal valve is cut gently.

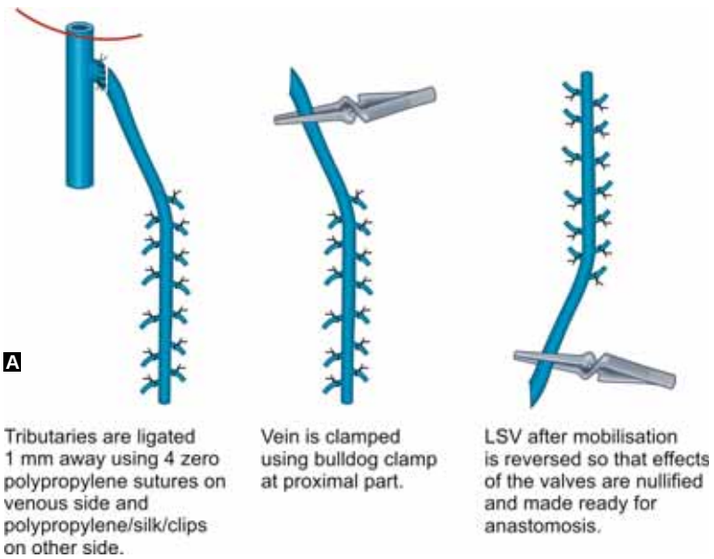


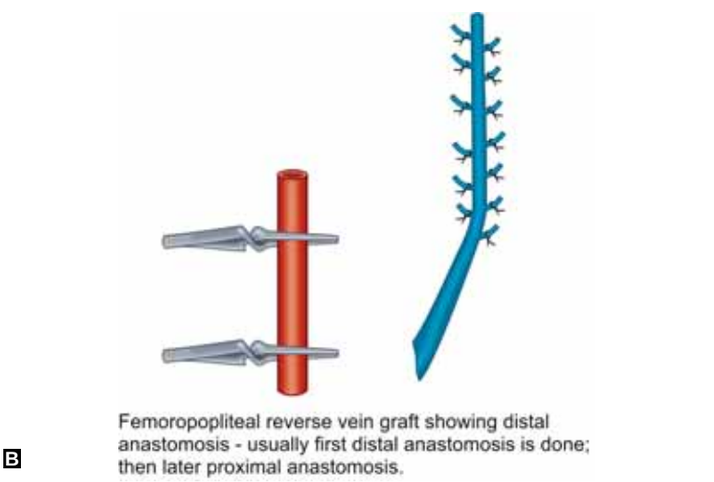
Proximal anastomosis is done into the common femoral artery; valvulotome is further pulled down along each valve to cut it; till lower end valves are cut.

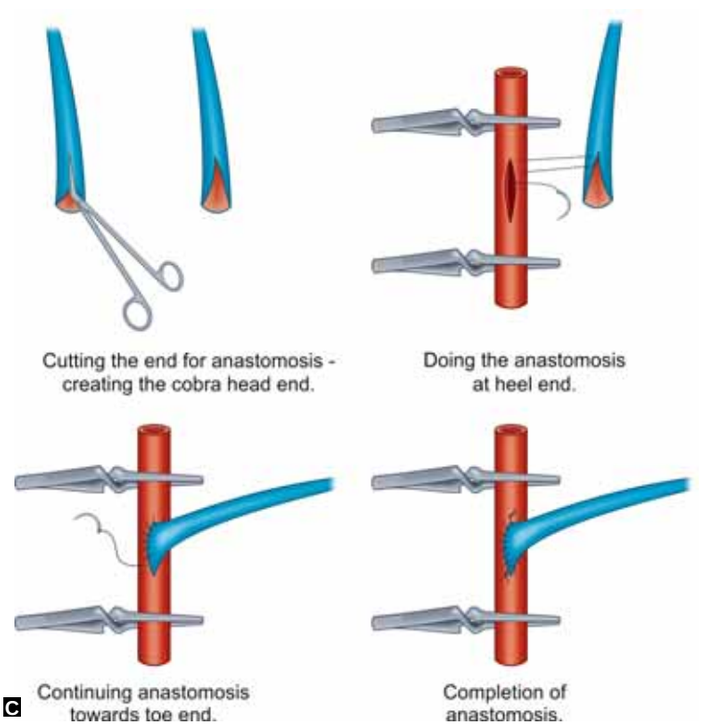
Figs 11-52A and B: In situ saphenous vein graft for femoropopliteal bypass.

vein is exposed and tributaries are ligated. Tributaries in the deeper aspect of the vein should be identified and ligated. Angiogram is done to identify and ligate the site of tributaries. Tributaries are identified using a Doppler probe; pinching the graft distal to probe, flow to the tributary proximally can be recognized **(Figs 11-53A to D)**.

Distal anastomosis between end of the saphenous vein and side of the artery (end to side) is decided. It may be either lower popliteal, anterior tibial, tibioperoneal or posterior tibial depending on the site and extent of the block. Vein end is tailored like a cobra head. Magnifying loop or glass may be used for distal anastomosis. Small bulldog clamps or vascular loops are used to occlude the vessel all around prior to anastomosis. 6 zero or 7 zero polypropylene sutures are used for distal anastomosis. Any arteriovenous fistula in 'in situ saphenous graft' is carefully felt (by thrill); if present identified and ligated securely. It can also be identified by doing on table angiogram or on table Doppler study.


A
Tributaries are ligated 1 mm away using 4 zero polypropylene sutures on venous side and polypropylene/silk/clips on other side.
Vein is clamped using bulldog clamp at proximal part.
LSV after mobilisation is reversed so that effects of the valves are nullified and made ready for anastomosis.


B
Femoropopliteal reverse vein graft showing distal anastomosis - usually first distal anastomosis is done; then later proximal anastomosis.


Cutting the end for anastomosis - creating the cobra head end.
Doing the anastomosis at heel end.
C
Continuing anastomosis towards toe end.
Completion of anastomosis.

Figs 11-53A to C

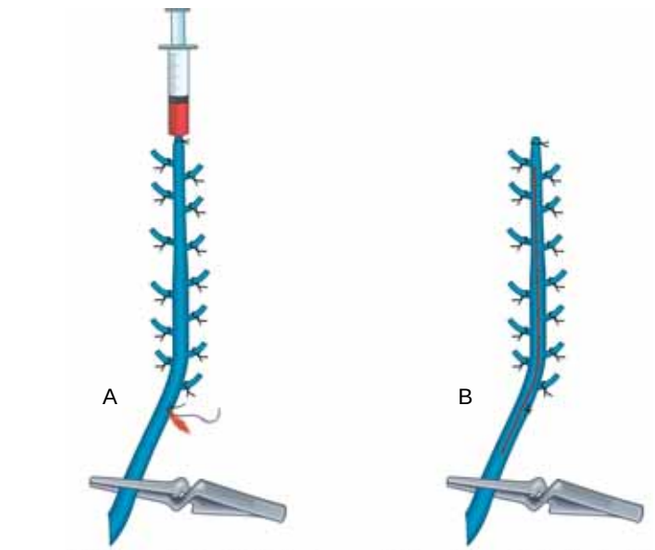

A
B
D
(A) Reversed vein is filled and passed with cold heparinised patient's blood using syringe with ball tipped needle. Any bleeding point is sutured using fine 6 zero polypropylene suture to make vein ready (B) for graft.

Fig. 11-53D

Figs 11-53A to D: In situ saphenous vein graft for femoropopliteal bypass graft.

In 'In Situ Saphenous Vein Graft' usually *proximal anastomosis is done first*; later distal anastomosis.

Free Reversed Saphenous Vein Graft

LSV is used commonly. LSV should be available as a normal vein. Opposite LSV can also be taken as graft. Diseased vessel cannot be harvested. Preoperative Duplex/venous Doppler scan should be done. Procedure is done under spinal/epidural anaesthesia. It may be a single long incision along the course of the vein or skip incisions or interrupted incisions. Saphenous vein is divided at saphenofemoral junction; cut vein end on femoral vein side is closed using 4 zero polypropylene suture.

Vein is dissected; all large and small tributaries are ligated at 1 mm distance. Creating flaps under the skin or undermining the skin should be avoided as necrosis of skin flap can occur. Vein should be irrigated continuously using saline to prevent desiccation. Vein should be held very carefully without causing any adventitial injury. Vein is completely dissected off the surrounding tissue and rotated 180° to reverse it. Fine needle (*ball tipped* needle) with syringe containing *cold heparinised patient's blood* is passed through the distal aspect of the vein (reversed vein proximal part). Plain saline solution should not be used. Solution containing saline, albumin, heparin and papaverine can be used. Vein is gently flushed with the heparinised blood causing distension of the vein. Care should be taken not to force blood/fluid rapidly to create over distension which may lead into intimal damage. A pressure over 200 mm Hg is not advisable (rapid force in usual syringe creates pressure more than 200 mm Hg). Any leaking points are identified and securely ligated using 8 zero polypropylene suture without narrowing the lumen. *Magnifying lens* may be used for suture ligation.

Short/small saphenous vein when needed is harvested in prone position. Flexion and inward rotation of the hip is also used which avoids change of position for graft suturing. Small saphenous vein which is located behind the lateral malleolus is identified. Longitudinal skin incision (from lateral malleolus up to mid calf level)

is made; skin should not be undermined; identified vein is dissected off the adjacent tissues with ligation of tributaries. In proximal ⅓ of leg vein penetrates the deep fascia. Continuous papaverine irrigation into the vein is needed to prevent spasm.

If both LSV and SSV are not good for graft then *cephalic vein* is used as autologous vein graft. Cephalic vein is harvested from lateral side of wrist to deltopectoral triangle. Anatomical variations are common in upper limb veins. Upper limb veins are more adherent to skin compared to lower limb veins and so it is more difficult to harvest them without traumatizing. Both cephalic and basilic veins can be used as one conduit. Lateral lengthy single incision or multiple incisions may be used.

Tunneling to pass the graft is done either in deeper plane or superficial subcutaneous plane. Graft placed in deeper plane avoids kinking and block; but access for possible eventual stenosed area becomes difficult. Above knee popliteal graft is placed in superficial plane where vein is harvested upon. Below knee popliteal graft is passed through deeper plane to avoid kinking by hamstrings. *Twist in the vein should be avoided.* After proximal anastomosis clamp is released; twist can be made out during blood flow. Often *ink marking* is done on the surface of the vein to identify the twist if it develops. *Completion angiogram* also shows twist along with leak.

Common, superficial and deep femoral arteries are exposed properly through thigh incision. These arteries are occluded using vascular clamps. Arteriotomy is done (No. 11 blade) on the common femoral artery with lower end of incision *directed towards* deep femoral artery. Incision can be easily extended into deep femoral artery if there is localized stenosis of the orifice of the deep femoral artery.

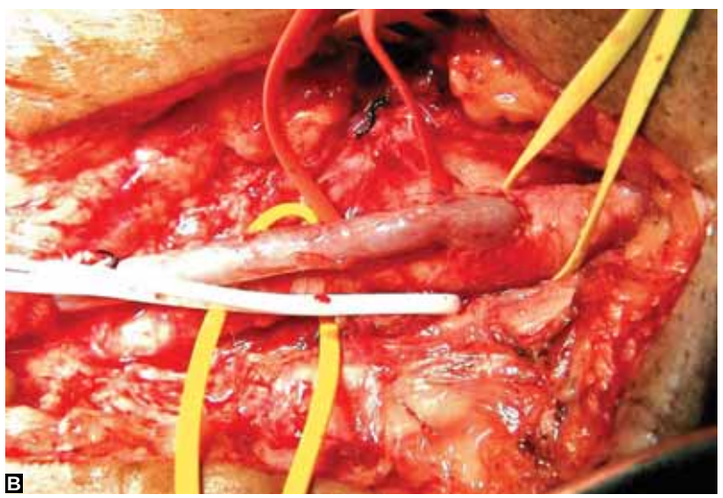
Anastomosis is done either as distal anastomosis first and later proximal anastomosis or as proximal anastomosis first. Many surgeons prefer to do distal anastomosis first. Either way is acceptable.

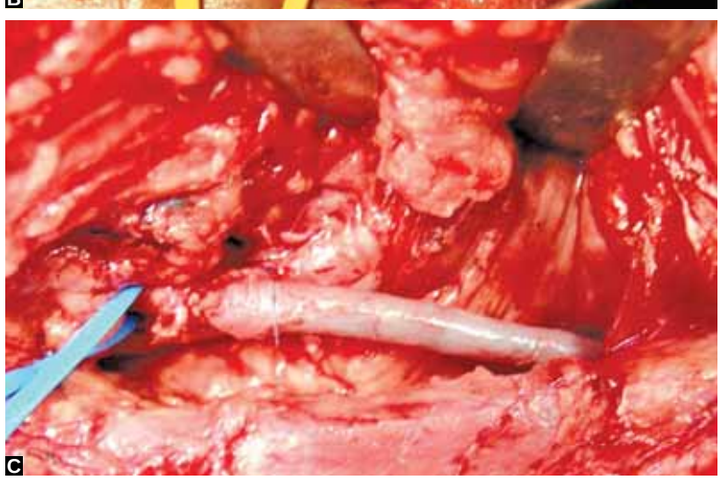
Proximal side-to-end anastomosis is done. Proximal cut end of the vein is made oblique by cutting on one edge. It reduces the tension on the anastomotic line and also makes the stoma wider. Sutures are placed from inside of the artery towards outside to avoid intimal flap formation. 'Heel' *should be distal* part of the anastomotic stoma and '*toe' should be proximal* part. Before last suture, clamp is released to confirm the back flow and down flow. Anastomosis is irrigated with heparinised saline. Clamp is reapplied and anastomosis is completed. Clamp on the venous side distal to the anastomosis is applied.

Distal anastomosis is done as end-to-side. End of the vein is cut and spatulated like a '*cobra head'* to widen the stoma at end-to-side anastomosis into the arteriotomy of distal popliteal artery. Here '*heel' end* of anastomosis is proximal; '*toe' end* is on distal side. Arteriotomy is done in the popliteal artery either above knee or below knee. As anastomotic site is smaller than proximal part, three initial stay sutures are placed near 'toe end' to achieve perfect anastomosis. Parachute or sliding technique may be also used beginning at the 'heel' end of the anastomosis in difficult situation. Back flow is checked during completion of anastomosis and heparinised saline irrigation is done **(Figs 11-54A to C)**.

Completion angiogram is a must to check for leak, adequate filling, and twist. 20 ml of water soluble iodine dye is injected. C-arm imaging is used. Suction drain is placed and kept for 72 hours. Wound is closed.

Intraoperative heparin or dextran is given to prevent formation of clot. Heparin is given 100 units/kg body weight at cross clamping. It is continued daily for 4 days **(Fig. 11-55)**.





Figs 11-54A to C: Femoropopliteal bypass reverse vein graft.

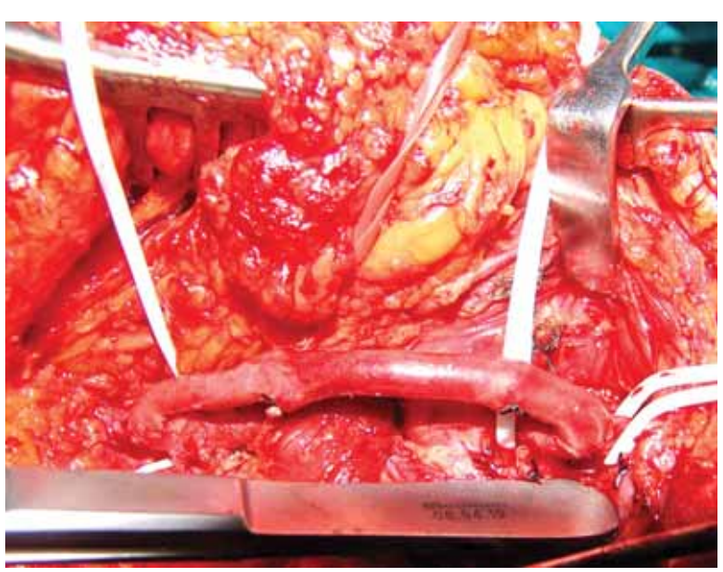


Fig. 11-55: Femoral artery to popliteal artery saphenous vein bypass graft.

Postoperative Care and Follow-up

It is common use to take oral anticoagulants and antiplatelet drugs even though graft survival by these drugs alone is not entirely proved.

ICU care, postoperative low molecular dextran are needed for 48–72 hours.

Smoking should be stopped to improve the graft survival.

Circulation should be checked by regular checking of pulse or using Doppler. Duplex scan is very useful to identify the stenosed areas. Stenosis is commonly observed at anastomotic site, at the level of valves. Duplex scan is done 3 weeks after surgery; then afterwards once in three months for one year. Late occlusions are less in 'in situ graft' than in reversed saphenous vein graft or synthetic graft.

Complications

Bleeding, thrombosis, graft leak, graft thrombosis, infection and failure are known complications.

Early occlusion of the graft – If occlusion occurs within 30 days of graft it is called as early occlusion. It is commonly due to technical cause, poor selection of patient, inadequate 'run–in' and/or inadequate 'run–off'. A revision procedure may be tried; but amputation is commonly needed in such patients as revascularisation is impossible. Catheter thrombectomy, angioscopy, angiographically guided thrombolysis are tried to revascularise the limb. Balloon angioplasty, short jump bypass graft are all tried to salvage the limb.

Late occlusion can occur which is due to progression of disease, smoking, persisting precipitating factors. Angiogram confirms the occlusion. It is difficult to manage late occlusion.

AXILLOFEMORAL GRAFT

Prerequisites

Donor axillary artery should be disease free. Blood pressure measuring in both arms is done; duplex scanning of axillary artery is essential. It is *extra anatomical indirect graft*.

Surgical Anatomy of Axillary Artery

It is the continuation of subclavian artery from outer border of first rib to lower margin of teres major muscle with its 1st part occupying superior, 2nd part behind and 3rd part is inferior to pectoralis minor muscle. When the arm is held at right angle to body with palm facing upwards, surface marking is done as a straight line from midpoint of clavicle to a point at the junction of anterior ⅓ and posterior ⅔ of lateral wall of axilla. Here axillary artery is palpated against humerus. Superficial relations in first part are skin, superficial fascia, supraclavicular nerves, clavicular part of pectoralis major, clavipectoral fascia with cephalic vein, lateral pectoral nerve, thoracodorsal vessels, communicating loop between medial and lateral pectoral nerves; in the second part it is deep to pectoralis minor muscle; in the third part it is deep to pectoralis major muscle. Deeper relations are first intercostals space, external intercostal muscle, serratus anterior digitations, brachial plexus, latissimus dorsi and teres major below. Axillary vein is below, medial and superficial to artery. Axillary artery is covered by axillary sheath which is derived from prevertebral layer of deep cervical fascia. Axillary vein is not covered by axillary sheath.

Of *6 branches of axillary artery* one (superior thoracic) branch arises from first part; two (acromiothoracic/thoracodorsal and lateral thoracic) from 2nd part and three branches (subscapular {*largest branch*}, anterior circumflex humeral, posterior circumflex humeral) arise from 3rd part of axillary artery.

Incision – A small transverse incision below the middle of the clavicle extending laterally to a point below the medial part of the deltopectoral groove.

Procedure – Skin and pectoral fascia are incised; pectoralis muscle is split along the line of fibers and retracted. Clavipectoral fascia is identified and split to reach pectoralis minor muscle. Pectoralis muscle is cut or retracted to feel the axillary artery pulsation. Axillary vein is below and superficial to artery with close relation. Posterior minor branches of the artery should be ligated; fine sling is passed around the artery to have gentle traction over the artery **(Figs 11-56A to D)**.

Axillofemoral tunnel is created to place the prepared selected graft in the tunnel. Tunnel is created using finger under the pectoralis major in front of chest wall along the midaxillary line and later medial to anterior superior iliac spine to reach the groin below the inguinal ligament into common femoral artery. If both common femoral arteries are needed to perfuse then bifurcation axillofemoral graft can be used; or use a cross over graft from axillofemoral graft of one side to opposite common femoral artery. In between additional horizontal small incisions may be made as needed to facilitate the proper graft placement in the tunnel without kinking. Length of the graft should be adequate enough to prevent shortening and to allow adequate range of movements of shoulder and hip joints. Prior heparinisation is done; vascular clamps are placed to vessels; arteriotomy is done to both axillary and femoral arteries. Anastomosis is done first at proximal and then distally using polypropylene sutures.

Indications and Advantages

- It is done in conditions where already placed aortic graft is infected or as an alternate to aortofemoral graft.
- Advantages are major muscles are not incised; abdomen is not opened; aorta is not dissected and clamped.
- If it is done in case of infected aortofemoral graft original graft should be removed with ligation of aorta and proximal femoral arteries. Tunneling should avoid infected field.

FEMOROFEMORAL CROSSOVER GRAFT

It is done when one side vessel is diseased but other side is relatively normal with adequate perfusion. Initial angiogram and Duplex scanning are done to assess the flow and success of the procedure.

It is done in spinal or epidural anaesthesia as an *extra anatomical graft* technique.

Both sides' common femoral arteries are exposed through vertical groin incision. Arteriotomies are done in common femoral arteries. *Oblique* arteriotomies are preferred so as to place anastomosis obliquely to maintain the curve of the placed graft. Donor arteriotomy is slightly at higher level than recipient arteriotomy. Both arteries are clamped; tunnel is created in the suprapubic region with a curve; graft is placed in the tunnel. Care must be taken not to injure the urinary bladder (catheterization is a must). Graft is anastomosed to donor artery and then at recipient artery in similar fashion as side-to-end. Clamps are released. Drains are placed on both wounds.

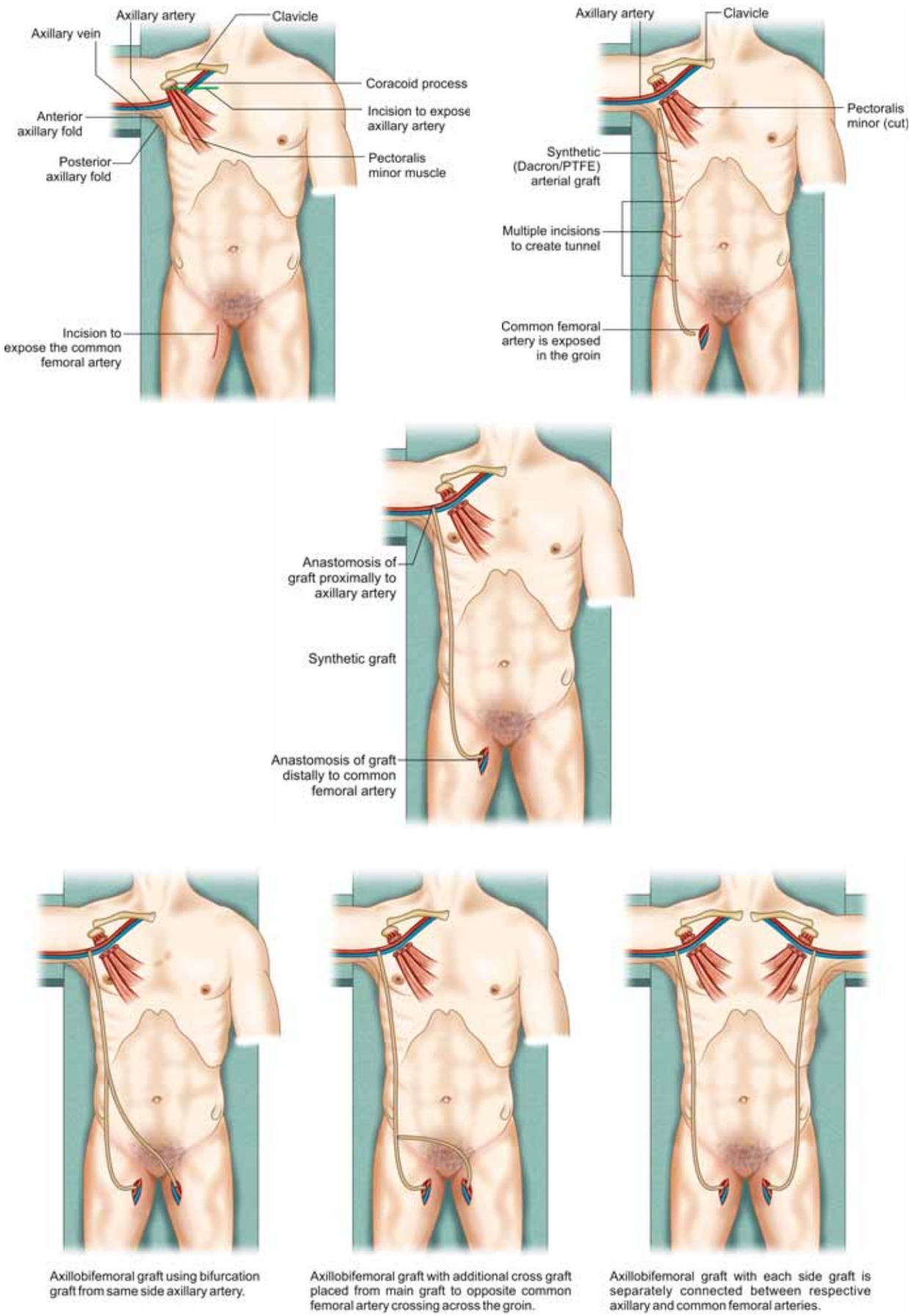

Axillary artery
Clavicle
Axillary vein
Coracoid process
Incision to expose axillary artery
Anterior axillary fold
Posterior axillary fold
Pectoralis minor muscle
Incision to expose the common femoral artery
Axillary artery
Clavicle
Pectoralis minor (cut)
Synthetic (Dacron/PTFE) arterial graft
Multiple incisions to create tunnel
Common femoral artery is exposed in the groin
Anastomosis of graft proximally to axillary artery
Synthetic graft
Anastomosis of graft distally to common femoral artery
Axillobifemoral graft using bifurcation graft from same side axillary artery.
Axillobifemoral graft with additional cross graft placed from main graft to opposite common femoral artery crossing across the groin.
Axillobifemoral graft with each side graft is separately connected between respective axillary and common femoral arteries.

Fig. 11-56: Axillofemoral bypass graft. It is an extra anatomical graft.

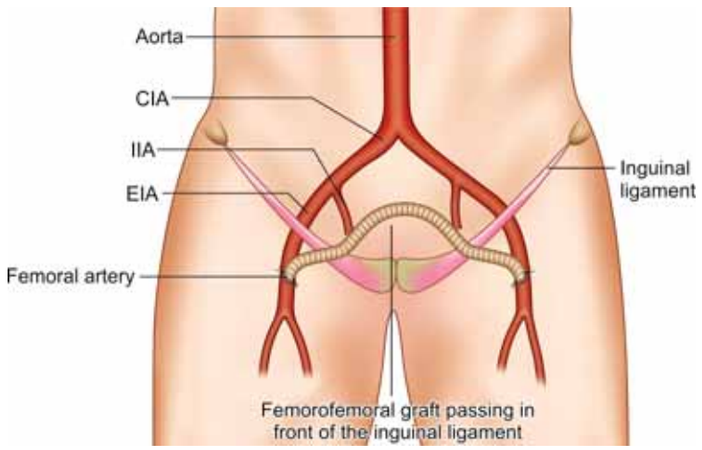


Fig. 11-57: Femorofemoral crossover graft.

Advantages

It is an extra-anatomical graft; easier to place; simple and effective.

Disadvantages

One side artery should be relatively adequate and normal to perfuse both limbs.

Injuries to urinary bladder, graft failure/blockage are the problems.

DISTAL ARTERIAL BYPASS

Block distal to popliteal artery is difficult to manage. Reconstruction is difficult and is possible only if artery distally is patent. Commonly it is done to anterior tibial, posterior tibial, peroneal arteries and rarely to dorsalis pedis artery.

Anterior Tibial Artery Exposure

It is small terminal branch of popliteal artery beginning at lower part of the popliteus opposite tibial tuberosity; enters the anterior compartment of the leg by passing close to the fibula (2.5 cm below the medial side of the fibular head) through an opening in upper part of the interosseous membrane. At midway between two malleoli it continuous as dorsalis pedis artery (at distal margin of superior extensor retinaculum). It lies between tibialis anterior and extensor digitorum longus; middle third between the tibialis anterior and extensor hallucis longus; lower third between extensor hallucis longus and extensor digitorum. Artery is crossed from lateral to medial side by extensor hallucis longus tendon. Deep peroneal nerve is lateral to artery. Anterior tibial artery may be partially or completely replaced by perforating branch of peroneal artery and perforating branch of posterior tibial artery. Artery gives muscular branches, anastomotic branches; medial and malleolar network branches. Artery is accompanied by two venae comitantes.

Incision – Vertical incision is made between the lateral subcutaneous margin of tibia and anterior border of fibula. Incision is deepened between tibialis anterior and extensor digitorum. Artery is exposed at various levels as needed either at middle third or lower third of the leg. Graft is passed from common femoral artery in thigh crossing from medial to lateral to pass onto lateral aspect of the knee joint to reach the leg. Alternatively graft can be crossed in the upper part or in the lower part of the leg.

Posterior Tibial Artery Exposure

It is larger terminal branch of the popliteal artery beginning at lower border of popliteus (in the midline on the back of calf at the level tibial tuberosity) between tibia and fibula deep to gastrocnemius; runs between medial malleolus and medial calcaneal tubercle deep to flexor retinaculum to divide as medial and lateral plantar arteries. It is related superficially to gastrocnemius, soleus and superficial transverse septum in the upper ⅔ of leg; it is in front and on medial border of tendoachilles in lower ⅓ of the leg. In the ankle it lies on capsule of ankle joint; between flexor digitorum longus and flexor hallucis longus. Artery is accompanied by two venae comitantes. Artery is accompanied and crossed by tibial nerve from medial to lateral side. It gives several branches - largest being peroneal artery; others are muscular artery, nutrient artery, anastomotic arteries, circumflex fibular artery, communicating branches, malleolar and calcaneal branches and terminal medial and lateral plantar arteries.

Incision – Vertical incision 1 cm posterior to medial subcutaneous border of the tibia extending like a 'hockey stick' under the medial malleolus. Lower down it is located between flexor digitorum longus and flexor hallucis longus. It is commonly used for 'in situ saphenous vein graft' **(Fig. 11-58)**.

Peroneal Artery Exposure

It is the largest branch of posterior tibial artery. It begins 2.5 cm below the lower margin of the popliteus; runs towards fibula → along the medial crest of the fibula → behind inferior tibiofibular joint and ankle joint → medial to peroneal tendons → ends as lateral calcaneal branches. Variations are common. It may replace posterior tibial/dorsalis pedis artery. It gives muscular branches, fibular nutrient artery, and anastomotic branches. Peroneal artery runs lateral to the tibial nerve in the groove between the fibular origin of flexor hallucis longus and tibialis posterior.

Both medial and lateral approaches are used. Graft placement is easier through medial approach.

In *lateral approach* incision is placed over lower part of lateral aspect of the leg; often segment of the fibula may need to be excised to pass the graft towards the peroneal artery. Once fibula is removed artery is directly seen.

In *medial approach*, as peroneal artery runs lateral to the tibial nerve in the groove between the tibialis posterior and fibular origin of flexor hallucis longus.

Dorsalis Pedis Artery Exposure

It is the main artery of dorsum of foot begins as continuation of the anterior tibial artery; extends from a point midway between the two malleoli to a point at the proximal end of first intermetatarsal space. It runs on the medial side of the foot lateral to extensor hallucis longus tendon to dip deep between two heads of first dorsal interosseous muscle at first intermetatarsal space to end in the sole as plantar arterial arch. It is palpated over intermediate cuneiform bone. Extensor hallucis brevis crosses the artery from lateral to medial. Medial branch of deep peroneal nerve is lateral to the artery. Artery may be replaced by perforating branch of the peroneal artery in 14% of individuals. It runs over talus, navicular and intermediate cuneiform bones. Branches are medial and lateral (larger) tarsal arteries; arcuate artery which gives 2nd, 3rd, and 4th dorsal metatarsal arteries and first dorsal metatarsal artery.

Reverse saphenous vein graft into distal artery - to posterior tibial artery
Distal anastomosis adjacent to medial malleolus into posterior tibial artery
Proximal anastomosis into the femoral artery after tunnelling in the subcutaneous/deeper plane
Completed anastomosis

Fig. 11-58: Saphenous vein graft (reverse) into the posterior tibial artery through femoral artery.

Dorsalis pedis artery is exposed by vertical incision on the medial dorsal aspect of the foot for needed type of reconstruction.

ABDOMINAL AORTIC ANEURYSM

Indications for Surgery

Size more than 5.5 cm transverse diameter is an indication. Risk of rupture is 1% if size is less than 5.5 cm; it is 20% if size is 7 cm. Mortality in rupture is 90% at community level; 50% if they reach hospital and undergoes surgery immediately.

Symptomatic aneurysm like pain/tenderness—whatever the size of aneurysm is.

Ruptured aortic aneurysm is *an emergency situation* with high mortality. It needs immediate surgery and aneurysm repair. Rupture may be anterior (20%) into the peritoneal cavity or posterior (80%) with formation of retroperitoneal haematoma.

Preoperative Preparation

It is essential in relation to cardiac, renal and pulmonary functions. Mass in the abdomen may be palpable clinically with a bruit over it. Lower limb ischaemia often may be evident on both sides. Thrombus from the aneurysm may cause emboli. CT abdomen or CT angiogram is a must. Size, thickness of the wall, course of ureter, site of left renal vein and status of visceral arteries are important findings to be assessed.

Preoperative bowel (colonic) preparation is essential **(Fig. 11-59)**.

Prophylactic antibiotics are given just during incision time.

Central line, an arterial line, nasogastric tube, warming blanket to upper body, urinary catheter - are needed **(Figs 11-60 and 11-61)**.

Epidural catheter with general anaesthesia is used. Both hands are tied over chest wall.

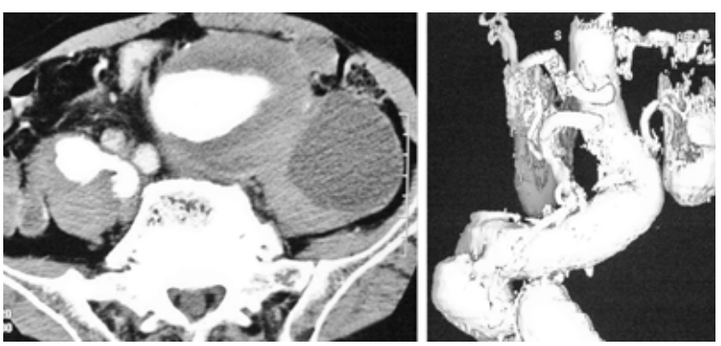


Fig. 11-59: CT scan showing abdominal aortic aneurysm.

Fig. 11-60: Aortogram showing aortic aneurysm.

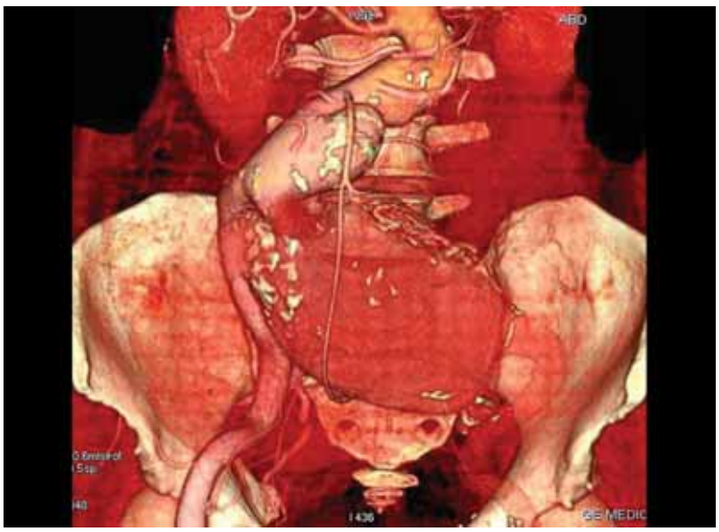


Fig. 11-61: Reconstructed CT angiogram showing abdominal aortic aneurysm.

Surgical Procedure

Midline incision from xiphisternum to pubic symphysis. Occasionally horizontal incision or midline incision extending across the costal margin is done. Abdomen is explored for additional pathologies, if any to confirm. Manipulation of the aneurysm should be avoided. Surgeon usually stands on left side of the patient but can stand on right side if he feels comfortable. Entire small bowel is mobilised towards the right side of the abdomen to visualise the base of mesentery; gut is wrapped with sterile towel and placed in a gut bag. Transverse colon is lifted above packed superiorly. Posterior peritoneum is divided at the junction of small bowel mesentery on right and large bowel mesentery on left. Division is continued up towards duodenojejunal junction which is identified by inferior mesenteric vein. Duodenum should not be injured. Left renal vein should be identified above, which runs usually in front of the aorta from left side. Rare anatomical variation of retroaortic left renal vein should be remembered. Inferior mesenteric vein is displaced above or ligated at its orifice. Left renal vein is usually above the level of the neck of the aneurysm. Left gonadal and left adrenal veins are not ligated but occasionally there will be a need to ligate left renal vein if neck of the aneurysm extends above this level. In such situation left gonadal and adrenal veins should be intact to drain left kidney **(Fig. 11-62)**.

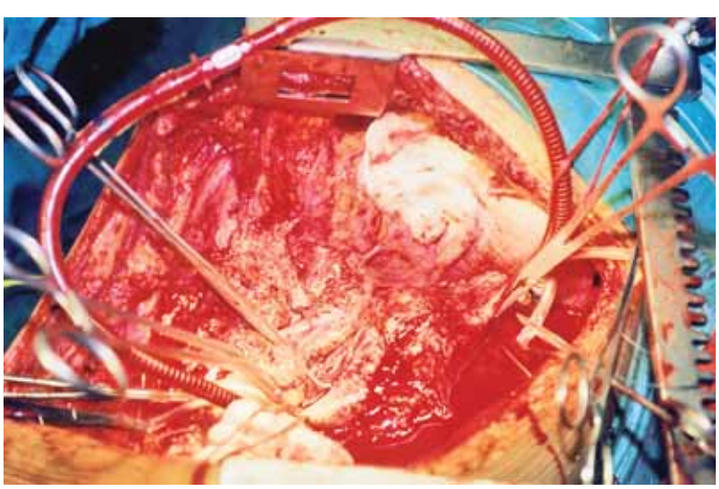


Fig. 11-62: Aneurysm if extensive blood flow can be diverted temporarily by placing arterial catheter from proximal to distal part.

Junction of aorta where it enlarges as aneurysm is identified in upper part. 1 cm of normal aorta above is dissected carefully. Sides of the normal proximal aorta is only dissected; never posteriorly. Posterior dissection by finger or instrument will unnecessarily injure lumbar vessels to cause torrential bleeding. Often renal arteries arise from the neck of the aneurysm at upper end. Renal arteries should be preserved.

Dissection below is done by exposing both iliac arteries. Ureters run in front of iliac arteries. Ureters should not be disturbed; dissection is done on either side of the ureter. Stretched ureter falls aside once aneurysm is dealt with. Blood supply of the ureter should be kept intact. Left iliac artery is often difficult to dissect due to presence of sigmoid colon. Sigmoid is mobilised by incising the sigmoid mesentery laterally and mobilising it entirely towards right side. It is important especially if there is extended aneurysm towards left iliac artery.

Vascular clamps are applied to iliac arteries on both sides at sufficient distance from aortic bifurcation. If there are aneurysms extending to common iliac arteries then external and internal iliac arteries are dissected separately and clamps are applied individually to them. It is often difficult to dissect the internal and external iliac arteries off their accompanying veins as veins are closely adherent to arteries at this level. In such occasion both arteries and veins are clamped together. Intraluminal balloon tamponade also can be used. If aneurysm extends down into both branches of common iliac arteries then femorals including deep femorals should be dissected for clamping. Deep femorals should be retained especially if bilateral internal iliac arteries are having aneurysm.

Preclotting of knitted Dacron graft is done. Patient is heparinised before clamping the aorta and arteries by giving 5000 to 10000 units of heparin. First iliac arteries are clamped. Aortic clamp is placed above the neck of the aneurysm. Glover's clamp can be placed easily from front to back instead from side-to-side. Aortic clamp should be tightened only to stop the distal pulsation.

Aorta is opened towards right side in front at the level of inferior mesenteric artery; it is extended above along the midline; downwards and below towards right side. At the neck of the (upper part) aneurysm anterior wall is cut transversely to open the aneurysmal sac. Also just above the bifurcation below, aortic anterior wall is cut transversely. Thrombus is scoped out. Origin of inferior mesenteric artery is held in the left flap of the aneurysm sac with vascular clamp to prevent bleeding (retrograde) from the inferior mesenteric artery. Initial profuse bleeding from the posterior wall of the aneurysm wall is from the lumbar arteries which are securely ligated using 4 zero polypropylene sutures. All origins of lumbar arteries should be ligated as once graft is placed its continuity cannot be restored **(Fig. 11-63)**.

Proximal part of the graft is sutured to the neck of the aneurysm using 3 zero polypropylene continuous sutures. Bites should be at 1 mm gap. Bite is taken from inside aorta to outside and from outside graft towards inside graft. Edge bite should be 2 mm from cut margin of aorta and also of graft. Knot should be towards left side to avoid closeness towards duodenum to prevent the possible aortoduodenal fistula.

Graft is clamped just distal to anastomosis and aortic clamp is released to check any leaks. Distal end of the graft is measured and cut adequately. It should not protrude beyond the bifurcation. Posterior bites of the suture material should be taken carefully as left common iliac vein lies close to its posterior wall. Continuous 4 zero or 3 zero polypropylene sutures are used often by parachute technique. Just prior to finishing the distal anastomosis, all clamps are released to clear clots and debris. First iliac artery clamp is released; and after few minutes clamp on other iliac artery is released. This is to avoid rapid

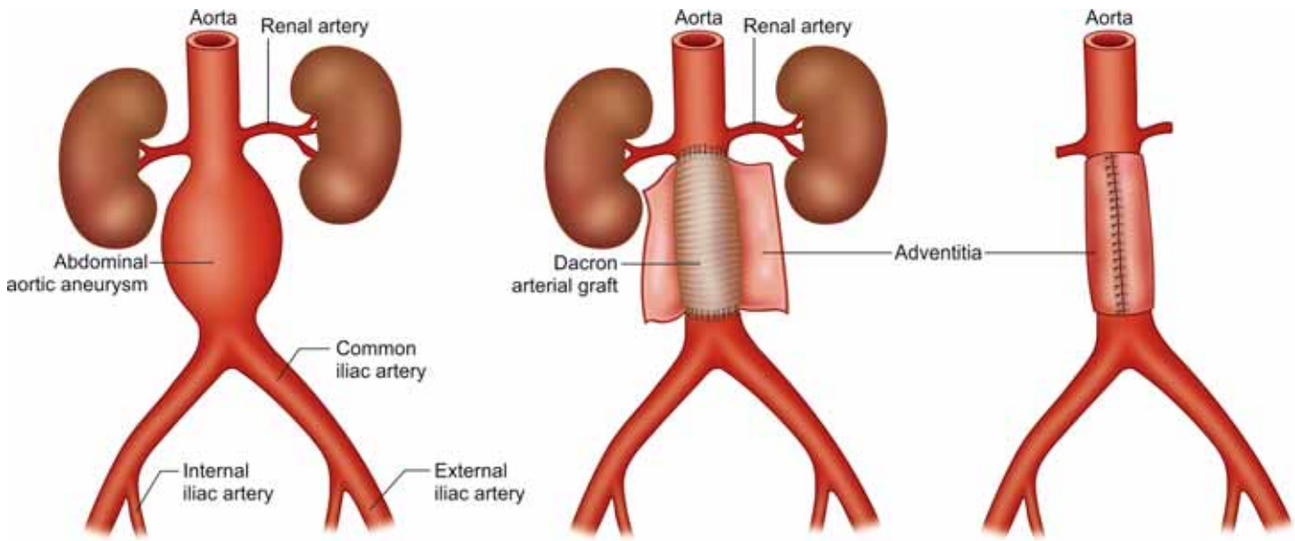


Fig. 11-63: Infrarenal aortic aneurysm repair.

fall in blood pressure after releasing the clamp which is due to return of cold deoxygenated blood, activated white cells, CO_2 and lactic acid causing cardiac depression and pulmonary vasoconstriction. A drop of 20 mmHg blood pressure is accepted. Back bleeding from inferior mesenteric artery is checked before ligating it. If it is not adequate then it needs to re-implant into the graft at proper place to maintain the adequate colonic perfusion. Sac is closed around the graft to prevent direct contact of the graft and gut **(Fig. 11-64)**.

If aneurysm is extending into both common iliac arteries then bifurcation graft is placed; both distal ends are sutured at the junction of origins of external and internal iliac arteries. Graft should be placed within the aneurysmal sac. If there is aneurysm at iliac bifurcation but not involving internal iliac artery then external iliac artery distal to the aneurysm level is transected; its distal cut end is anastomosed to the similarly cut end of the internal iliac artery; graft is sutured to side of external iliac artery as 'end-to-side'. If internal iliac artery is also aneurysmal then it is ligated; graft is sutured to distal cut end as 'end-to-end' anastomosis **(Fig. 11-65)**.

Postoperative Care

ICU monitoring, measurement of output, assessment of clotting factors, pain management, antibiotic coverage are usual requirements in postoperative period. Heparin is used to prevent DVT. FFP, platelet and blood are often needed. Patient is observed for bleeding and when suspected evaluation by haematocrit, US or CT abdomen is done. Any leak/disruption needs re-exploration.

Complications

Immediate Complications

Haermorrhage can occur from leak or bleeding from the branch vessels like lumbar arteries. Occasionally it may be due to injury to adjacent veins. It needs re-exploration and control of bleeding appropriately.

Later Complications

Colonic ischaemia (10%) develops if there is poor back bleeding in the cut inferior mesenteric artery origin. In such occasion, it is better to do re-implantation of the inferior mesenteric artery origin to the graft in front. Once ischaemia develops patient needs laparotomy and resection which carries high mortality due to sepsis.

Myocardial infarction is the commonest complication in first 2 days of surgery. Strict cardiac monitoring and management is required.

Renal failure is not uncommon especially if aneurysm extends up near the origins of the renal arteries. Patient may often require dialysis. It is the commonest non-cardiac complication.

Massive transfusion may cause complications like hyperkalaemia, electrolyte imbalance.

Tracheostomy may be needed for prolonged ventilation.

Sexual dysfunction may develop when internal iliac arteries are involved.

Aortoduodenal fistula/aortoenteric fistula at anastomotic site can occur. It is prevented by proper closing the sac over graft and placing knot of the suture away from the bowel site towards left side. It presents with haematemesis, melaena or hematochezia which is often massive. It needs blood transfusion, exploration and correction of the fistula. It carries high mortality.

Infection is major problem which needs graft removal. It is often a challenging situation to manage.

Microemboli from aneurysm site are called as '*thrash' emboli*. Early clamping of the distal parts of the aneurysm area, flushing out of debris prior to placing last suture bite may prevent this. If it occurs then embolectomy or prostacyclin infusion may be required.

Graft leak, graft thrombosis and graft failure may require regrafting.

Spinal cord ischaemia can develop leading to paraplegia. It is due to block in the perfusion of spinal cord at its localized segment.

Prosthetic infection or migration may occur which needs graft removal.

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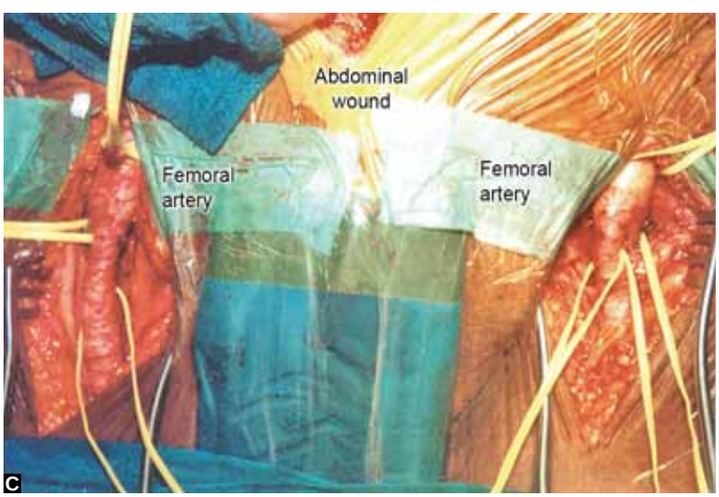
B



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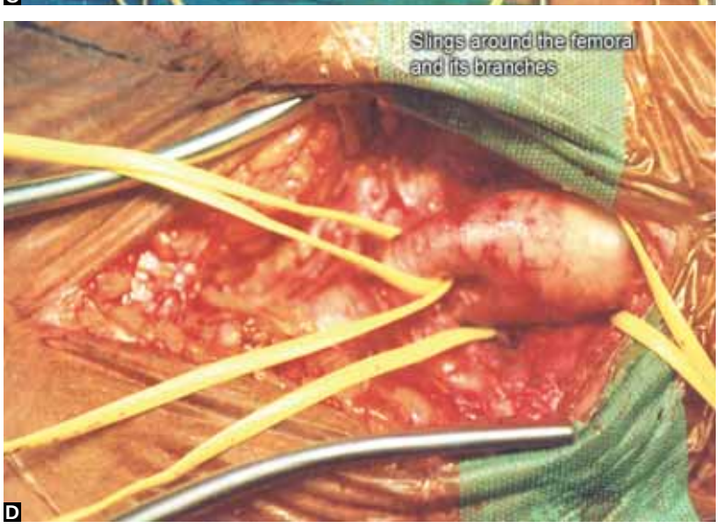

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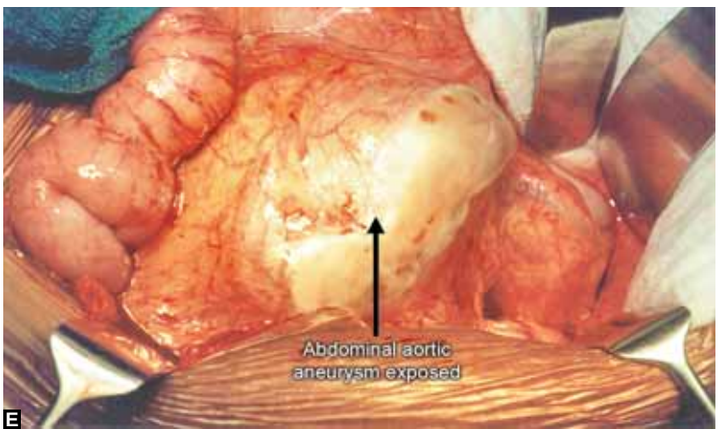

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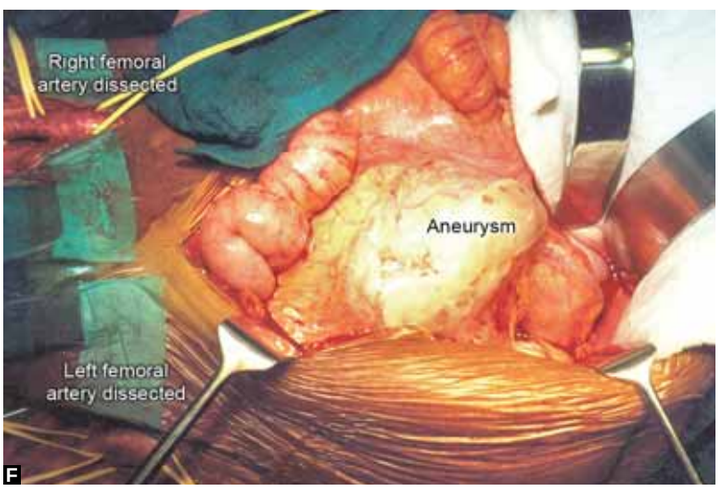

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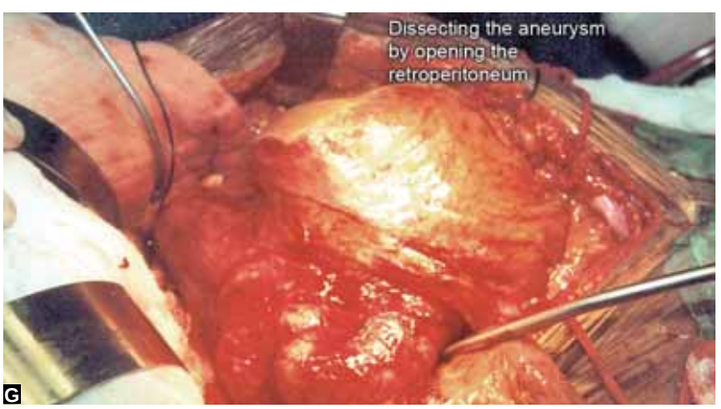

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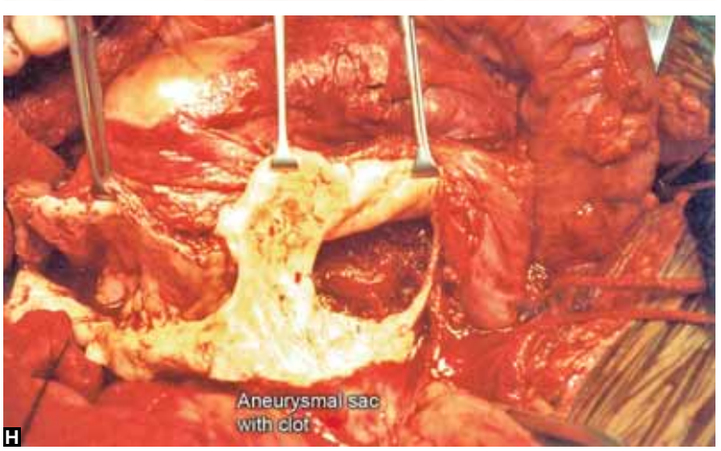
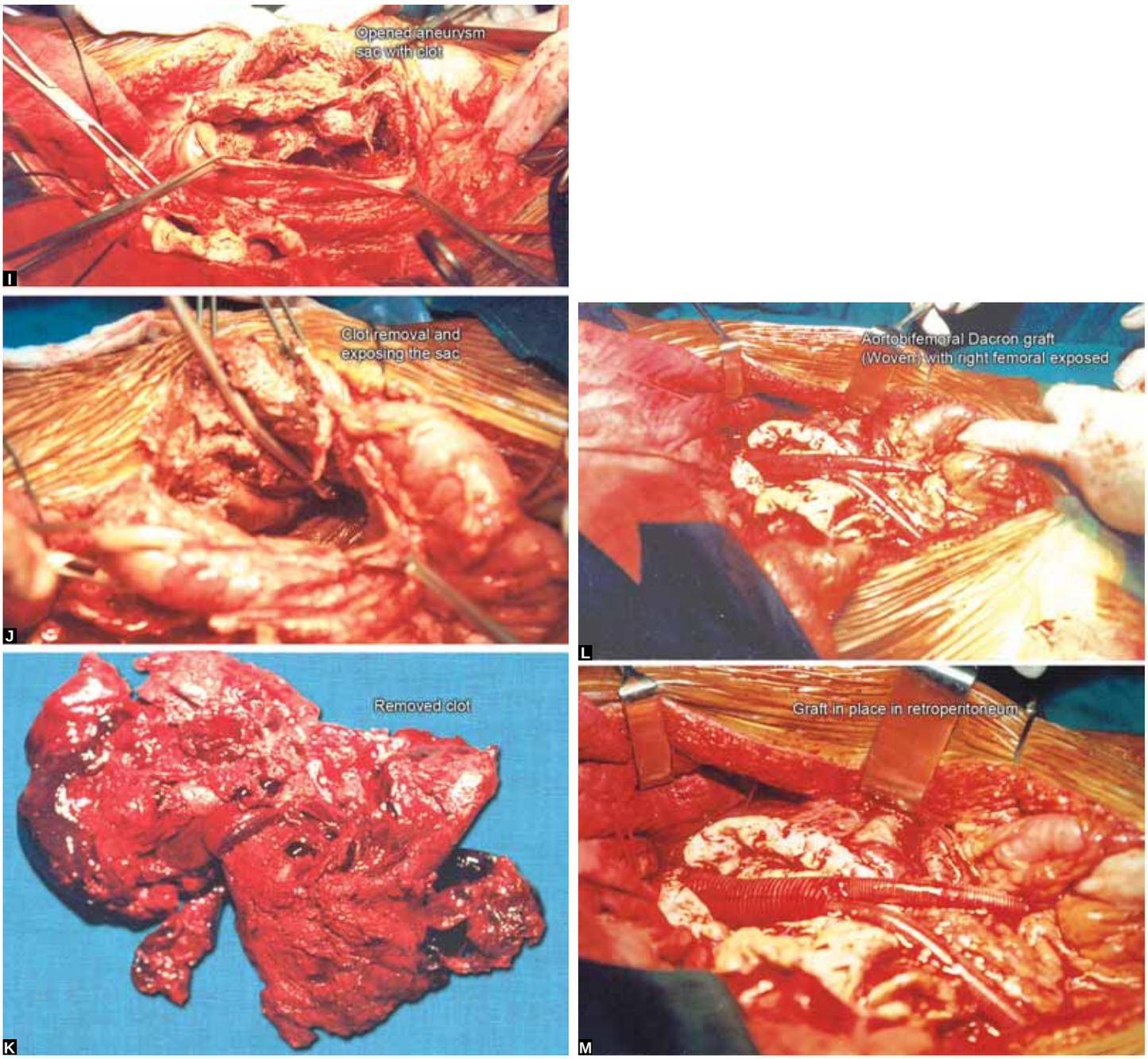


H

Figs 11-64A to H



Figs 11-64I to M

Figs 11-64A to M: Abdominal aortic aneurysm. Operative steps.

Ruptured Aortic Aneurysm

Ruptured aortic aneurysm is a surgical emergency. Intraperiton rupture though less common (20%) has got very high mortality. In *retroperitoneal rupture* which is *more common,* after initial temporary bleeding, it stops due to tamponade effect of peritoneum and so patient can reach the hospital for definitive procedure on emergency basis. Central line, arterial line, urinary catheter and blood (10–20 bottles) for transfusion should be kept ready as preoperative measures. Emergency CT scan can be done if patient is stabilized.

Management of retroperitoneally ruptured aortic aneurysm is same as elective approach. But heparin is not given during procedure. It is administered at all only after clamping the aorta. Heparin solution can be flushed down the iliac vessels to prevent thrombosis of these vessels. Intra-operative complications like persistent ooze, disseminated intravascular thrombosis, myocardial infarction and cardiac arrest are dreaded complications which are not possible to reverse.

In intraperitoneal rupture which is much more critical as there is no temporary tamponade effect by peritoneum, emergency laparotomy is done. Direct pressure is applied over the neck of the aneurysm. A Foley's catheter may be passed into the aorta and inflated at the neck to control bleeding until patient is reasonably resuscitated. Alternatively vascular clamp may be applied directly over the aorta under the diaphragm at the level of crus to have an effective control. Once everything is under control, if patient is stable or reviving, then only repair of aneurysm may be undertaken. Massive blood transfusion

is required. Patient may develop cardiac arrest and succumb at any stage of the procedure.

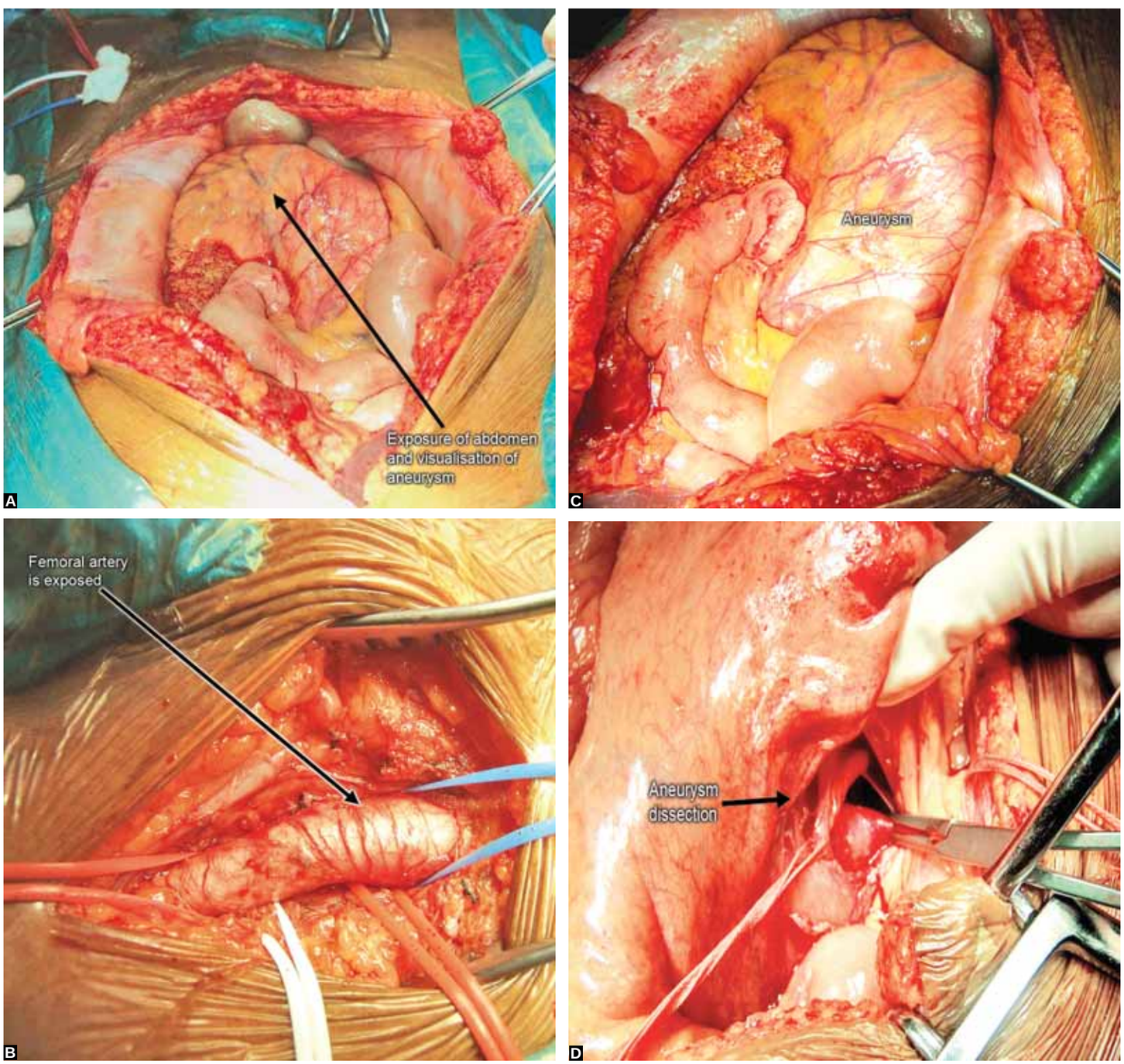
Aorto-Vena Caval Fistula

Aorto-vena caval fistula is a late dreaded complication of aneurysm. Often it is identified during ruptured aortic aneurysm also. It presents with bruit, poor perfusion of both lower limbs, hyperdynamic cardiac status. CT/MR angiogram is diagnostic. Aneurysmal sac is opened from the graft and is sutured using running 3 zero polypropylene sutures. Aorto-caval fistula is a complication of aneurysm repair itself often wherein fistula can occur at graft aorta junction with IVC. On table bleeding is controlled by vena caval finger occlusion or by passing a balloon over the fistula across saphenous vein.

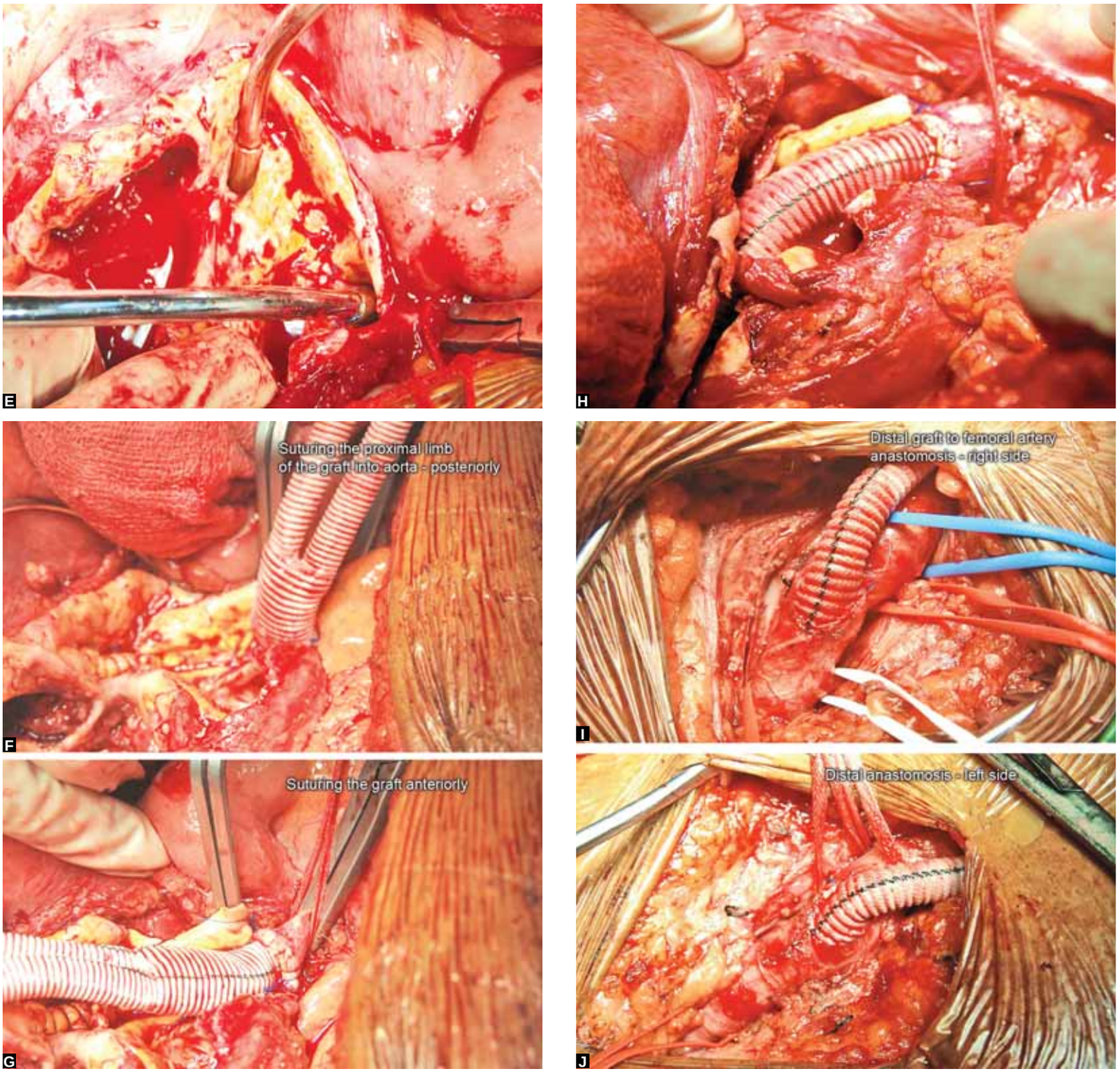
ENDOVASCULAR ANEURYSM REPAIR (EVAR)

In 1991 Juan *Parodi* and Julio Palmaz first did endovascular aneurysm repair. It is less invasive, less morbid with less mortality rate and shorter hospital stay. It is basically aneurysm exclusion method. It is useful in old age and patients who are not fit for surgery. EVAR is basically a prophylactic procedure.

Femoral artery is cannulated; retrograde angiogram is done to evaluate the entire abdominal aorta including renal arteries. Cannulation → guidewire → stent device/graft placement are the steps. Special endovascular prosthesis/device is used and placed in place under guidance. First proximal part at infrarenal level is secured; then distal part



Figs 11-65A to D



Figs 11-65E to J

Figs 11-65A to J: Aortic aneurysm exposure and placing aortofemoral graft.

of the prosthesis is secured on the femoral artery. Contralateral femoral artery is cannulated and prosthesis limb to opposite common iliac artery and femoral artery is placed. Suprarenal endovascular prosthesis needs fenestration for placement to maintain renal perfusion.

Percutaneous femoral artery puncture for device placement is also done. But open method is commonly advocated and safer.

Iliac vessels are also often used as access vessel.

EVAR is indicated if aneurysm is less than 5.5 cm in men and less than 5.0 cm in women. It is usually done in patients after 65 years.

Dacron or ePTFE is the material used as stent. Stent graft type, delivery system and skill for technique are essential. Many anatomical requirements are designed for successful EVAR.

Infrarenal neck is part of aorta between lowest renal artery and beginning of the aneurysmal sac. Anatomical requirements for effective EVAR are – proximal neck length should be more than 15 mm; diameter should be 18-32 mm; suprarenal angulation should be less than 60 degrees; infrarenal angulation should be less than 70 degrees; distal neck diameter should be more than 20 mm; common iliac vessel should be more than 15 mm in length; diameter is 8-25 mm.

Proper preoperative assessment is essential about site, extent and morphology of the aneurysm. Entire technique is done under radiological guidance and so C arm and radiologist's help is essential.

Technique

General or spinal or epidural or local anaesthesia is needed. Abdomen and both groins are prepared. After exposing both common femoral arteries with a small vertical groin incision, using loops proximal and distal control is achieved. Heparin infused as 100 units/kg dose. Both side femoral arteries are cannulated using 18 gauge needle and flexible J guidewire is passed under C arm guidance into thoracic aorta. Needle is removed; 7–9 French sheath is passed across guidewire; guidewire is removed; superstiff specialised guidewire (Meier wire) is inserted into the catheter and kept just below the left subclavian artery. Intra-operative intravascular ultrasound (IVUS) is very sensitive method of evaluating the aortic wall. Angioscaled pigtail catheter is passed through opposite common femoral artery into the abdominal aorta upto L_1, i.e. level of the renal arteries and aortogram is done to confirm the position of the renal arteries. Selected aortic endovascular graft is marked properly to identify upper part, right (same) side/limb and left limb. Graft is passed through *same side first* common femoral artery along superstiff guidewire; upper most part of the graft is positioned just below the level of renal arteries. Main body of the graft and same side limb of the graft are released and position is confirmed by C arm image. Superstiff guidewire is removed from same side common femoral artery. Position of opposite limb gate of the graft is confirmed by passing an angled guidewire and guide catheter through opposite limb into main body of the graft followed by injecting contrast agent. A balloon catheter passed through opposite limb of the graft and once balloon is in the body of the graft its position can be confirmed if inflated. IVUS is also very useful to confirm the position across opposite limb gate. Superstiff guidewire is passed through opposite common femoral artery across graft and aorta unto left subclavian artery level. *Opposite limb of graft* is inserted and deployed. Using a compliant balloon inflation upper end and lower ends of the graft is made to seat and seal properly into the aortic wall. A final check angiogram is done to find out endoleaks and confirm position. Sheaths and wires are pulled out. Arterial puncture site may often need polypropylene suture closure. Wound is closed. Distal pulses are checked.

Patient is discharged in 2 days. In postoperative period patient is monitored for leak, thrombosis, embolism and infection.

In suprarenal aneurysms branched or fenestrated aortic grafts are placed. But it is technically demanding.

EVAR is under trial in ruptured aortic aneurysm **(Figs 11-66A to D)**.

Problems and Complications

Problems are cost, displacement/malposition of graft, dissection, thrombosis, infection, iliac artery avulsion, need for replacement later often and endoleak. *Other complications* are – myocardial infarction; infection either local or wound or urinary or respiratory; ischaemia of sigmoid colon; distal embolisation; clamp injuries; renal failure; stent migration, stent fracture and kinking are other complications.

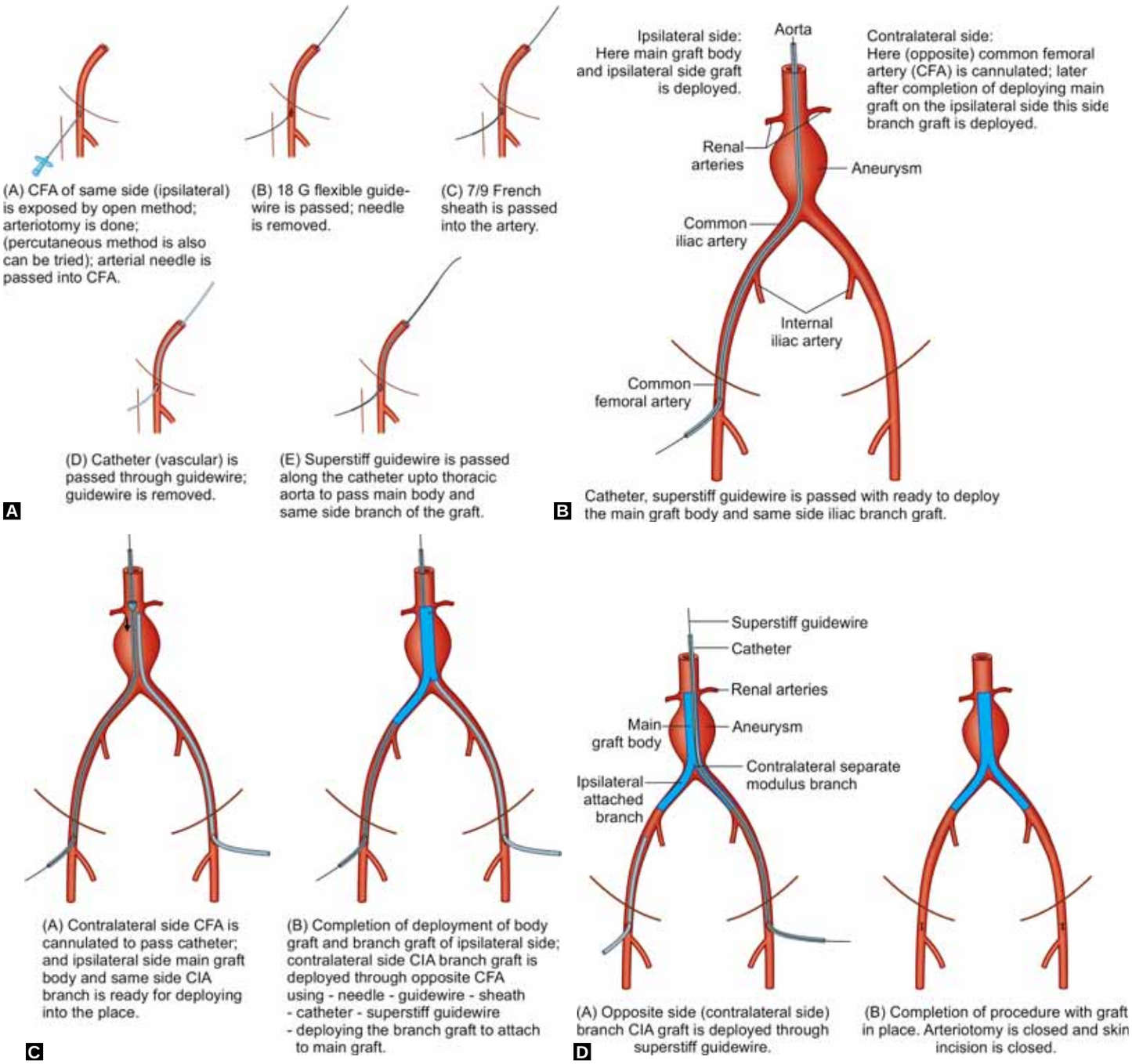
Endoleak is blood leak across the placed endovascular prosthesis material. Four types can occur in abdominal aortic endovascular prosthesis leak. Type I – Leak from proximal or distal ends from sides of the graft into aneurysm (Ia – proximal; Ib – distal; Ic – iliac plug site). Type II – Back bleeding from lumbar or inferior mesenteric artery into the aneurysmal sac which is the most common leak (IIa – single vessel bleed; IIb – multiple vessel inflow and outflow bleed). Type III – Leak from inadequate graft to graft overlap at junctions (IIIa – modular junction leak or disconnection; IIIb – graft fabric tear). Type IV – Leak from graft itself due to porosity of graft. All type I and II leaks need intervention; type III is mostly treated conservatively.

COMPLICATIONS OF REVASCULARISATION IN ACUTELY ISCHAEMIC LIMB

- *Reperfusion* injury
- 'No reflow' phenomenon – It is due to severe capillary oedema causing poor peripheral tissue hypoperfusion in spite of major vessel revascularization.
- Acute compartment syndrome can occur due to massive ischaemic oedema especially of skeletal muscles deep to deep fascia which compress on venules exceeding tissue interstitial pressure causing further compromise in tissue perfusion. Compartment pressure when measured using transducer needles will be more than 40 mm Hg or > 30 mm Hg for 3 hours or above the mean arterial pressure. Muscle weakness, sensory changes, leg pain which is aggravated by dorsiflexion of toes.
- Other complications are – sepsis, reblock, bleeding and catheter related complications.

Reperfusion Injury

- It occurs after reestablishment of arterial flow to an ischaemic tissue bed which further leads to tissue death causing specifically *peripheral muscle infarction*. It is due to sudden release of oxygen free radicals which block the microcirculation, with release of high levels of potassium (hyperkalaemia) and myoglobin (myoglobinaemia and myoglobinuria). Haemodynamically patient becomes unstable with lactic acidosis, intracellular changes, interstitial oedema and cardiac dysfunction. It is often life threatening.
- *Haimovici triad* of revascularisation injury (1960) – (1) Muscle infarction; (2) Myoglobinuria; (3) Acute renal failure.
- Severe ischaemia causes oedema in the muscular compartment with raise in compartment pressure more than the essential capillary perfusion pressure causing *acute compartment syndrome*. It is common in the anterior compartment of the leg. It is basically in the skeletal muscles deep to deep fascia. Compartment pressure when measured using transducer needles will be more than 40 mm Hg or > 30 mm Hg for 3 hours or above the mean arterial pressure. Muscle weakness, sensory changes, leg pain which is aggravated by dorsiflexion of toes.
- *No re-flow phenomenon* due to tissue oedema causing to capillary perfusion block. Even though compartment syndrome and 'no reflow' phenomenon are separate entities they are always seen together along with reperfusion injury.
- Metabolic acidosis, acute tubular necrosis causing acute renal failure and cardiac arrhythmias set in and become life threatening.
- **Features are** – toxaemia; oliguria; persistent pain and oedema in the leg with muscular tenderness; raised blood urea and serum creatinine with features acute ischaemia in the limb.
- **Treatment** –
  - Mannitol to prevent renal failure; fluid therapy.
  - Fasciotomy to reduce raised compartment pressure. All four compartments of lower limb should be decompressed surgically. Long vertical lateral deep fasciotomy incision in the calf behind the fibula along the deep fascia and its fibular attachments


(A) CFA of same side (ipsilateral) is exposed by open method; arteriotomy is done; (percutaneous method is also can be tried); arterial needle is passed into CFA.
(B) 18 G flexible guide-wire is passed; needle is removed.
(C) 7/9 French sheath is passed into the artery.
(D) Catheter (vascular) is passed through guidewire; guidewire is removed.
(E) Superstiff guidewire is passed along the catheter upto thoracic aorta to pass main body and same side branch of the graft.
A
Ipsilateral side: Here main graft body and ipsilateral side graft is deployed.
Aorta
Contralateral side: Here (opposite) common femoral artery (CFA) is cannulated; later after completion of deploying main graft on the ipsilateral side this side branch graft is deployed.
Renal arteries
Aneurysm
Common iliac artery
Internal iliac artery
Common femoral artery
Catheter, superstiff guidewire is passed with ready to deploy the main graft body and same side iliac branch graft.
B
(A) Contralateral side CFA is cannulated to pass catheter; and ipsilateral side main graft body and same side CIA branch is ready for deploying into the place.
(B) Completion of deployment of body graft and branch graft of ipsilateral side; contralateral side CIA branch graft is deployed through opposite CFA using - needle - guidewire - sheath - catheter - superstiff guidewire - deploying the branch graft to attach to main graft.
C
Superstiff guidewire
Catheter
Renal arteries
Main graft body
Aneurysm
Contralateral separate modulus branch
Ipsilateral attached branch
(A) Opposite side (contralateral side) branch CIA graft is deployed through superstiff guidewire.
(B) Completion of procedure with graft in place. Arteriotomy is closed and skin incision is closed.
D

Figs 11-66A to D: Technique of endovascular aneurysm repair (EVAR).

is a must. Bleeding as patient is heparinised is common after fasciotomy. Infection of the wound can occur. Later once patient is stabilized and oedema subsides with healthy wound, secondary suturing or skin grafting is done. If fasciotomy is not done and if patient survives, it is with eventual Volkmann's ischaemic contracture.

– Antibiotics and supportive therapy.

ACUTE ISCHAEMIA

Acute ischaemia is a surgical emergency. It is common in lower limb but can occur in upper limb, mesenteric vessels, kidney, brain, etc.

Acute Limb Ischaemia

Acute limb ischaemia is either due to embolus or thrombosis. In embolic block critical period is 6 hours otherwise ischaemic damage is likely to occur. So early intervention to remove the block and to achieve revascularisation is needed. Once limb is non-viable and gangrenous attempt to revascularisation should be avoided as it will lead into multiorgan failure and death. Thrombolysis is not a suitable option in acute limb ischaemia as it takes time to act; before that limb becomes nonviable. Emergency Doppler is sufficient. If facilities are available angiogram can be done; but for the sake treatment cannot be delayed. On table angiography is very useful. Immediate

anticoagulation is done with 10,000 units of heparin. C*ommon sites of embolus block* in limbs are—common femoral artery in the groin and brachial artery in elbow. Embolus block precipitates thrombus formation proximally and distally which propagates on both directions **(Figs 11-67 to 11-69)**.

Femoral Embolectomy

It is done under local anaesthesia. *C arm imaging facility* should be there ideally in theatre while doing embolectomy. If additional procedure like bypass graft is required then spinal or general anaesthesia is needed. Entire limb should be prepared for the procedure to observe distal perfusion. Oblique or vertical incision is made in the thigh along the line of femoral artery; skin, subcutaneous tissue, Scarpa's fascia is incised. Common femoral, superficial femoral and profunda femoris arteries are identified; dissected and slings are placed around each. Longitudinal or oblique arteriotomy is done in the common femoral artery often extending into the profunda femoris artery in case if profundaplasty with venous patch is needed. Size 4 Fogarty catheter is passed along the iliac artery proximally to clear the thrombus to achieve good inflow; immediately iliac artery is flushed with heparinised saline (2000 units in 500 ml of saline). Size 3 Fogarty catheter is passed distally along the superficial femoral artery; small fragments or ribbon arterial cast with propagated thrombus is extracted from distal part. It is repeatedly passed until all fragments are cleared with adequate back bleeding. Usually catheter is passed around 40 cm distally to achieve good embolectomy **(Fig. 11-70)**.

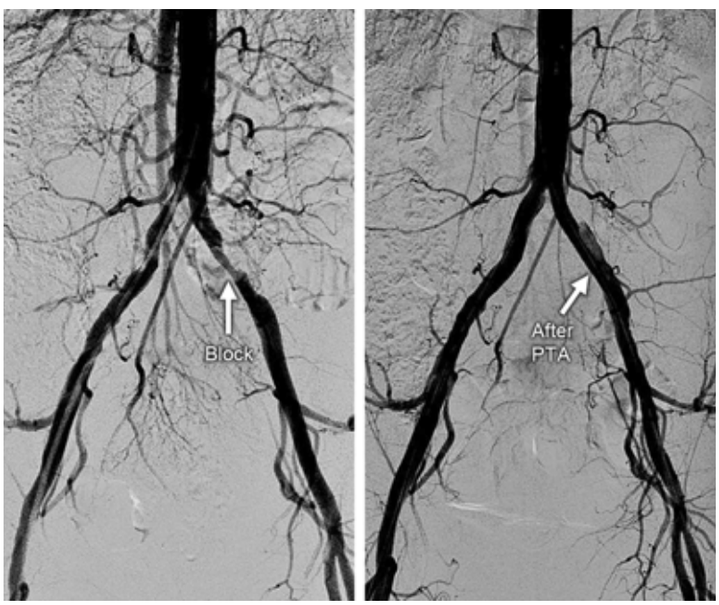


Fig. 11-67: Digital subtraction angiogram showing block in left aortoiliac segment. It is corrected by PTA (percutaneous transluminal angioplasty).

Fig. 11-68: Digital subtraction angiogram showing superior mesenteric artery block/stenosis which is corrected by PTA.

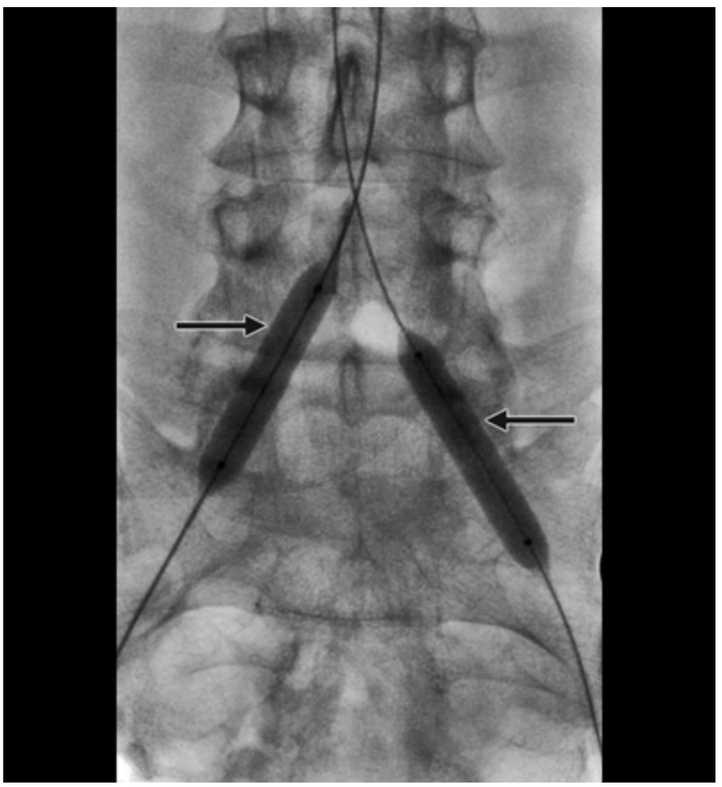


Fig. 11-69: Percutaneous transluminal angioplasty (PTA) balloon catheter in place.

A completion angiogram is done to confirm the adequacy of the flow, if reperfusion is poor, if Fogarty cannot be passed beyond adductor hiatus. Adherent clot can be lysed by direct injection of the tissue plasminogen activator (TPA) 10 mg in 20 ml saline, into the clot for 30 minutes. Profundaplasty may be added to prevent narrowing and rethrombosis.

Brachial Endarterectomy

Usual site of embolic block is at its bifurcation in antecubital fossa. Procedure is done usually under local anaesthesia. Entire limb should be cleaned from shoulder and axilla to hand. A lazy S incision is made from medial part of lower arm across biceps tendon down into the forearm. Brachial artery is deep to bicipital aponeurosis which can be divided. Median nerve should be taken care of and retracted. Brachial artery with its bifurcation branches is dissected and isolated with slings/loops. Bulldog clamps are applied to arteries. A transverse

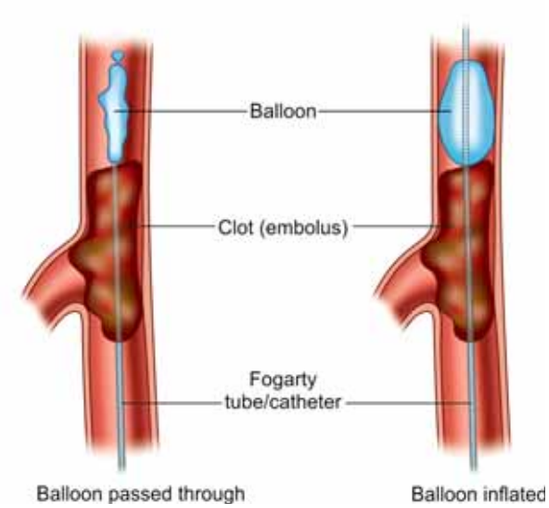


Fig. 11-70: Technique of arterial embolectomy.

arteriotomy is made 1 cm proximal to bifurcation over brachial artery. Fogarty catheter is passed proximally and block is removed to clear inflow which is infused with heparinised saline. Distal arteries are also cleared by passing Fogarty catheter into ulnar and radial arteries. Clamps are released—first the proximal clamp and then distal clamps. Good back feeding should be achieved. Completion angiogram is done. Arteriotomy is closed using 6 zero polypropylene sutures.
Complications are – bleeding, thrombosis, infection and failure.

Saddle Embolus

It is the large embolus blocking at bifurcation of aorta presenting with acute ischaemic features in both limbs. Doppler and angiogram is diagnostic. It is usually due to large mural thrombus blocking at the bifurcation. Cardiac opinion and echocardiography is a must **(Fig. 11-71)**.

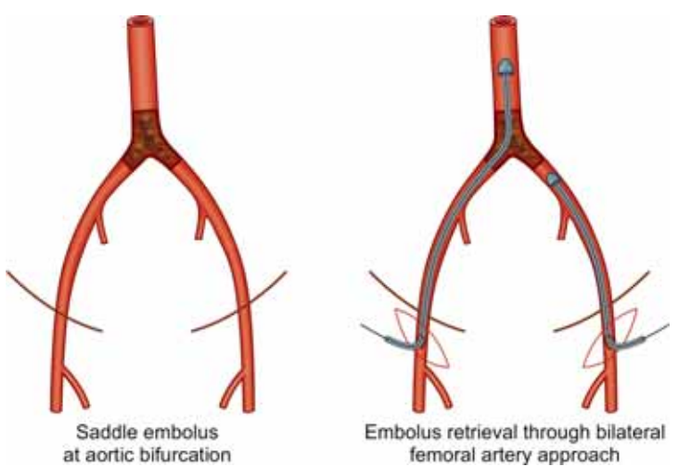


Fig. 11-71: Saddle embolus at the aortic bifurcation. It is retrieved by embolectomy from bilateral femoral artery approach.

Embolectomy is done by passing Fogarty catheter balloon through both femoral arteries. Patient should be heparinised. On table angiogram is a must.

THORACOABDOMINAL ANEURYSM

Type I – It involves descending thoracic aorta and abdominal aorta up to the origin of visceral vessels.

Type II – Aneurysm involving entire descending thoracic and entire abdominal aorta.

Type III – It involves lower part of descending thoracic aorta and entire abdominal aorta.

Type IV – Entire abdominal aorta including suprarenal portion (but aorta above the diaphragm is normal) **(Fig. 11-72)**.

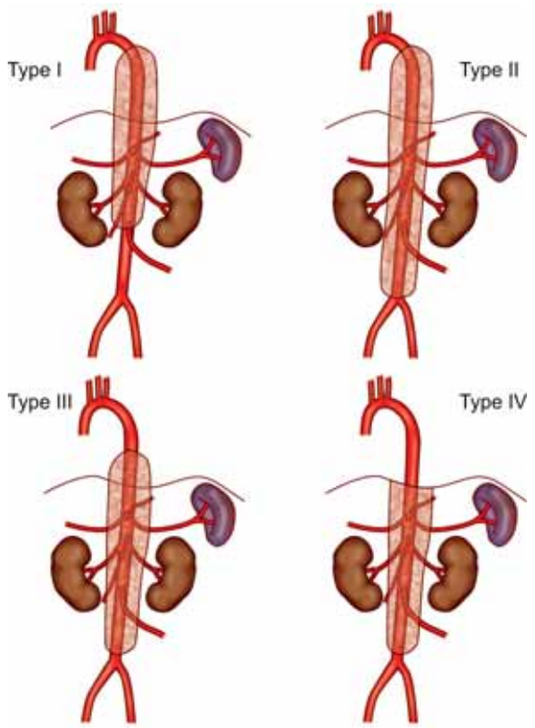


Fig. 11-72: Classification of thoracoabdominal aneurysm.

Exposure - Patient is placed of left side thorax and abdomen upwards with thoracoabdominal approach. Spleen with left kidney is rotated medially to access the abdominal aorta upper part. Left lung is collapsed to visualise the thoracic aorta. Inflow may be maintained by temporary shunting or left heart bypass to femoral artery which will maintain visceral perfusion. Cooling of the kidneys and diuretics is needed as an additional protection. Aneurysm is opened. Pair of intercostal vessels is reimplanted into the graft first to maintain the blood flow of spinal cord. Graft is sutured proximally into the thoracic aorta after proximal clamping distal to bypass. Visceral arteries (coeliac trunk, SMA, IMA, right renal artery) are anastomosed with a part of native aorta at their origin into the hole made in the graft. Left renal artery origin is separately implanted into the graft with a similar patch of native aorta. Distal end of the graft is anastomosed to distal end of the aorta distal to aneurysm level. Procedure is done usually by a cardiothoracic or vascular surgeon.

Problems are – spinal cord ischaemia with paraplegia; myocardial ischaemia; reperfusion injury.

RENAL REVASCULARISATION

Renal artery stenosis more than 70% will deteriorate the kidney function. Angioplasty is ideal in stenosis due to fibromuscular dysplasia.

Renal endarterectomy can be done with a venous patch over the stenosed area.

A graft can be used between terminal renal artery and infrarenal part of the aorta. Renal artery is ligated at its origin. Distal end of renal artery is anastomosed into the end of the arterial graft, the other end of it to side of the infrarenal portion of the aorta. If aorta is very much diseased, then right renal artery is anastomosed to hepatic artery and left renal artery is anastomosed to splenic artery after splenectomy **(Fig. 11-73).**

EXPOSURE OF CAROTID ARTERY

It is indicated in endarterectomy to prevent stroke; excision of carotid body tumour; carotid artery aneurysm repair; in trauma of carotid artery.

Anaesthesia – general or local (in case of emergency).

Position – supine with head extended and turned away from the side of the surgery with sandbag under the shoulder.

Incision – from upper margin of the medial end of the clavicle along the anterior margin of the sternocleidomastoid muscle to the angle of the jaw extending above further backwards. Transverse skin crease/S shaped incision are also helpful for a better cosmetic look.

Anatomy

Right CCA begins as a branch of brachiocephalic artery behind the right sternoclavicular joint. *Left CCA* arises from arch of aorta in the thorax in front of trachea and behind left of the manubrium to continue in the neck under left sternoclavicular joint. In the neck it runs upwards along and deep to inner border of sternocleidomastoid muscle; in front of transverse processes of lower four cervical vertebrae. At the level of thyroid cartilage it divides into external and internal carotid arteries. In front it is related to superior belly of omohyoid (crosses artery), descending hypoglossi nerve, superior thyroid vein, sternothyroid, ansa cervicalis, sternohyoid, anterior jugular vein, middle thyroid vein and sternomastoid. Behind the CCA sympathetic chain descends and ascending cervical artery ascends behind the CCA; inferior thyroid artery crosses medially behind the CCA; left side thoracic duct crosses CCA laterally behind. *Carotid sheath* encloses CCA, IJV (lateral to artery) and vagus nerve (behind). *Carotid sinus* is dilated terminal CCA and beginning of ICA which has got thin media and thick adventitia with rich glossopharyngeal and sympathetic innervations which act as baroreceptor. Carotid body is a small, oval reddish brown body located behind bifurcation of CCA with glossopharyngeal innervation; acts as chemoreceptor.

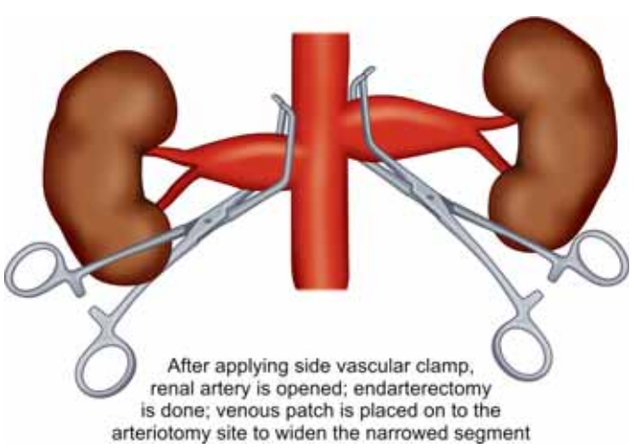

After applying side vascular clamp,
renal artery is opened; endarterectomy
is done; venous patch is placed on to the
arteriotomy site to widen the narrowed segment

Fig. 11-73: Renal endarterectomy with venous patch over the stenosed area.

ECA begins as one of the terminal branches of CCA and runs as anteromedial to ICA in lower part and anterolateral to ICA in upper part. ECA is convex towards front in lower part; concave towards front in upper part. In the carotid triangle, ECA is crossed in front by cervical branch of facial nerve, hypoglossal nerve, facial, lingual and superior thyroid veins; deeply it is related to pharynx, superior laryngeal nerve with its external and internal branches. Above the carotid triangle ECA enters the parotid gland; here it is related in front to retromandibular vein and facial nerve; behind to (1) ICA; (2) styloglossus, stylopharyngeus, glossopharyngeal nerve, pharyngeal branch vagus, styloid process (which passes between ECA and ICA); (3) superior laryngeal nerve and superior cervical sympathetic ganglion (are deep to ICA). Branches of ECA (8) are – In front are superior thyroid, lingual and facial; behind are occipital and posterior auricular; medial is ascending pharyngeal and terminal are larger maxillary and smaller superficial temporal.

ICA is one of the terminal branches of CCA beginning at upper level of thyroid cartilage opposite C3 and C4 vertebral disc entering into carotid canal to reach the cranial cavity. It has got 4 parts – cervical; petrous; cavernous; and cerebral. At the beginning there is dilatation called as carotid sinus. In the carotid triangle below it is related in front to sternomastoid muscle, hypoglossal nerve, descending hypoglossi, occipital artery, common facial and lingual veins, and ECA (anteromedial). In the digastrics triangle above it is related in front to posterior belly of digastric, stylohyoid, posterior auricular artery, stylopharyngeus, styloid process, parotid, glossopharyngeal nerve, pharyngeal branch of vagus, cartilaginous part of auditory tube, tensor veli palatine. Posteriorly it is related to longus capitis, superior cervical ganglion, superior laryngeal nerve, carotid sheath, pharyngeal veins, vagus (posterolateral), glossopharyngeal, hypoglossal and accessory nerves. There are no branches to ICA in neck.

Exposure (Fig. 11-74)

Cervical branch of facial nerve should not be injured in upper most part of the incision especially in transverse incision (upper posterior part of the incision should be 1.5 cm below the angle of the mandible in transverse). Platysma and deep fascia are incised in the line of incision → external jugular vein is divided between ligatures → flaps are raised → anterior margin of sternomastoid is dissected and retracted behind → common facial vein which crosses CCA just below the bifurcation in front is identified and divided (supraorbital and supratrochlear veins join to form angular vein which continues as facial vein down and is joined by deep facial vein which is an extension vein from pterygoid plexus; this facial vein is joined by anterior division of retromandibular vein to form common facial vein which joins IJV. Posterior auricular vein joins posterior division of retromandibular vein to form external jugular vein which joins subclavian vein below) → IJV is identified as bluish tubular structure with thin wall and is retracted backwards → carotid is identified → descending branch of hypoglossal nerve (can be cut if needed) and main hypoglossal nerves (just above CCA bifurcation) are identified and retained. Thyroid and strap muscles are retracted anteromedially to expose superior thyroid artery and superior laryngeal nerve (deeper); posterior belly of digastric and parotid and greater auricular nerve are identified above. ICA above in the neck is dissected properly (if needed) by dividing digastric tendon, stylohyoid muscle; or often with subluxation of jaw in forward direction **(Figs 11-75 and 11-76)**.

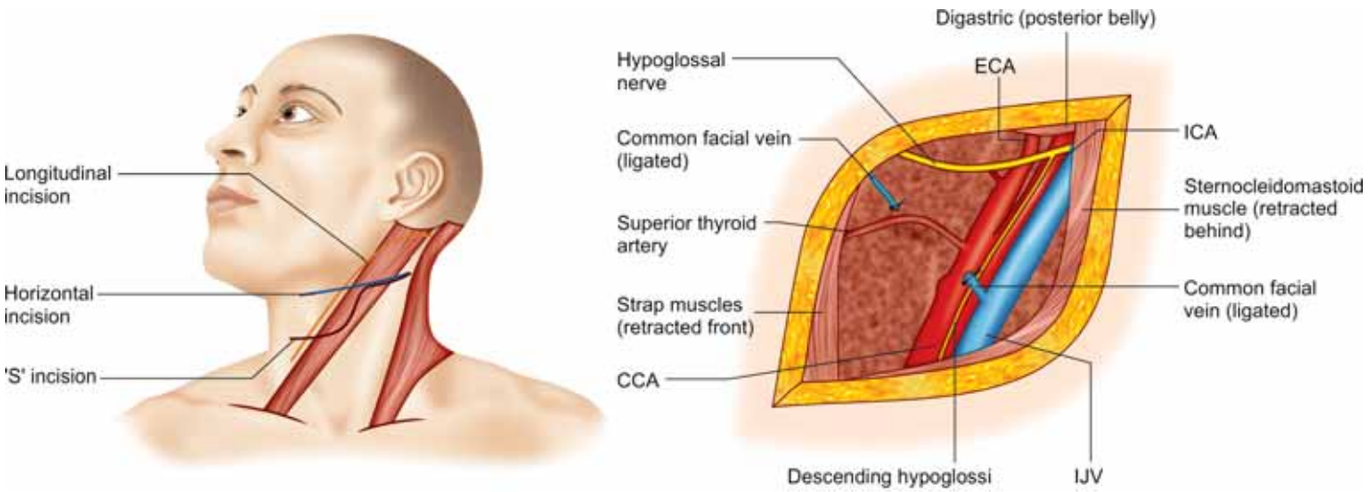


Fig. 11-74: Incision and exposure of carotid artery.

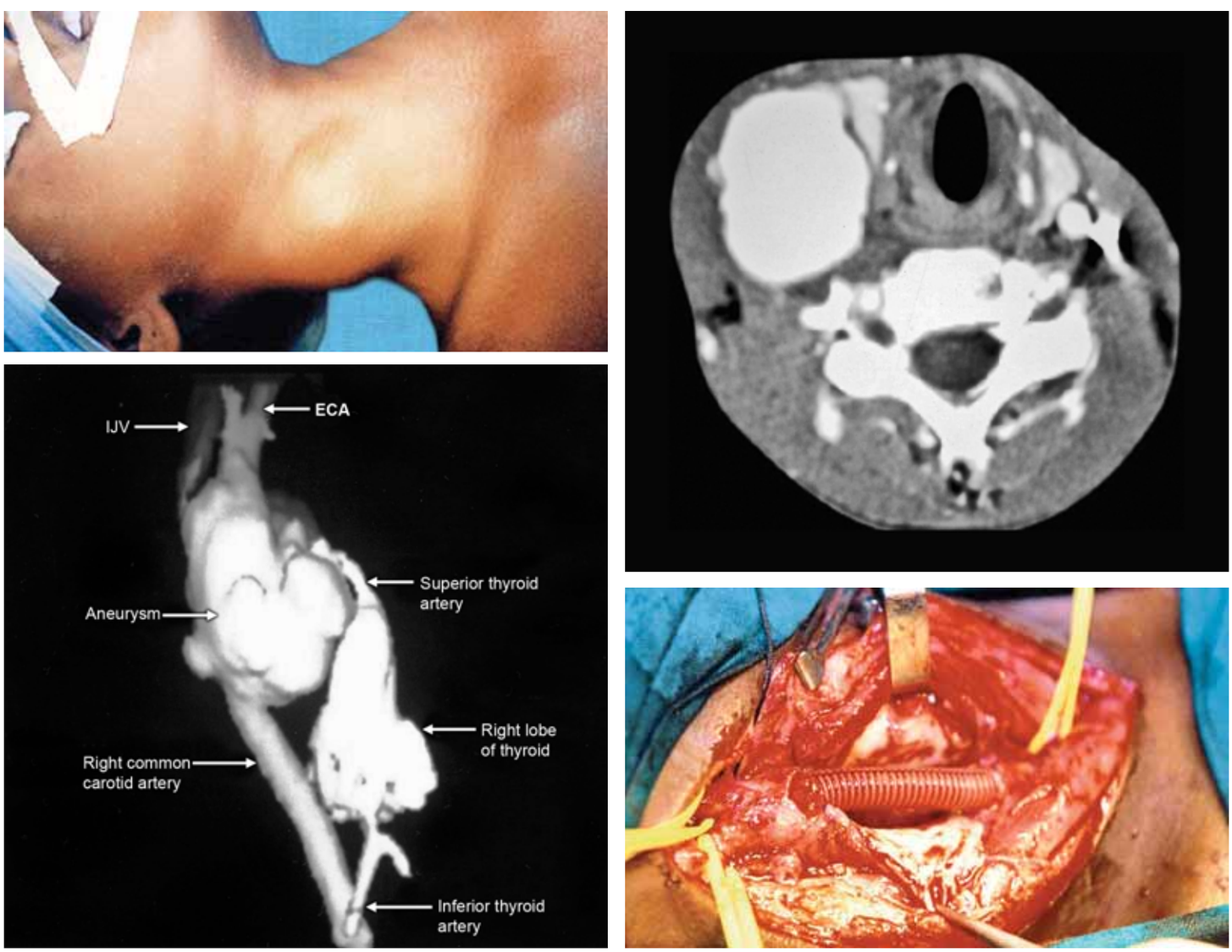


Fig. 11-75: Carotid artery aneurysm and its repair using graft.

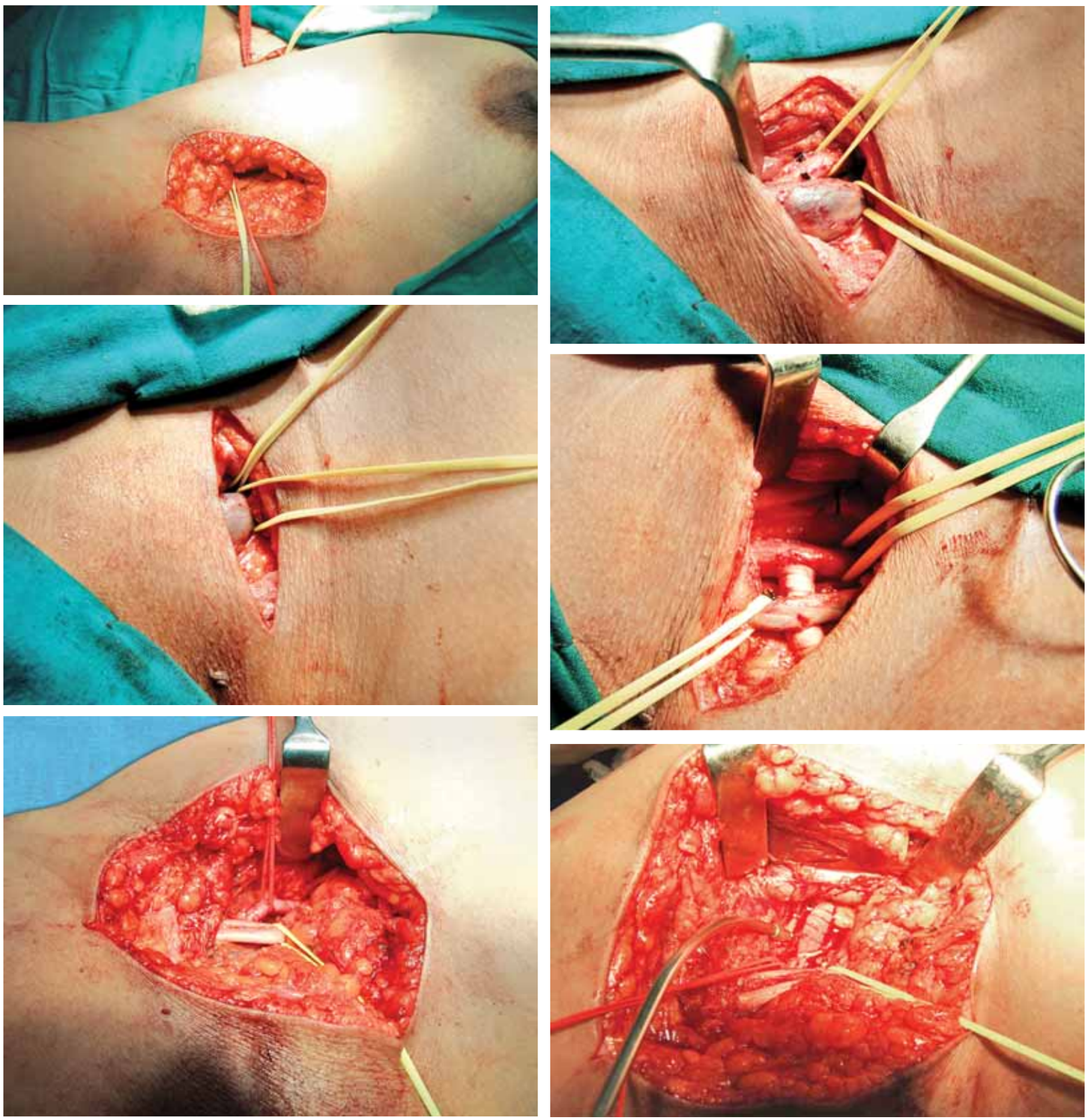


Fig. 11-76: Carotid-axillary bypass. It bypasses the subclavian artery in its stenosis/blockage.

Different procedures of carotids can be undertaken like repair of carotid using venous patch, endarterectomy, carotid artery aneurysm repair using graft, graft reconstruction, ligation of ECA. *ECA ligation* is done just above the level of the superior thyroid artery to avoid turbulence effect on the carotid and so formation of thrombus proximally. ECA is ligated in torrential bleeding in face, antrum, larynx, traumatic damage of the ECA. CCA and ICA should not be ligated but should be reconstructed as chance of the person developing hemiplegia is 40%.

EXPOSURE OF VERTEBRAL ARTERY

Anatomy

It originates from first part of subclavian artery ends by joining the opposite vertebral artery to form basilar artery. It has got 4 parts. First part extends from its origin to transverse process of 6th cervical vertebra. First part is located in vertebral triangle bound by scalenus anterior and longus colli muscles; runs upwards and

backwards; related (anteriorly) to carotid sheath, vertebral vein, inferior thyroid artery and thoracic duct on left side; posteriorly to transverse process of C_7 vertebra, inferior cervical ganglion and ventral rami nerves of C_7,C_8. Second part runs through foraminae of transverse processes of upper six vertebrae. It is accompanied by venous plexus and large branch of stellate ganglion. Third part lies in suboccipital triangle lying on the posterior arch of the atlas bone extending from transverse foramina of atlas to vertebral canal across lower arched margin of posterior atlanto occipital membrane. It is related to atlas, vertebral muscles, and first cervical nerve. Fourth part extends from atlantooccipital membrane to lower part of pons to join opposite vertebral artery to form basilar artery. It pierces the dura, arachnoid in front of roots of hypoglossal nerve, medulla to reach lower margin of pons. Branches are – spinal, muscular, anterior spinal, posterior inferior cerebellar (largest), often posterior spinal and medullary.

Exposure

Oblique incision lateral to the sternocleidomastoid muscle → lateral part of the muscle is cut → IJV is exposed → vagus is identified → both IJV and vagus are retracted laterally → carotid artery is identified and dissected meticulously to retract medially → dissection is done between carotid and IJV → vertebral vein runs crossing the artery in front from medial to lateral → vertebral artery is identified behind the vein with crisscrossed cervical sympathetic chain. Vertebral vein can be divided to expose the artery properly. Sympathetic fibers crossing the artery can be divided **(Fig. 11-77)**.

Distal part of the artery is also exposed by extending the same incision above; levator muscle is identified and is divided after protecting the accessory nerve which crosses the muscle. Anterior ramus of C2 nerve is seen crossing the artery which can be divided.

EXPOSURE OF SUBCLAVIAN ARTERY

Anatomy

Subclavian artery arises on the right side from brachiocephalic artery and left side from arch of aorta. It begins behind the sternoclavicular joint curving with convexity upwards reaching outer part of the first rib to continue as axillary artery. Left artery has got thoracic part behind the left side of manubrium and left of left common carotid artery. Artery is divided into three parts by scalenus anterior muscle. First part is medial; second part is behind; third part is lateral to scalenus anterior.

Artery is related *in front* from medial to lateral to – CCA, ansa cervicalis, cardiac branches of vagus, sympathetic trunk, vagus, vertebral vein, IJV, phrenic nerve (left side it is in front of first part; right side it is in front of second part) and thoracic duct (left side), scalenus anterior, transverse cervical artery, suprascapular artery, subclavian vein, anterior jugular vein, suprascapular vessels, external jugular vein, transverse cervical vein, subclavius muscle, middle ⅓ of clavicle, sternocleidomastoid muscle.

Behind it is related to suprapleural membrane, cervical pleura, apex of lung, ansa subclavian, right recurrent laryngeal nerve (right side), scalenus medius, lower trunk of brachial plexus. *Above* it is related to inferior belly of omohyoid, upper and middle trunks of brachial plexus. *Below* it is related to first rib.

Branches are usually four – vertebral (largest), internal thoracic and thyrocervical arteries arise from first part of the subclavian artery. Thyrocervical artery gives inferior thyroid, suprascapular and transverse cervical branches. Costocervical artery arises from second part of the subclavian artery on right side (from first part on left side) which gives superior intercostal and deep cervical arteries. Occasionally dorsal scapular artery as a 5th branch may arise from third part of the subclavian artery.

Right subclavian artery may originate from descending thoracic aorta passing behind the oesophagus causing dysphagia called as *dysphagia lusoria*.

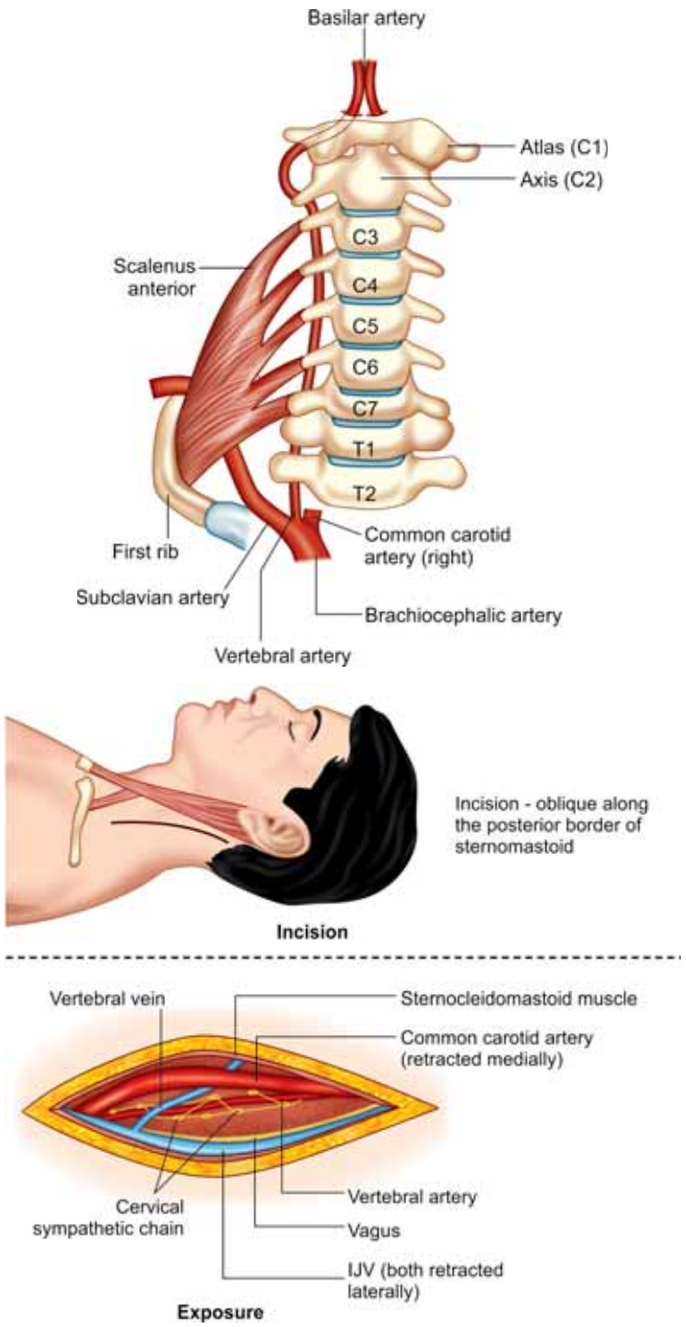


Fig. 11-77: Anatomy and exposure of vertebral artery.

Exposure

Arm is placed to the side of the patient and drawn downwards to depress the shoulder with head turning to opposite side. Incision is made just above (1 cm) and parallel to clavicle from sternal head

of sternocleidomastoid to anterior margin of trapezius. Superficial fascia, platysma and deep fascia are divided in the line of incision. External jugular vein is ligated. Supraclavicular nerve is identified and cut or retracted. Omohyoid is retracted above. Suprascapular artery, vein and nerve are identified crossing the third part of the subclavian artery superolaterally. Subclavian artery is identified along with upper and middle trunks of brachial plexus. To expose the 2nd and 3rd parts clavicular head of sternomastoid and scalenus anterior are cut. Care should be taken not to injure phrenic nerve which crosses the scalenus anterior in front from lateral to medial. Nerve is gently slinged and retracted. IJV is retracted medially to expose the subclavian artery. Division of sternal head of sternocleidomastoid and median sternotomy is needed to approach the origin of subclavian artery and brachiocephalic artery **(Figs 11-78 and 11-79)**.

Distal 3rd part of subclavian and proximal 1st part of the axillary artery is exposed by infraclavicular incision or supraclavicular incision extending laterally and across the clavicle. Division of clavicle in this exposes the entire subclavian artery. In inevitable situation 3rd part of subclavian artery can be ligated.

EXPOSURE OF AXILLARY ARTERY

Axillary artery as a continuation of subclavian artery extends from outer border of first rib to lower border of teres major muscle. It is

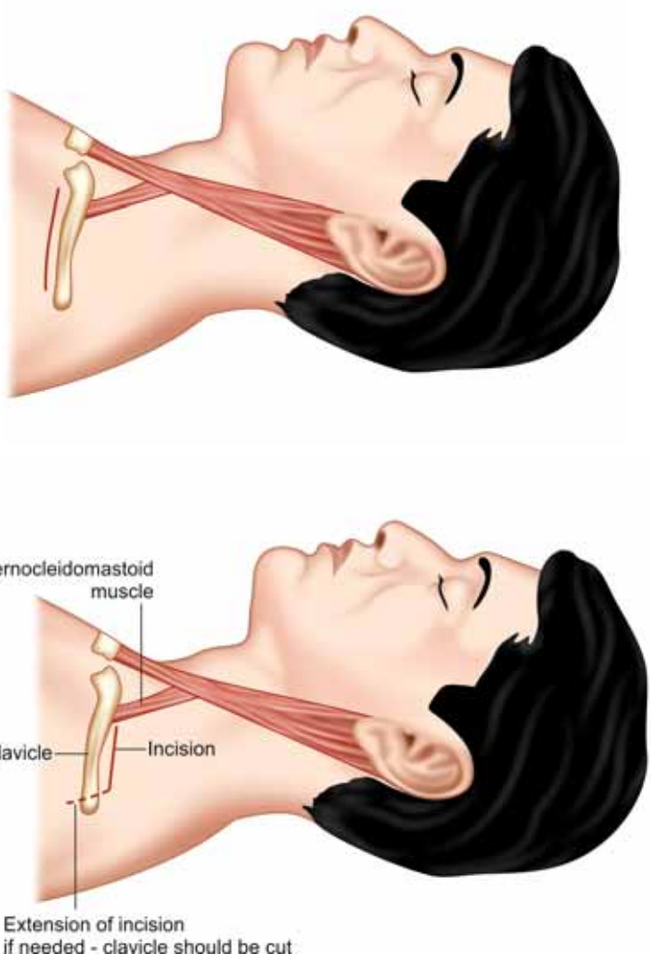
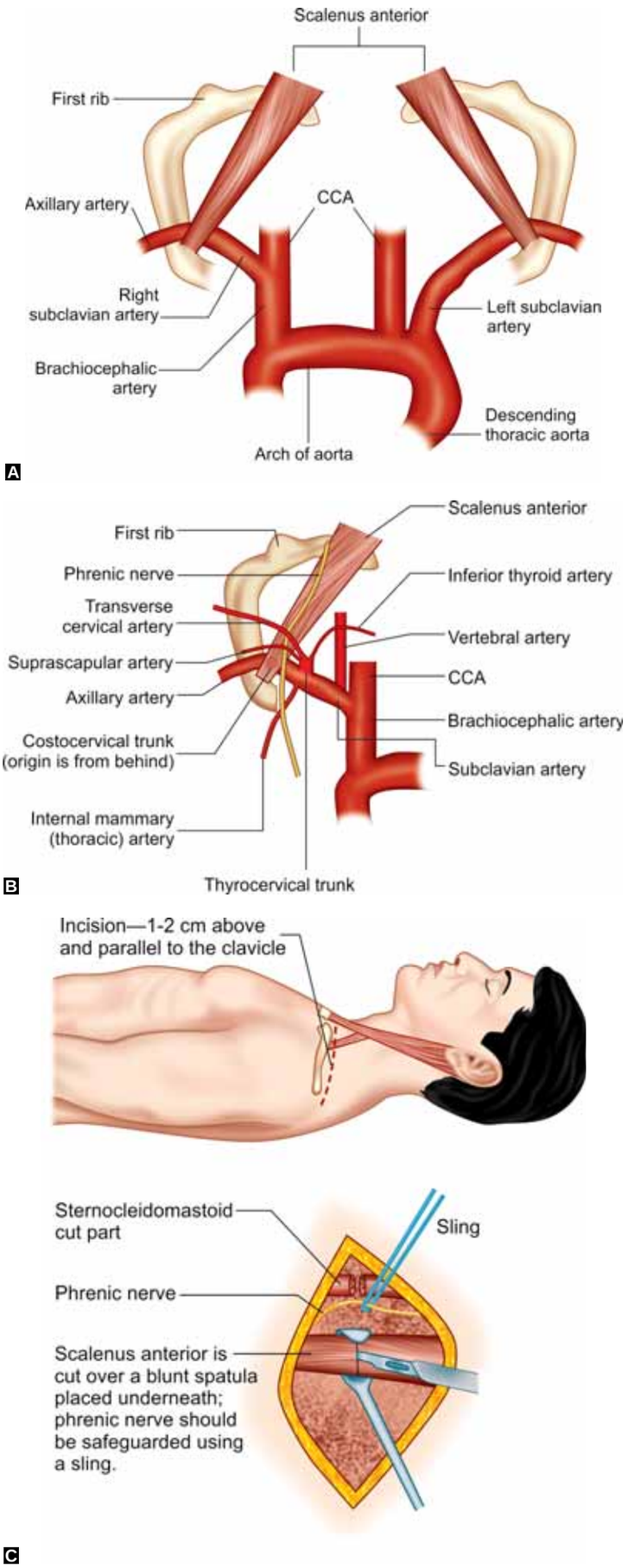


Fig. 11-78: Incision for subclavian and axillary artery exposure. If needed clavicle is cut.



Figs 11-79A to C

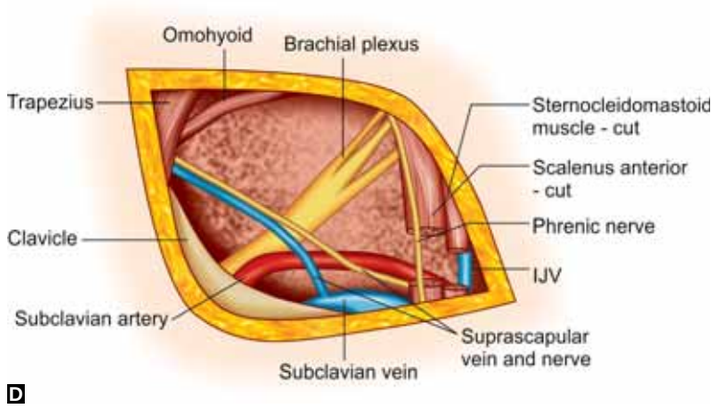


Fig. 11-79D

Figs 11-79A to D: Anatomy and exposure of subclavian artery.

divided into three parts by pectoralis minor as above (first part), behind (second part) and below (third part). It is related in front to skin, superficial fascia, platysma, supraclavicular nerves, deep fascia, pectoralis major, and clavipectoral fascia with cephalic vein, lateral pectoral vein and thoracoacromial vessels and pectoralis minor. Behind it is related to parts of brachial plexus, serratus anterior digitations, coracobrachialis, tendons of latissimus dorsi and teres major. Medially it is related to axillary vein. Axillary sheath encloses the axillary artery and brachial plexus which is derived from prevertebral layer of deep fascia. Axillary sheath *does not enclose* the axillary vein.

Branches of axillary artery are—superior thoracic artery (first part), thoracoacromial artery (second part), lateral thoracic artery (second part), subscapular artery (largest branch, third part), and anterior circumflex and posterior circumflex arteries (third part) **(Fig. 11-80)**.

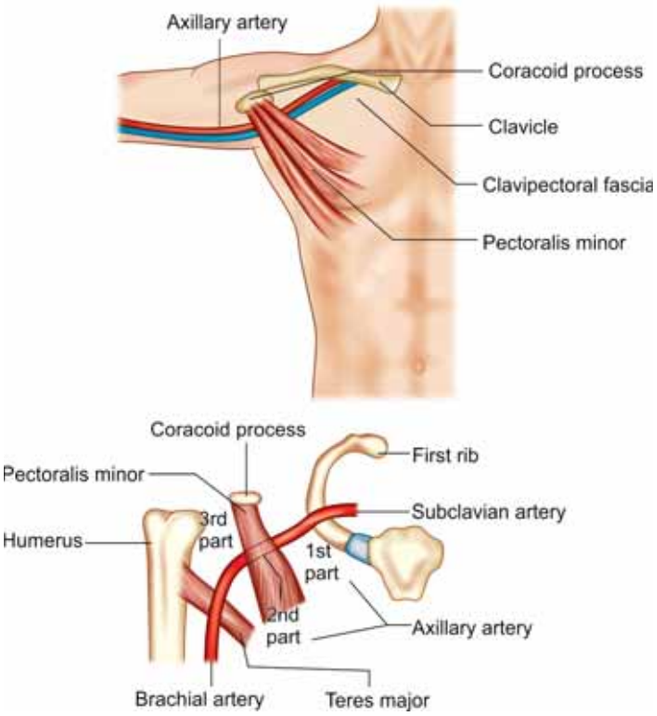


Fig. 11-80: Anatomy of the axillary artery.

Surface Marking of Axillary Artery

Arm is held at right angles to the trunk with palm facing forward; it extends from midpoint of the clavicle to a point at the junction of anterior 1/3rd to posterior 2/3rd of the lateral wall of axilla at its lower limit.

Exposure

Two incisions can be used. One is lengthy incision along the deltopectoral groove from lower border of clavicle to lower border of anterior axillary fold. Another is small incision in infraclavicular area horizontally placed along the clavipectoral fascia. This incision is also used to expose the third part of the subclavian artery. Often in trauma more extensive exposure of axillary and subclavian arteries together is needed and in such situation lengthy deltopectoral groove incision extending upwards into the neck across clavicle with resection of the middle third of the clavicle is done **(Fig. 11-81)**.

EXPOSURE OF BRACHIAL ARTERY

Anatomy

Brachial artery is the continuation of the axillary artery extending from lower border of teres major to a point in front of the elbow at the level of neck of radius just medial to the biceps brachii. It runs downwards and laterally to end in front of elbow bifurcating into radial and ulnar arteries. It is superficial throughout its extent and is accompanied by two venae comitantes. In the upper part it is related to medial cutaneous nerve of the forearm; in the middle part it is crossed by median nerve from lateral to medial side; in front of the elbow it is crossed/covered by bicipital aponeurosis (crosses artery from lateral to medial side). Posteriorly it is related to triceps, radial nerve, profunda brachii artery, coracobrachialis, brachialis. Medially in the upper part it is related to ulnar nerve, in the lower part to median nerve (crosses the artery from lateral to medial in front). Laterally it is related to coracobrachialis, biceps, median nerve in the upper part; tendon of biceps in the lower part. In the elbow, structures from lateral to medial are—radial nerve, biceps tendon, brachial artery and median nerve. It divides as terminal branches in *cubital fossa* in the elbow. It is a triangular hollow situated in front of the elbow; its lateral border is formed by medial margin brachioradialis; medial border is by lateral margin of pronator teres; base is directed upwards is formed by line joining the two epicondyles of humerus with apex pointing downwards **(Fig. 11-82)**.

It gives muscular branches, profunda brachii artery, superior ulnar collateral branch, nutrient artery, inferior ulnar collateral branch, radial and ulnar arteries. Brachial artery may divide into radial, ulnar, common interosseous branches at higher level than usual; or as radial and common trunk of ulnar and common interosseous branches.

Exposure (Fig. 11-83)

Incision is made in the upper arm along its medial border just behind the biceps muscle. Once skin and deep fascia is incised, identified biceps muscle is retracted in front; triceps posteriorly; artery is identified with median nerve lying superiorly and laterally which later crosses the artery in front towards medial side. Basilic vein will be lying medial to the artery in the upper part; two venae comitantes accompany the artery in the lower part. Basilic vein is retracted posteriorly to identify the ulnar nerve.

Bifurcation is exposed at cubital fossa using an S shaped incision; not with vertical incision. A transverse incision can also be used.

Fig. 11-81: Exposure of axillary artery aneurysm and repair and reconstruction using graft.

Bicipital aponeurosis which runs in front from lateral to medial side is divided. Median nerve will be posteromedial to the artery.

EXPOSURE OF RADIAL AND ULNAR ARTERIES

Anatomy

Radial artery is a smaller terminal branch (and more superficial compared to ulnar) of brachial artery extending from a point in front of the elbow at the level of neck of the radius medial to the tendon of the biceps brachii to a point at the wrist between anterior border of the radius laterally and the tendon of the flexor carpi radialis medially. It runs downwards to the wrist and enters the anatomical snuff box turning posteriorly. It is overlapped by brachioradialis above and skin, superficial and deep fascia below. Posteriorly it is related to biceps tendon, supinator, pronator teres tendon, radial origin of flexor digitorum superficialis (FDS) and flexor pollicis longus (FPL), pronator quadratus, lower end of radius. Medially it is related to pronator teres above and flexor carpi radialis in the lower 2/3rd; laterally to brachioradialis entirely and radial nerve in the middle third. Artery

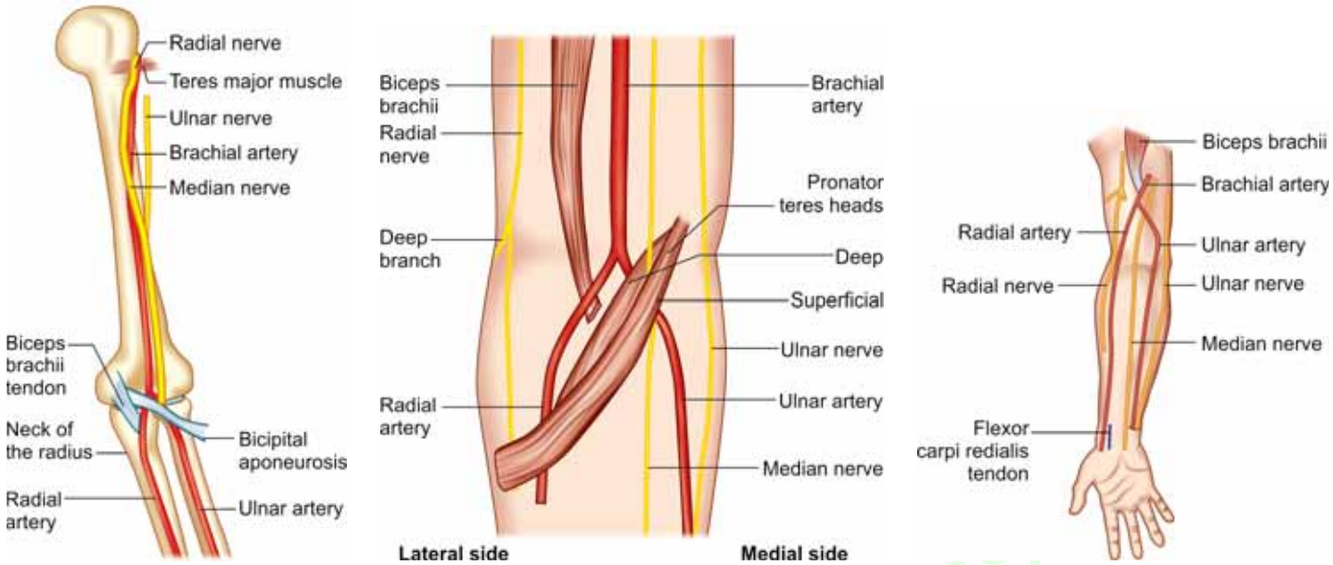


Fig. 11-82: Anatomy and branches of brachial artery.

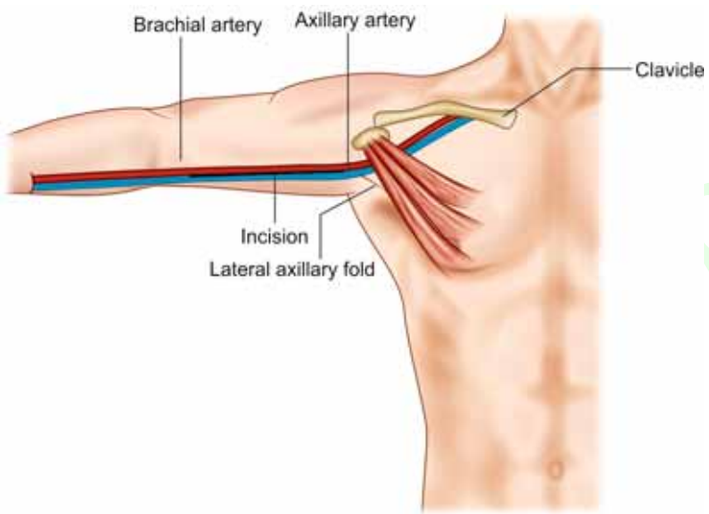


Fig. 11-83: Incision for exposure of brachial artery.

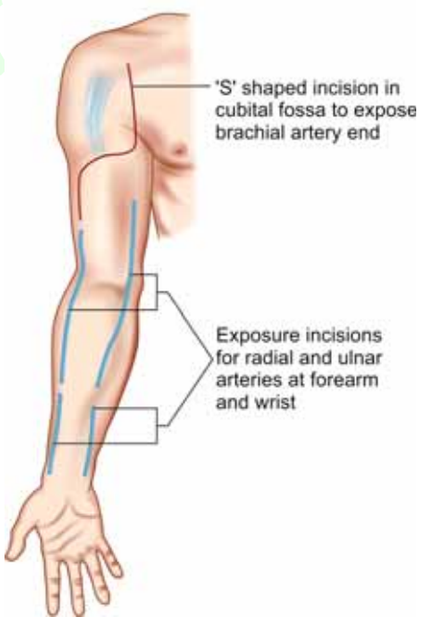

'S' shaped incision in cubital fossa to expose brachial artery end
Exposure incisions for radial and ulnar arteries at forearm and wrist

Fig. 11-84: Exposure of brachial bifurcation and branches (radial and ulnar arteries).

is accompanied by a pair of venae comitantes. *Branches are* – radial recurrent, muscular, palmar carpal, superficial palmar.

Ulnar artery is the larger terminal branch of brachial artery beginning at cubital fossa running obliquely downwards and medially in upper 1/3rd of forearm; vertically in lower 2/3rd of forearm enters the palm by passing superficial to flexor retinaculum. At lateral part of the pisiform bone it enters the palm. Artery in its upper half is covered by pronator teres with median nerve, flexor carpi radialis, Palmaris longus, flexor digitorum superficialis, flexor carpi ulnaris; lower half is covered by skin, superficial and deep fascia and palmar cutaneous branch of ulnar nerve; posteriorly above brachialis and below flexor digitorum profundus; medially to ulnar nerve and flexor carpi ulnaris; laterally flexor digitorum superficialis. *Branches are* – anterior and posterior ulnar recurrent arteries, common interosseous artery, anterior interosseous artery, muscular branches, palmar and dorsal carpal branches **(Fig. 11-84)**.

Both arteries are *exposed* through different vertical incisions on either side of the forearm. Radial artery is exposed by retracting the brachioradialis medially and flexor carpi radialis laterally. Ulnar artery is exposed by dissecting pronator teres and brachioradialis laterally and flexor digitorum medially.

EXPOSURE OF ASCENDING AORTA AND ARCH OF THE AORTA

Anatomy

Five cm long ascending aorta originates from upper end of left ventricle enclosed with pericardium; it begins at the level of lower border of 3rd costal cartilage behind the left half of the sternum, runs upwards, forwards and right continuing as arch of aorta at the upper

border of the 2nd costal cartilage. At the root of the aorta there are 3 sinuses (dilatations) – right and left posterior and anterior. Right coronary artery arises from anterior sinus; left coronary arises from left posterior aortic sinus.

Arch of aorta is situated in superior mediastinum behind the lower half of the manubrium sterni. From the upper end of ascending aorta it runs upwards, backwards and to left of trachea near carina, then passing behind the left bronchus arching over the root of left lung to continue as descending aorta at the level of left side lower border of the body of 4th thoracic vertebra. It begins anteriorly and ends posteriorly. Anteriorly it is related to left phrenic nerve, lower cervical branch of left vagus, upper cervical cardiac branch of left sympathetic chain, left vagus; left superior intercostal vein between phrenic and vagus nerves; left pleura and lung, thymic remnants. Posteriorly it is related to trachea, deep cardiac plexus, tracheobronchial lymph nodes, oesophagus, left recurrent laryngeal nerve, thoracic duct and vertebra. Below to pulmonary trunk bifurcation, left bronchus, ligamentum arteriosus and left recurrent laryngeal nerve. Branches are—brachiocephalic artery, left common carotid and left subclavian arteries; often thyroidea ima artery and occasionally vertebral artery.

Exposure (Fig. 11-85)

Vertical sternotomy incision is used. After skin incision, a Robert's or Kocher's clamp is passed underneath the sternum along the free space underneath to pass a Gigli saw by which sternum is divided. Electric saw also can be used. Sternum is retracted using self retaining retractor; brachiocephalic vein is retracted downwards. Aortic arch, roots of brachiocephalic, left carotid and subclavian arteries are exposed.

Aortic arch branches are exposed through an additional transverse neck incision on the upper part of the sternotomy. Through this transverse incision if sternocleidomastoid and scalenus anterior is divided, subclavian artery can be exposed at neck in its entire length.

EXPOSURE OF DESCENDING THORACIC AORTA

Anatomy

It is continuation of the arch of aorta at the level of 4th thoracic vertebral body, descending downwards with right side inclination in posterior mediastinum at the lower border of the 12th thoracic vertebra. It is related anteriorly to root of left lung, pericardium, heart, oesophagus in the lower part and diaphragm; posteriorly to hemiazygos vein and vertebrae; to the right side oesophagus in upper part, azygos vein, thoracic duct, right lung and pleura; to the left side left lung and pleura. Branches are – 3rd to 11th intercostal arteries (total 9 × 2 = 18); two subcostal arteries one on each side; two left bronchial arteries (*Note*: Right bronchial artery is arising from right 3rd posterior intercostal artery usually, occasionally from upper left bronchial artery); oesophageal branches; pericardial branches; superior phrenic arteries.

Exposure

Descending thoracic aorta is exposed through left posterolateral thoracotomy through 5th or 8th intercostal space. Usually rib is removed and thoracic cavity is entered; lung is displaced forward; descending aorta will be seen posteriorly running vertically **(Fig. 11-86)**.

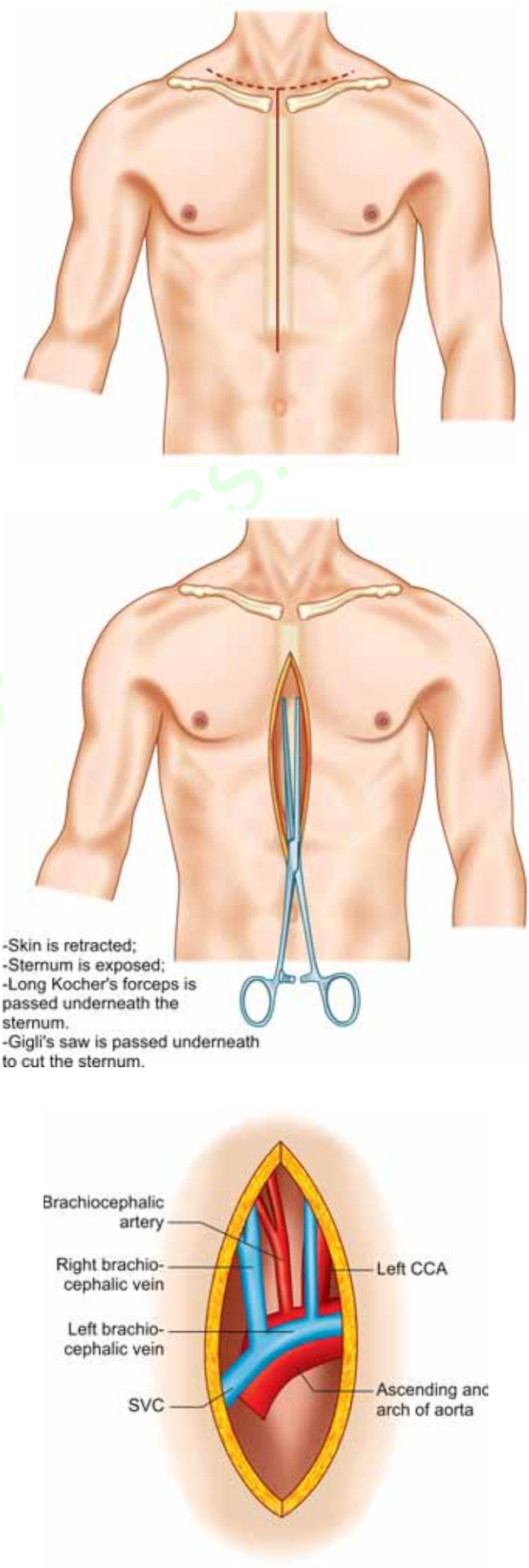


Fig. 11-85: Exposure of ascending aorta technique.

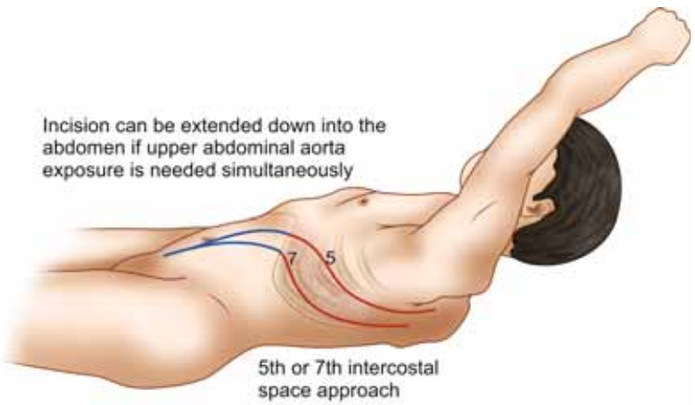

Incision can be extended down into the abdomen if upper abdominal aorta exposure is needed simultaneously
7
5
5th or 7th intercostal space approach

Fig. 11-86: Exposure of descending thoracic aorta either through 5th or 7th intercostal space which can be extended down into abdomen if needed to expose the proximal abdominal aorta also.

Same incision can be extended down in middle over the abdomen to expose the *upper abdominal aorta along with thoracic aorta.* Diaphragm is divided transversely close to the costal margin to avoid damage to phrenic nerve. Vertical incision in the costal margin will expose better but often damages the phrenic nerve. Through the wound liver, spleen, abdominal contents are visualised; peritoneum lateral to the spleen is incised to mobilise the spleen, colon, pancreas towards the right. It exposes the upper abdominal aorta with its branches in the upper part namely coeliac artery, superior mesenteric artery and renal vessels with left renal vein crossing the aorta in front towards IVC.

EXPOSURE OF ABDOMINAL AORTA AND BRANCHES

Anatomy

Abdominal aorta begins from aortic opening of diaphragm at the level of lower border of T12 vertebra, running downwards and slightly left in front of lumbar vertebra ending at lower border of L4 vertebra about 1 cm left of midline by dividing into two common iliac arteries.

Its surface marking is – from a point 2.5 cm above the transpyloric plane in midline to a point 1.25 cm below and left of the umbilicus.

Anteriorly abdominal aorta is related to celiac plexus, aortic plexus, body of pancreas, splenic vein, left renal vein, 3rd part of the duodenum, retroperitoneum and intestine in abdominal cavity. Posteriorly it is related to bodies of upper four lumbar vertebrae, anterior longitudinal ligament, left lumbar veins, origin of lumbar arteries; towards the right related to IVC with sympathetic chain behind, right crus of diaphragm, cisterna chyli, azygos vein, lumbar lymph node; towards left it is related to left crus of diaphragm, pancreas, 4th part of the duodenum, left sympathetic chain, lumbar lymph nodes.

Branches of abdominal aorta – *Ventral (supply gut)*: Coeliac trunk, superior mesenteric artery (SMA), inferior mesenteric artery (IMA); *Lateral (supply structures from intermediate mesoderm)*: Inferior phrenic arteries, middle suprarenal arteries, renal arteries, gonadal arteries; *Dorsal (somatic)*: 4 pairs of lumbar arteries, median sacral artery.

Infrarenal aorta is more mobile and accessible than suprarenal. IMA and gonadal arteries can be sacrificed. Origins of major arteries prevent mobilisation of upper abdominal aorta. Celiac trunk, pancreas, splenic vein, left renal vein, duodenum all obscure proper mobilisation.

Exposure

Lengthy midline (common) or transverse or oblique incision is used. Once peritoneum is opened, omentum and transverse colon is pushed upwards; small bowel is displaced to the patient's right; duodenojejunal flexure is identified and an incision is made lateral to the 4th part of duodenum; retroperitoneum is opened; entire small bowel with duodenojejunal flexure is mobilised medially towards right (medial mobilisation of the viscera). Aorta is identified and mobilised; infrarenal aorta is occluded with vascular clamp with finger guidance with care about IVC and left renal vein.

Coeliac axis is exposed through lesser omentum. Crura are dissected and divided. With careful blunt and sharp dissections coeliac trunk is identified **(Figs 11-87 and 11-88)**.

It is artery of foregut supplying lower oesophagus, stomach, duodenum up to sphincter of Oddi, liver, pancreas and spleen.

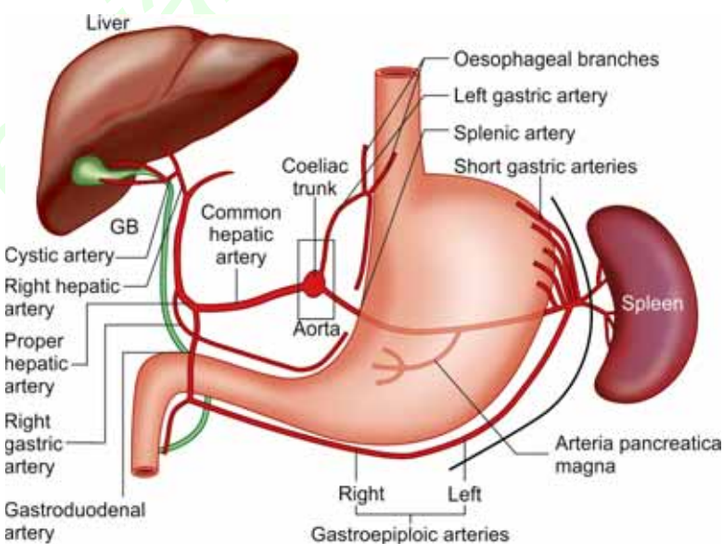
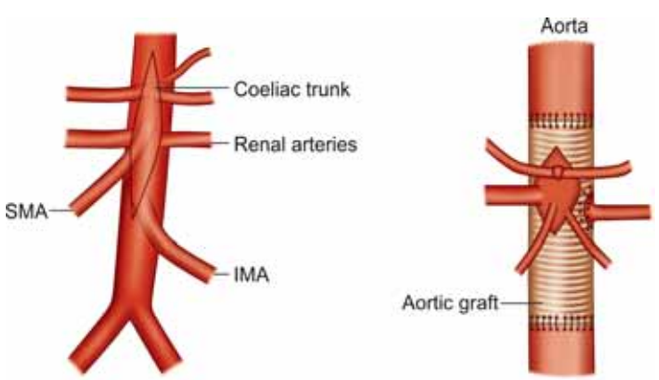


Fig. 11-87: Anatomy of coeliac trunk and branches.



Patch of native aorta with origin of visceral arteries and separate patch with origin of left renal artery are taken and implanted into the graft

Fig. 11-88: Origin of visceral branches of aorta with a cuff of native aorta can be removed and reimplanted into the aortic graft.

It originates just 1 cm below the aortic opening (T12 vertebra) at intervertebral disc level between T12 and L1. Trunk is *very short* in length (1.25 cm). It divides into three terminal branches—left gastric, common hepatic and splenic arteries. *Smallest left gastric artery* runs upwards to the left behind the lesser sac to reach OG junction where it turns forwards into the lesser omentum along the lesser curve towards right to anastomose with the right gastric artery. It gives oesophageal branches and gastric branches. Once branch enters the lesser omentum, it is often called as descending branch of left gastric artery. *Common hepatic artery (CHA)* runs forward, downward and towards right behind the lesser sac and at upper border of the duodenum it enters the lesser omentum in front of the portal vein and left of CBD to end as right and left hepatic arteries. Gastroduodenal artery is the first main branch of the CHA which arises at upper part of the first part of the duodenum as a large branch, runs downwards behind the 1st part of the duodenum dividing at its lower border as right gastroepiploic artery (runs along the greater curvature in the greater omentum to anastomose with left gastroepiploic artery) and superior pancreaticoduodenal artery (often 2 in number as anterior and posterior; runs in the pancreaticoduodenal groove ending by anastomosing with inferior pancreaticoduodenal artery, a branch of SMA). CHA distal to gastroduodenal artery is called as proper hepatic artery (PHA) which gives right gastric artery just distal to the origin of gastroduodenal artery runs towards left along the lesser curvature to anastomose with left gastric artery. *Small supraduodenal artery* often may be present to supply proximal duodenum. Cystic artery arises from right hepatic artery, runs behind the CHD and cystic duct to reach neck of the gallbladder and dividing into superficial and deep branches. *Splenic artery is the largest branch* of the coeliac trunk runs transversely towards left along the upper border of the pancreas behind the lesser sac crossing left adrenal gland and kidney entering lienorenal ligament and splenic hilum dividing into many branches to enter into the spleen. Splenic artery branches are—numerous pancreatic branches; arteria pancreatica magna; arteria caudae pancreatis; 5-7 short gastric arteries along the gastrosplenic ligament to supply gastric fundus; left gastroepiploic artery **(Fig. 11-89)**.

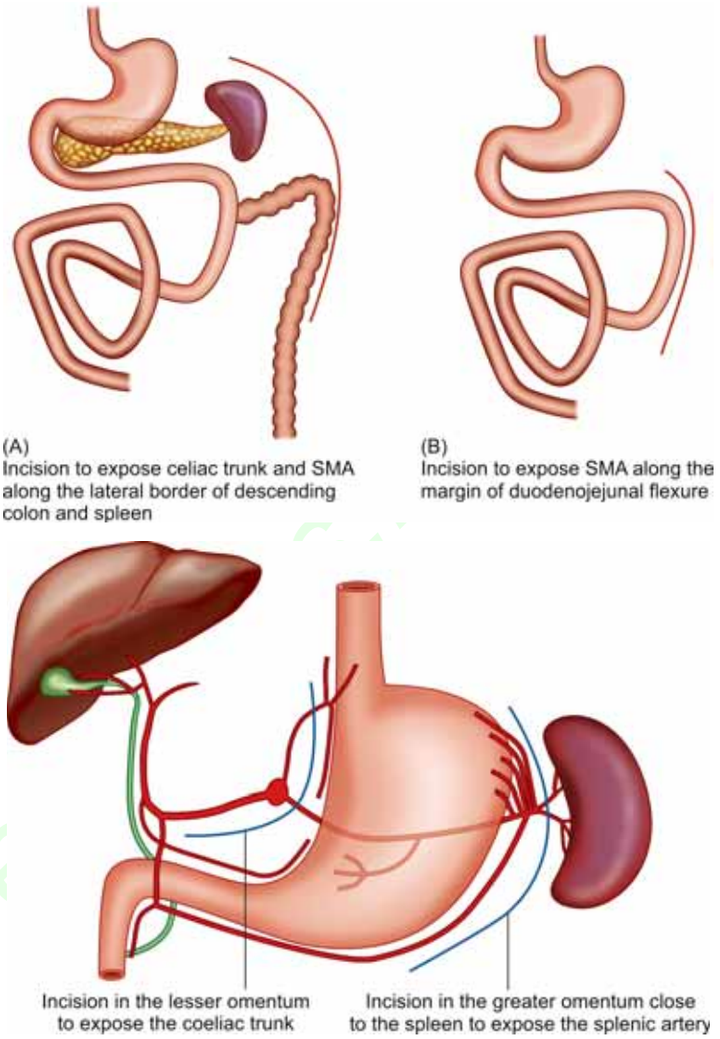

(A)
Incision to expose celiac trunk and SMA along the lateral border of descending colon and spleen
(B)
Incision to expose SMA along the margin of duodenojejunal flexure
Incision in the lesser omentum to expose the coeliac trunk
Incision in the greater omentum close to the spleen to expose the splenic artery

Fig. 11-89: Exposure of coeliac axis and its branches.

SMA origin is exposed by incising the peritoneum vertically lateral to spleen and colon and mobilising the spleen and pancreas in front of left kidney towards right side. Origin of SMA will be well exposed. SMA distal to its origin is exposed once small intestine is mobilised towards right; mesentery with its free edge is identified; mesenteric leaf is incised to expose the artery with superior mesenteric vein. SMV is towards the right of the SMA. SMA is the artery of midgut. It originates from the front of the aorta at the level of L1 behind the body of pancreas usually 1.0 cm below the origin of coeliac trunk. It descends down behind the pancreas body, in front of the uncinate process crossing the duodenum to enter the root of mesentery directed towards right with a convexity towards left, ends by anastomosing with ileocolic artery at right iliac fossa. Above and in front it is related to the body of pancreas, splenic vein; above and behind to aorta, left renal vein, uncinate process and duodenum. In the mesentery it crosses IVC, right ureter, right psoas; it is associated with SMV which is towards right. Superior mesenteric nerve plexus surrounds the artery. *Branches of SMA are* – middle colic artery originates from the right side of SMA just below the pancreas level, runs downwards and forwards in the transverse mesocolon dividing into right and left branches. Inferior pancreaticoduodenal artery arises from SMA at the upper margin of 3rd part of the duodenum running in the pancreaticoduodenal groove divides into anterior and posterior branches; later anastomose with its superior counterpart. Right colic artery arises from SMA occasionally from a common trunk with middle colic artery directs towards the ascending colon divides into ascending and descending branches. Ileocolic artery arises from SMA close to caecum divides into superior and inferior branches; inferior branch apart from anastomosis into the terminal branch of SMA also gives ascending colic, anterior caecal, posterior caecal and an appendicular and ileal branches. SMA from its left side gives around 15 jejunal and ileal branches.

EXPOSURE OF ILIAC ARTERIES

Anatomy

Common iliac arteries are terminal branches of abdominal aorta; right is longer than left. It begins at the level of L4 vertebra 1.25 cm to left of the midline passing downwards and laterally ending at the level of lumbosacral intervertebral disc over the sacroiliac joint by dividing into external and internal iliac arteries. Right CIA passes in front of lower end of IVC, right common iliac vein which is medial to artery below. Left CIA is crossed by inferior mesenteric vessels at its middle.

Internal iliac artery (IIA) is smaller, 4 cm long supplying mainly pelvic organs (other than ovaries and superior rectal artery), perineum, gluteal region, iliac fossa. It begins in front of the sacroiliac joint at the level of L5 – S1 disc, medial to psoas major muscle running downwards

and backwards ends at upper margin of greater sciatic notch by dividing into anterior and posterior divisions. It is related in front to ureter and ovaries and Fallopian tube (in females); behind to internal iliac vein, lumbosacral trunk and sacroiliac joint; laterally to external iliac vein and obturator nerve; medially to peritoneum. Branches of anterior division are—superior vesical; obturator; middle rectal; inferior vesical; inferior gluteal (largest branch of anterior division) and internal pudendal (In females inferior vesical artery is replaced by vaginal artery; also uterine artery as an additional branch). Posterior division branches are – iliolumbar, two lateral sacral, superior gluteal arteries.

External iliac artery continues downwards and laterally on the psoas major muscle; under the inguinal ligament continues as femoral arteries. Branches are—inferior epigastric artery and deep circumflex iliac artery. External iliac vein is medial to the artery.

Exposure

Transabdominal approach is used for emergency situation like aorto-iliac surgery, trauma and ruptured aneurysm. Abdomen is opened through midline or oblique incision depends on whether only one side or both sides' iliac arteries need to be exposed. Peritoneum over the vessels is incised and dissected to expose the vessels. Ureter overlies the vessel. On left side sigmoid should be mobilised medially by dividing the pelvic mesocolon laterally to expose the vessel.

Extraperitoneal approach is used for isolated exposure of the iliac vessel in iliofemoral bypass or reconstruction. Oblique incision is placed in the skin above the inguinal ligament below the umbilicus with patient tilted 45° towards opposite side after placing sandbags behind. Skin, two layers of superficial fascia, external oblique and internal oblique are incised; transverse abdominis is split to visualise the peritoneum; it is swept above and medially using blunt finger or gauze dissection to expose the retroperitoneum. Ureter is safeguarded. Artery is exposed adequately as needed. Care should be taken while dissecting close to iliac veins.

EXPOSURE OF FEMORAL ARTERY AND BRANCHES

Anatomy

It is the continuation of external iliac artery behind the inguinal ligament at mid-inguinal point, coursing downwards and medially in the femoral triangle and adductor canal; at lower end of adductor canal at the junction of middle and lower third of thigh it passes through the opening in the adductor magnus to continue as popliteal artery. In front it is related to skin, superficial and deep fascia and femoral sheath; behind it rests on psoas major, pectineus and adductor longus. Femoral artery proximal to origin of profunda femoris artery is called as *common femoral* and distal to that is called as *superficial femoral artery*. Femoral vein is medial to artery to begin with, but at the apex of the femoral triangle it becomes posterior to artery and later becomes lateral. Femoral nerve is lateral to artery. Femoral branch of genitofemoral nerve is lateral to the femoral artery. *Branches* – Superficial: superficial external pudendal, superficial epigastric, superficial circumflex iliac; Deep: profunda femoris, deep external pudendal and muscular.

Profunda femoris is the largest branch of femoral artery, arising from the lateral part of the femoral artery 4 cm below the inguinal ligament in front of the iliacus muscle; it passes behind the femoral vessels leaving the femoral triangle deep to adductor longus, then between adductor longus and brevis, then between adductor longus and magnus with terminal part piercing the adductor magnus to anastomose muscular branches of popliteal artery. *Branches are* – medial and lateral circumflex femoral arteries and four perforating branches **(Figs 11-90 to 11-92)**.

Popliteal artery begins at the junction of the lower third and middle third of the thigh from the opening/hiatus of the adductor magnus, running downwards and laterally to reach lower border of the popliteus muscle ending as anterior and tibioperoneal trunk which gives perineal artery and posterior tibial arteries. Superficially it is

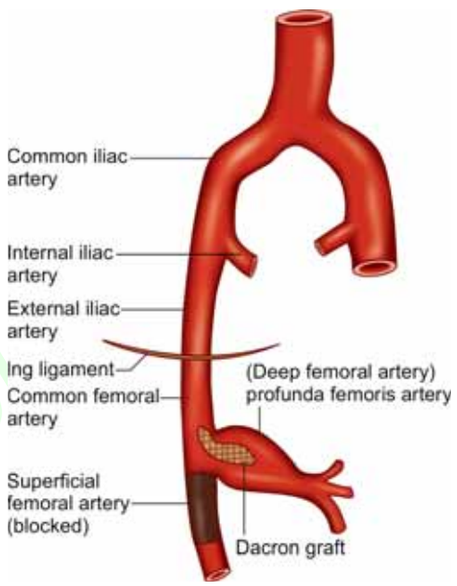


Fig. 11-90: Profundaplasty. It is done when there is localized stenosis at the origin of deep femoral/profunda femoris artery. It is done after proper exposure of the common femoral bifurcation through a vertical thigh incision. Proximal and distal parts of superficial and deep femoral arteries should be exposed to apply vascular clamps. Heparinisation is done. Arteriotomy is done at profunda femoris origin. Endarterectomy is done at the orifice adequately. A venous or prosthetic graft is sutured continuously into the arteriotomy wound to widen the origin of profunda femoris. Clamps are released. Check angiogram may be ideally done afterwards.

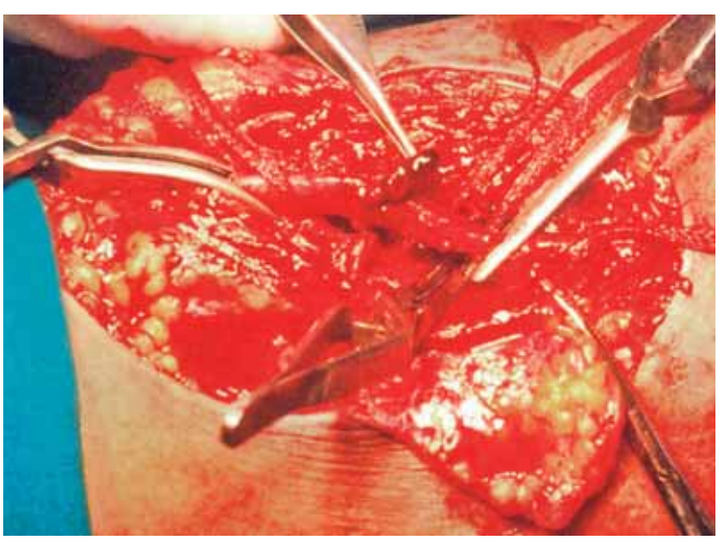


Fig. 11-91: Thrombectomy of femoral artery. It is not a common technique. Thromboendarterectomy is commonly done procedure.

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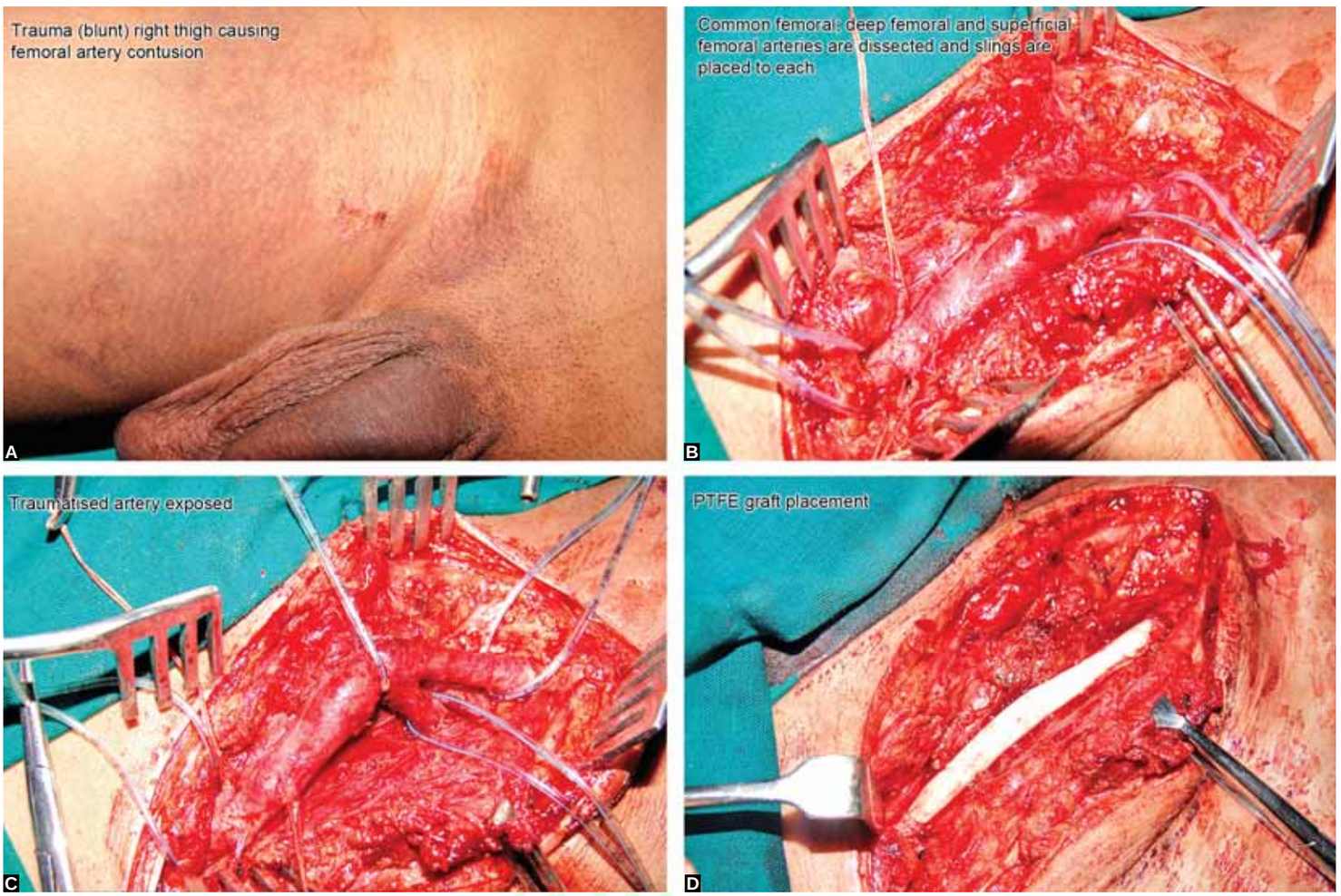

Trauma (blunt) right thigh causing femoral artery contusion
A
Common femoral, deep femoral and superficial femoral arteries are dissected and slings are placed to each
B
Traumatised artery exposed
C
PTFE graft placement
D

Figs 11-92A to D: Femoral artery trauma causing arterial contusion which is corrected by PTFE graft.

related to the tibial nerve which crosses the artery from lateral to medial side; popliteal vein which also crosses the artery from lateral to medial. Popliteal artery is overlapped by semimembranosus in the upper part and medial head of the gastrocnemius in the lower part. It lies on the knee joint and popliteus muscle in the deeper plane.

Exposure (Fig. 11-93)

Femoral artery is exposed by a vertical skin incision from mid-inguinal point downwards up to the apex of the femoral triangle. Skin, superficial and deep fascia is incised. Great saphenous vein is identified and retracted. Sartorius muscle is dissected and retracted laterally. Femoral sheath is incised to expose the common femoral artery and profunda femoris origin. Superficial femoral artery is exposed by retracting the sartorius medially and by cutting the fibrous bridge underneath roofing over the subsartorial canal.

Popliteal artery is *usually* exposed by *medial approach*. Patient is in supine position with knee slightly flexed – 15 -25°, hip externally rotated. Skin is incised 1 cm behind the tibial medial condyle extended upwards along the anterior border of the sartorius and distally 1 cm behind the posteromedial border of the tibia. Deep fascia is incised along the anterior border of the sartorius and is retracted behind. Division of adductor magnus tendon is needed to expose the femoropopliteal junction. Below deep fascia along the tendinous

Fig. 11-93: Incision for exposure of femoral artery.

part of three muscles sartorius, gracilis and semitendinosus is incised; tendinous insertion is retracted in front. Medial head of the gastrocnemius is retracted posteriorly **(Figs 11-94 and 11-95)**.

Extensive exposure of popliteal artery needs division of tendinous insertion and medial head of gastrocnemius. After separation of popliteal fat, popliteal fascia is incised longitudinally to expose the popliteal vein which should be dissected very carefully and gently as its tear leads into torrential bleeding. Tibial nerve is dissected and retracted with a sling. Bifurcation or trifurcation of the popliteal artery can be exposed by dividing soleus muscle and tibial vein. Anomalies of popliteal vein should be remembered. *Posterior approach* is limited and is used in treating popliteal entrapment. A transverse skin crease incision with medial upward and lateral downward extensions is used. Deep fascia is incised vertically to reach the popliteal fossa.

ARTERIOVENOUS FISTULA FOR HAEMODIALYSIS (HAEMODIALYSIS ACCESS)

End stage renal failure needs haemodialysis. For regular haemodialysis well perfused venous access is essential. AV fistula is created at different levels to achieve this hyperdynamic circulation so that regular venous access will not be a problem.

Scribner shunt (1921) is the shunt created by Dr Belding H Scribner and Dr Wayne Quinton (Quinton – Scribner shunt) using *Teflon tubes* as circulatory access placed into the adjacent artery and vein. Access is kept patent by connecting two tubes outside the body with a *U shaped Teflon tube*. It will shunt the blood from arterial side to the venous side. Infection and subcutaneous erosion of the tube are the complications. In 1962 Scribner started his first dialysis center (*Seattle Artificial Kidney Center*).

Dr Willem Kolff did first successful dialysis in 1943 to a 67-year old woman with uremic coma for 11 hours. Dr Nils Alwall also did extensive work on dialysis in University of Lund from 1946 to 1960.

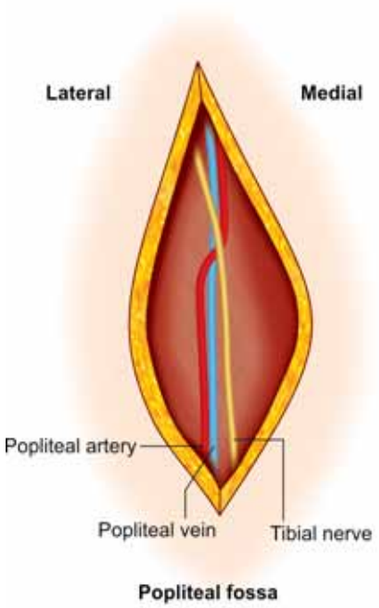


Fig. 11-94: Popliteal fossa anatomy.

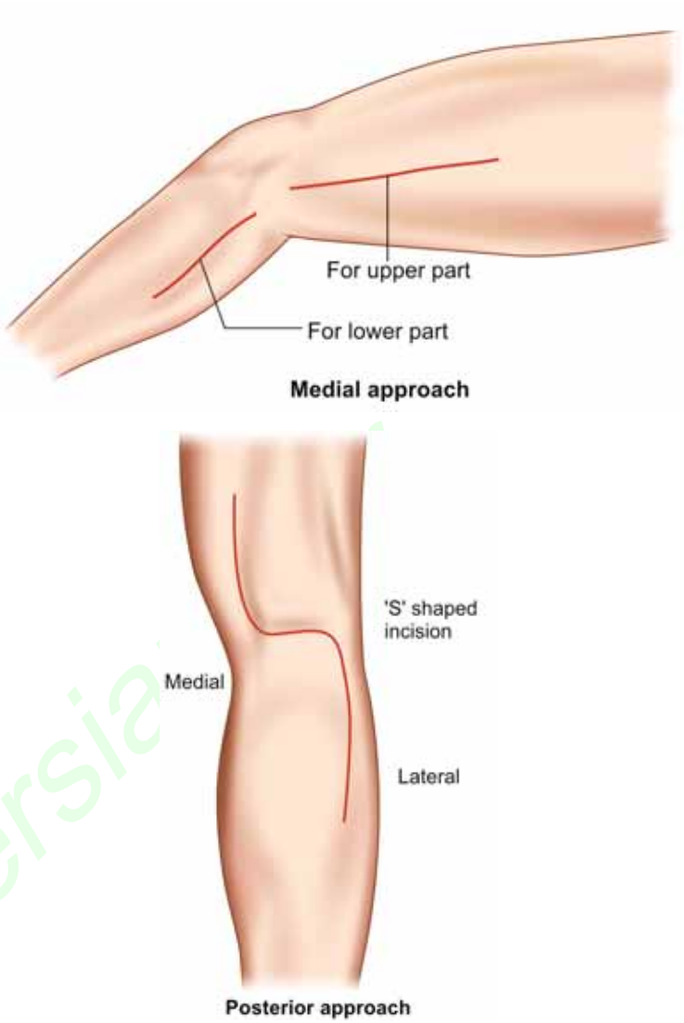


Fig. 11-95: Incision and exposure of popliteal artery.

Anatomy

Dorsal venous arch is formed from dorsal digital veins and dorsal metacarpal veins. Its efferent veins are cephalic (laterally; preaxial vein like GSV of lower limb) and basilic vein (medially; post-axial like SSV of lower limb) **(Fig. 11-96)**.

Cephalic vein begins at the lateral border of dorsal venous arch running upwards along the roof of the anatomical snuff box, lateral border of distal part of forearm, in front of the elbow, along the lateral border of the biceps brachii, piercing the deep fascia at lower margin of the pectoralis major muscle. Then it runs in the deltopectoral groove up to the infraclavicular fossa, piercing the clavipectoral fascia to join the axillary vein. Cephalic vein is accompanied by lateral cutaneous nerve of forearm and terminal branches of radial nerve. It communicates into basilic vein through median cubital vein. *A communicating vein* between cephalic vein and external jugular vein (neck) is present which runs across the clavicle. It is important for draining the upper limb in axillary vein removal (in carcinoma breast segment may be removed)/blockage.

Basilic vein begins at the medial side of the dorsal venous arch running upwards along the medial border of the forearm, near the elbow winds round towards the ventral aspect, continues upwards along the lateral border of the biceps brachii, in the middle of the arm

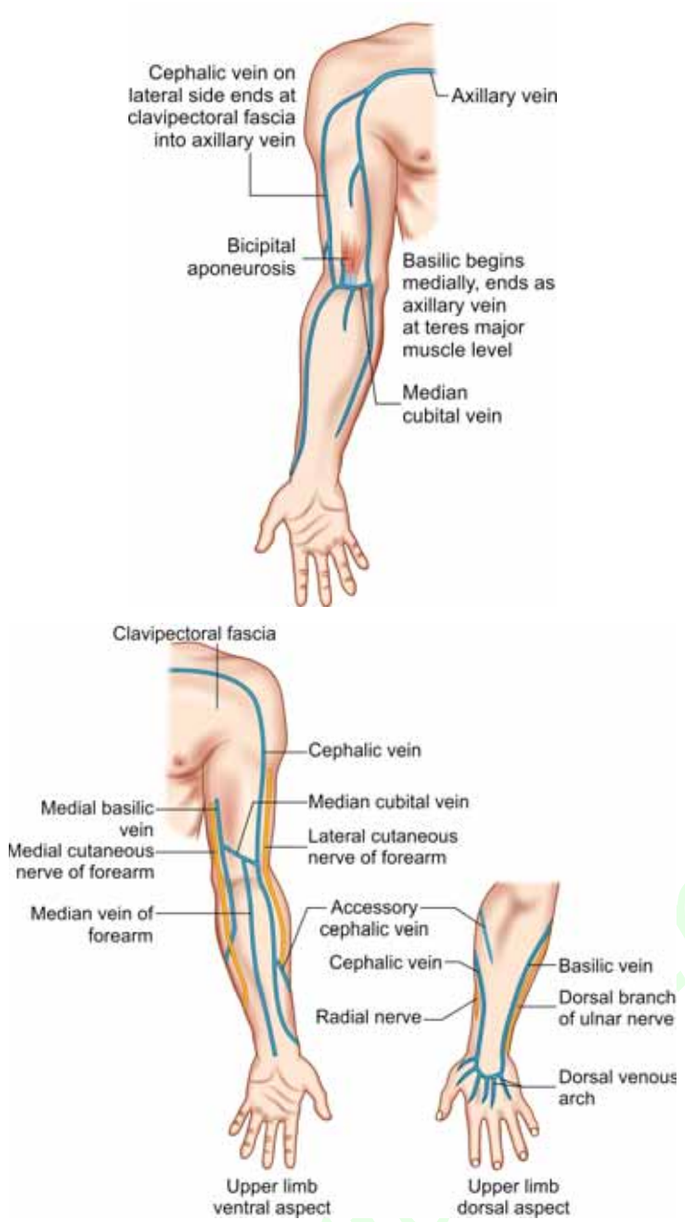

Cephalic vein on lateral side ends at clavipectoral fascia into axillary vein
Axillary vein
Bicipital aponeurosis
Basilic begins medially, ends as axillary vein at teres major muscle level
Median cubital vein
Clavipectoral fascia
Cephalic vein
Median cubital vein
Medial basilic vein
Lateral cutaneous nerve of forearm
Medial cutaneous nerve of forearm
Median vein of forearm
Accessory cephalic vein
Cephalic vein
Basilic vein
Dorsal branch of ulnar nerve
Radial nerve
Dorsal venous arch
Upper limb ventral aspect
Upper limb dorsal aspect

Fig. 11-96: Venous anatomy of upper limb to have vascular access for haemodialysis. Proper venous mapping is essential to create AV fistula.

it pierces the deep fascia, running along the medial side of the brachial artery becoming axillary vein at the lower border of the teres major. It is accompanied by posterior branch of the medial cutaneous nerve of the forearm and terminal part of the dorsal branch of the ulnar nerve. Basilic vein is the more efficient venous channel than cephalic vein.

Median cubital vein begins 2.5 cm below the lateral part of the elbow as a large communicating vein from the cephalic vein running obliquely upwards and medially in front of the bicipital aponeurosis (deep to this brachial artery is present) ending at basilic vein 2.5 cm above the elbow (medial epicondyle) at medial aspect of the arm. Perforator veins from deep veins pierce the bicipital aponeurosis to enter the median cubital vein which fixes the vein firmly to make the IV cannulation easier and stable. Median cubital vein is absent in 30% of individuals.

Median vein of forearm begins at palmar network ending at cephalic or basilic vein.

Variations: Entire cephalic vein may drain into basilic vein (20%); separate cephalic and basilic veins without communications (10%).

Principle

Usually upper limb is used for creation of AV fistula (*Cimino-Brescia fistula*). Radiocephalic; brachiocephalic; brachiobasilic; PTFE forearm graft prosthesis and upper arm prosthetic graft fistula are different sites for creation of AV fistula.

Fistula should be done initially as distal as possible (radial artery). Even first fistula may be at anatomical snuff box level (Snuff box fistula).

Nondominant side should be used first. One should avoid placing any venous lines in the proposed side/part of the fistula.

Graft fistula should be avoided as much as possible; it should be kept as reserve in inevitable need.

Donor artery should have an adequate pulsation, volume and devoid of calcification to make successful fistula.

Intravenous 3000 units heparin is given in all these patients on table. *Heparinised saline irrigation* to target artery and vein and wound is used during procedure.

Venous mapping and arterial Doppler is necessary in all patients **(Figs 11-97 to 11-99)**.

Radiocephalic AV Fistula (Cimino – Brescia)

Doppler is done to evaluate cephalic vein and radial artery. Preoperative vein mapping is a must. Ideally *target vein* should be

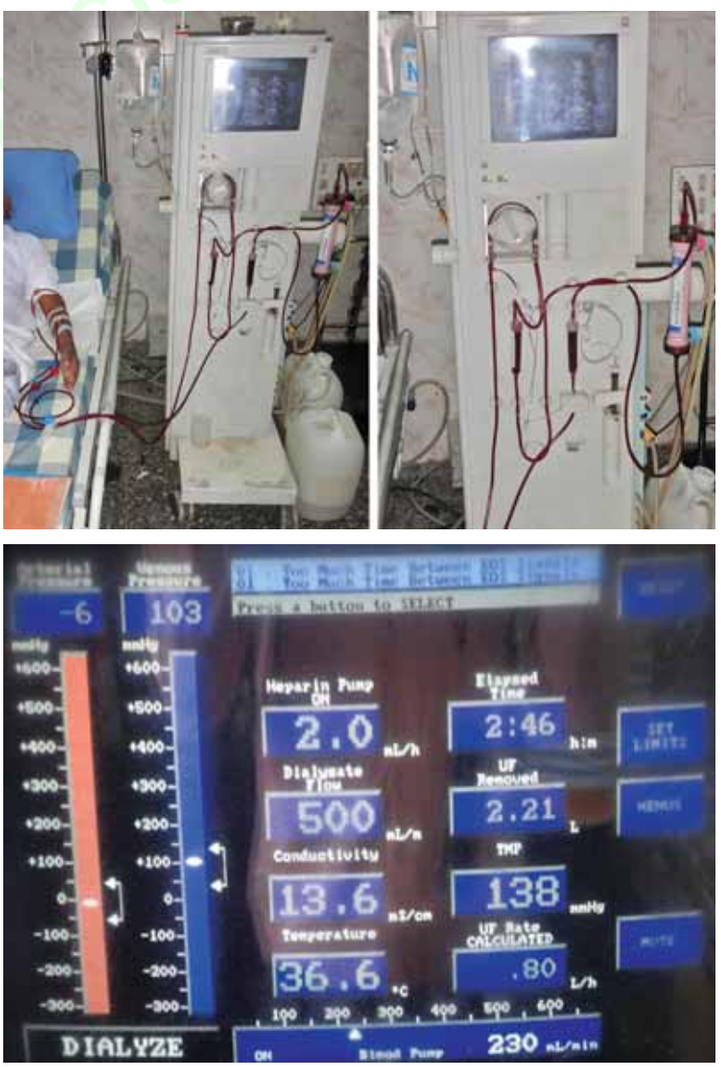
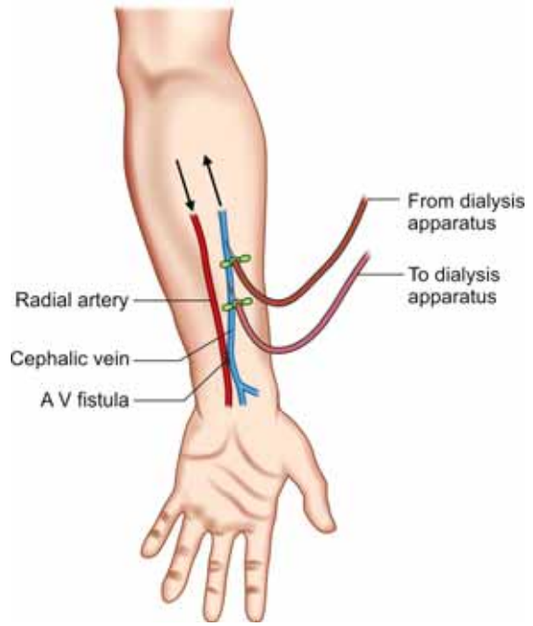
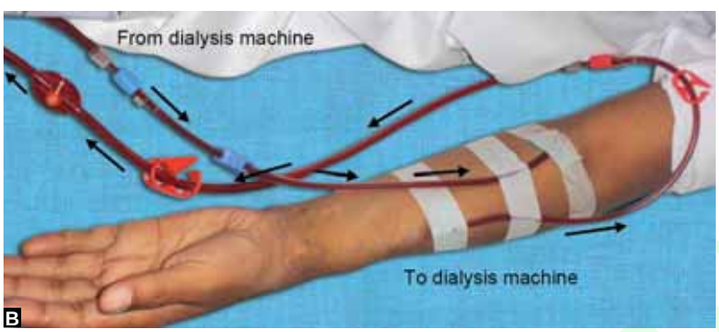


Fig. 11-97: Dialysis machine used for haemodialysis.





Figs 11-98A and B: A V fistula access during haemodialysis.

3 mm or more in diameter. But adequate good flow with proper patency may be sufficient. Allen test is done to confirm adequacy of ulnar artery blood flow to the hand. It is better to avoid any cannulation or needle prick for IV injections in the planned limb for several weeks. Access fistula is created first in nondominant upper limb; should begin always from distal to proximally. Vein transposition, PTFE graft fistula are the other alternatives should be kept in mind.

Procedure

It is done usually under local anaesthesia; brachial block can be given if needed. Regional anaesthesia causes venous dilatation to make venous identification and dissection easier. Preoperative antibiotics are given. Good light, using loupes may be better. Proper surgical anatomy of vein and artery should be valuable **(Fig. 11-100)**.

Patient is supine with arm placed on arm board. Either transverse skin incision or ***longitudinal incision*** between artery and target vein area is used. Skin flaps are raised adequately. Radial artery is identified deep to deep fascia and mobilised for 2 cm length. Small branches if present requires secure ligation using 4 zero silk. Proximal and distal control is obtained using silastic loops or bulldog clamps. Cephalic vein is identified and mobilised as distally as possible. Small tributaries are ligated using 4 zero vicryl or silk. Vein is also secured with silastic loops if needed. It is flushed with heparinised saline. Intraoperative US may be useful to identify and assess the patency of the vein. Cephalic vein may be divided as distally as possible if needed. Vein is brought close the artery to keep without any tension or kinking. Arteriotomy is done in radial artery. Venotomy is done in cephalic vein in case of side-to-side anastomosis **(Fig. 11-101)**.

End-to-side or side-to-side anastomosis (*Cimino-Brescia*) is done using 6 zero polypropylene sutures continuously. In end-to-side – distal end of the vein is ligated; proximal cut end is spatulated and its end is anastomosed to the side of radial artery. In side-to-side arteriotomy and venotomy wounds are approximated using 6 zero polypropylene continuous sutures. Once clamps (bulldog) are removed (proximal clamp is removed first and then distal clamp) cephalic vein is palpated for presence of thrill. On table venogram or Doppler is needed to confirm adequate flow. Wound is closed in layers.

Complications are—steal syndrome; bleeding; thrombosis and occlusion of the fistula; sepsis and failure to achieve sufficient arterialisation of venous network.

Brachiocephalic AV Fistula (Fig. 11-102)

After cleaning and draping, local anaesthesia xylocaine 0.5% plain is injected into the antecubital fossa. 6 cm transverse skin incision is made. Cephalic vein is identified; dissected for 5 cm length and stabilised with silastic loops. Deep fascia is opened; tendinous bicipital aponeurosis is identified and incised. Brachial artery is dissected and isolated using silastic loops. 3000 IU of heparin is injected intravenously. Area is irrigated with heparinised saline. Cephalic vein is ligated distally. 6 mm arteriotomy over the isolated brachial artery is done. Proximal cut end of the cephalic vein is spatulated and anastomosed to the brachial artery using 6 zero polypropylene continuous sutures. Forward flush and back bleed is done. Fistula and wound is irrigated with heparin saline.

Brachiobasilic AV Fistula (Fig. 11-103)

Here basilic vein is mobilised and tunneled in subcutaneous plane and then fistula is created through brachial artery. Initial Doppler venous mapping is done. Basilic vein is not superficial; it is deep in the basilic tunnel in the medial aspect of the arm. So it should be kept in the tunnel in subcutaneous plane to have access.

It is done in brachial block or general anaesthesia. With supine 90° outstretched arm position, after cleaning and draping, longitudinal incision is made in arm medially from antecubital fossa to axilla. Basilic vein in the lower part of its tunnel is identified and dissected with freeing all tributaries up to the axilla. It is also mobilised across the cubital fossa downwards. Brachial artery is identified in the antecubital fossa and distal part of the arm; it is dissected for about 3 cm circumferentially. IV heparin 3000 units given; heparin saline irrigation into the vessels and wound is also needed. Basilic vein distal to the cubital fossa is cut and ligated. Its proximal part is passed through the created tunnel in the subcutaneous plane (at 4 mm depth) in the anterior aspect of the arm downwards to the cubital fossa where it is passed through the deep fascia into the mobilised brachial artery. It is dilated manually. Kinking should be avoided while tunneling it. 6 mm arteriotomy is done in the brachial artery after placing silastic loops; spatulated proximal mobilised tunneled cut end of the basilic vein is anastomosed into the brachial artery as end-to-side. Thrill is checked in the venous side. Distal, radial and ulnar pulses are checked.

http://vip.persianss.ir

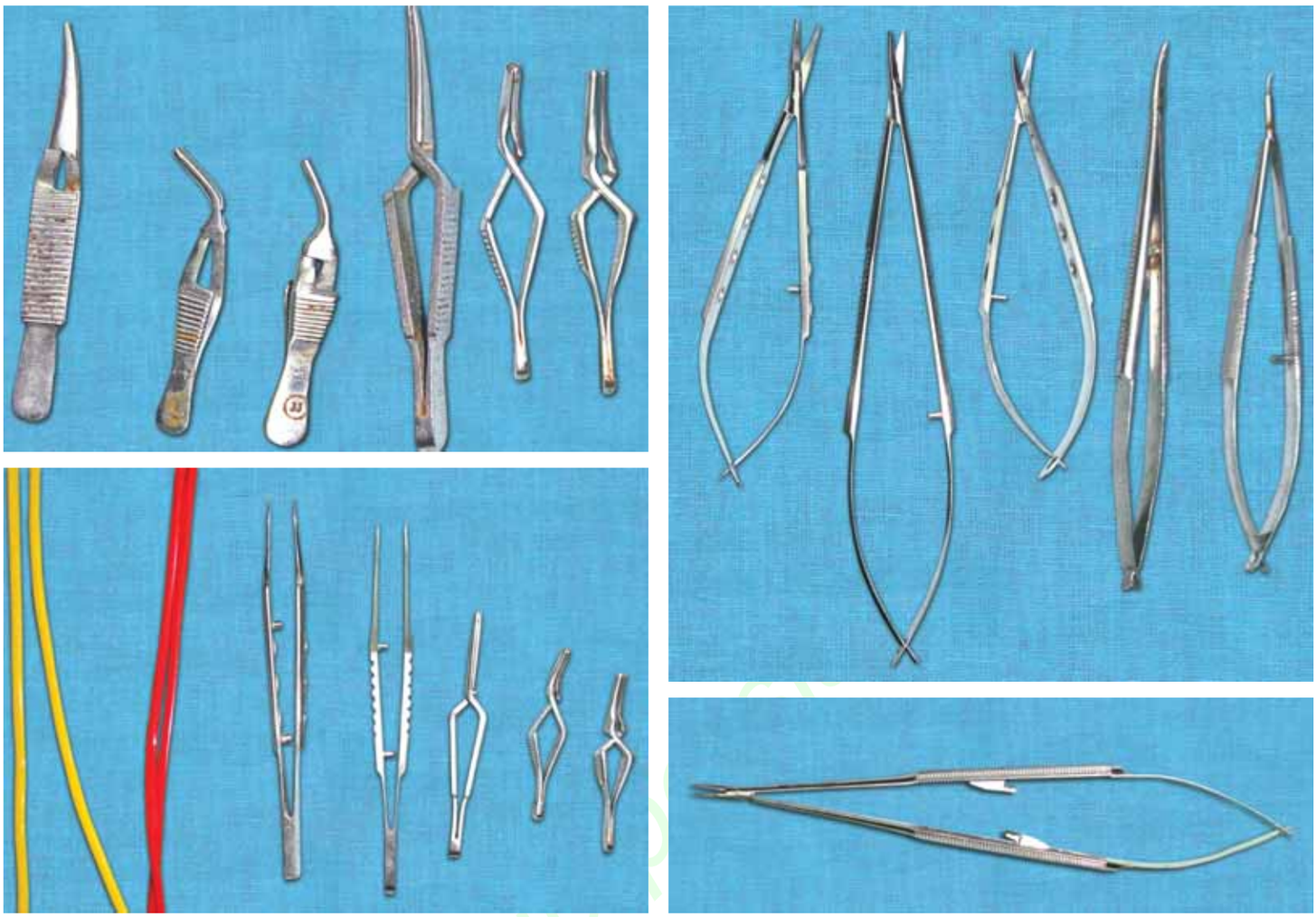


Fig. 11-99: Instruments used for AV fistula creation.

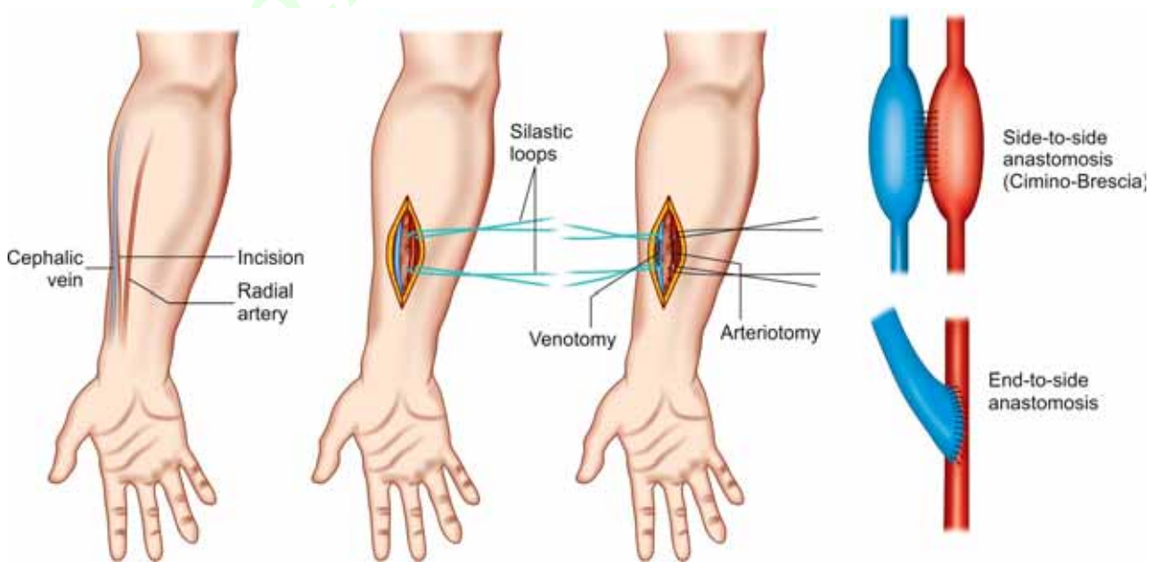


Fig. 11-100: Radiocephalic AV fistula creation.

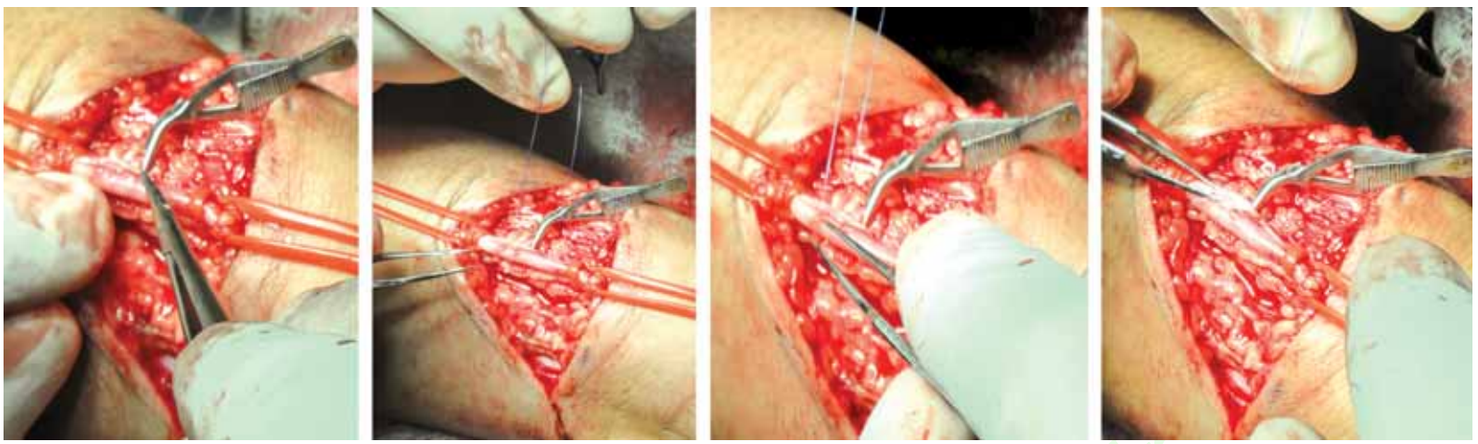


Fig. 11-101: Radiocephalic AV fistula.

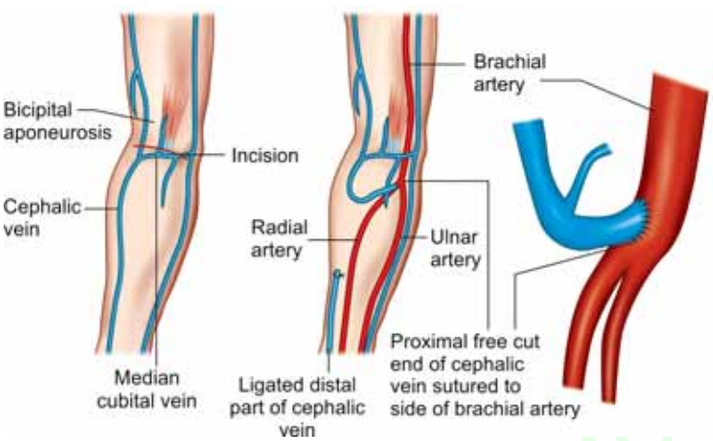


Fig. 11-102: Brachiocephalic AV fistula.

PTFE Graft AV Fistula in Forearm for Haemodialysis Access (Fig. 11-104)

It is done when primary AV fistula is not possible due to inadequate venous length/size/pattern. Graft interposition for creation of fistula between artery and vein is needed. Basilic or cephalic vein can be used. Brachial artery is usually used.

After Doppler venous mapping of the upper limb, under regional anaesthesia, transverse or longitudinal incision is made in the forearm. Brachial artery at the antecubital fossa or just above is dissected for 2-3 cm and isolated with silastic loops. Basilic vein on the medial and upper part of the forearm is dissected for 2-3 cm with ligation of tributaries. PTFE 6 mm graft is used of adequate length. Place where graft crosses the joint should be ringed. Subcutaneous tunneling is done using finger or haemostat or tunneling device. Graft is passed through the subcutaneously created tunnel without any kink. IV heparin 3000 units injected. Arteriotomy and venotomy

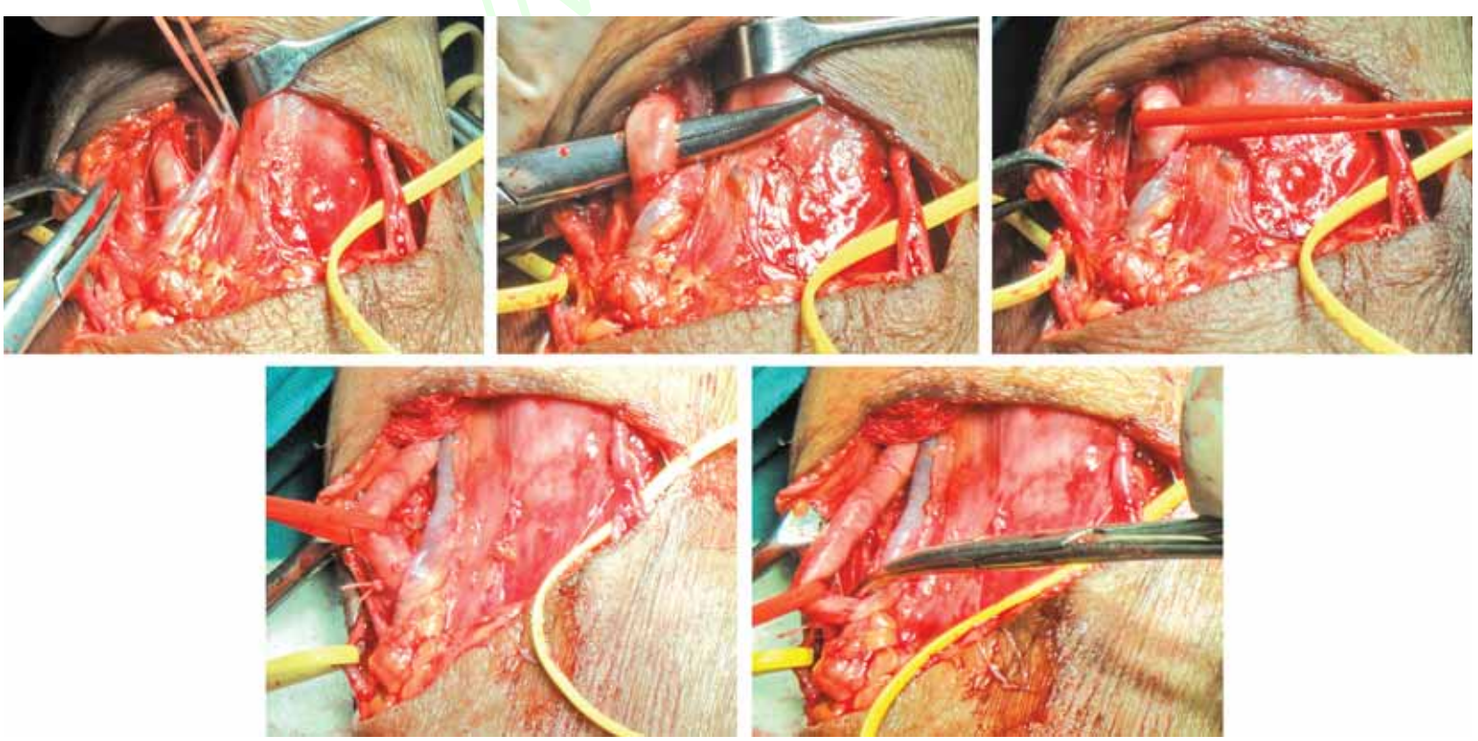


Fig. 11-103: Dissection of vessels for brachiobasilic AV fistula.

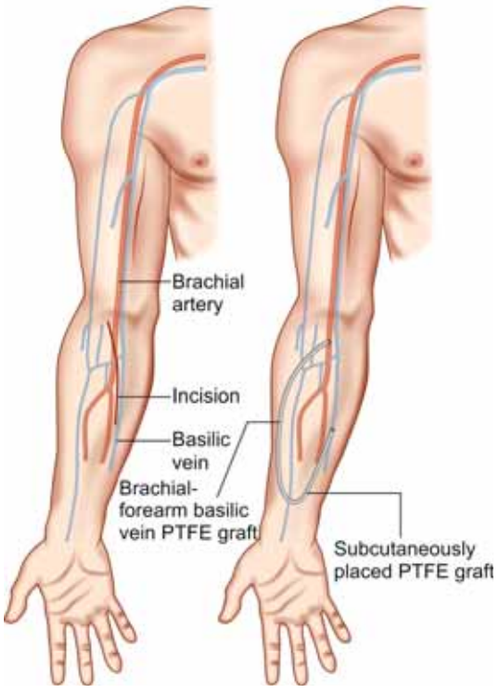


Fig. 11-104: AV fistula in forearm using PTFE graft between brachial artery and basilic vein.

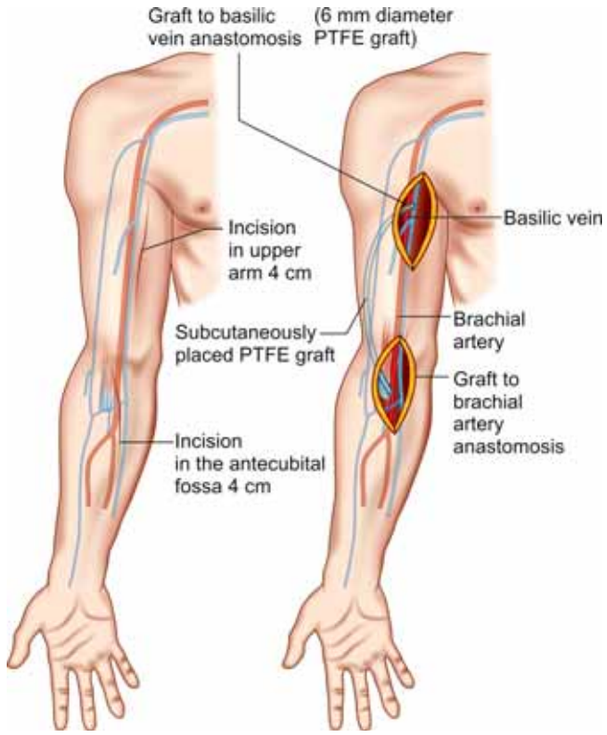

Graft to basilic vein anastomosis
(6 mm diameter PTFE graft)
Incision in upper arm 4 cm
Basilic vein
Subcutaneously placed PTFE graft
Brachial artery
Graft to brachial artery anastomosis
Incision in the antecubital fossa 4 cm

Fig. 11-105: Upper arm prosthetic AV fistula.

of 6 mm length is done. Graft is anastomosed to target artery (brachial) and target (basilic) vein as end-to-side using 6 zero polypropylene sutures. First graft to artery anastomosis is done; Graft is palpated ***for thrill***. Adequate distal pulse in radial/ulnar should be confirmed. Venogram may be needed at a later date if stenosis is suspected.

PTFE Graft in Upper Arm Prosthetic AV Fistula Access (Fig. 11-105)

It is done under general or regional anaesthesia. Patient is in supine position with arm at 90°. After cleaning and draping, a 5 cm incision is made on the medial aspect of the upper arm towards axilla. Basilic vein is identified in deeper plane medially and 4 cm length of the vein dissected, isolated circumferentially and silastic loops are placed. Brachial artery is identified and dissected through a 3-5 cm length incision over the antecubital fossa after incising bicipital aponeurosis. 2-3 cm of brachial artery is dissected to place silastic loops. A curved tunnel is created in the subcutaneous plane directed laterally to connect these tow wounds to place the prosthetic graft. Patient is heparinized (with 3000 units IV). 6 mm arteriotomy is done in brachial artery; 6 mm sized PTFE graft is spatulated to anastomose with arteriotomy as end-to-side using 6 zero polypropylene continuous sutures. Wound and site is irrigated with heparinized saline. Graft is passed through the tunnel to reach the basilic vein proximally. 10 mm venotomy is done; obliquely cut other end of the graft is sutured similarly to the venotomy. Backward bleeding from the venous side and forward bleeding from the graft was done. Thrill in the basilic vein is checked. Radial and ulnar pulses are also checked. Doppler is used to confirm adequacy of flow.

Complications are – sepsis, bleeding, finger ischaemia, nerve injury, fistula thrombosis and block.

Graft Revision after Graft Block

Graft may get blocked by graft thrombosis. Doppler is done to identify the site of block. Incision is made over the graft site extending above and below. Proximal and distal control is obtained. Patient is heparinised. *Balloon thrombectomy* is done through venous side and later through arterial side of the graft. Pulsation is checked after that to confirm the flow over the graft. Fistulogram is done to rule out distal stenosis. If it is present a *jump graft* is placed to bypass stenosis.

Note

- Fistula requires 6 weeks to mature; and 2 weeks in case of graft. Any swelling in the fistulas site after 2nd week should be evaluated for complications. Venous side branches in the fistula may prevent maturation, and so needs proper ligation of side branches.
- If fistula has not matured in 6 weeks, it should be assessed by Doppler study and fistulogram. Rule of 6's criteria in AV fistula if matured are – flow more than 600 ml/min; diameter > 6 mm; depth < 6 mm.
- Patient should do isometric hand exercise and should do daily self examination of fistula for thrill and features of infection.
- Vein should be checked for distension; nondistensible fistula is sclerotic and will not mature.
- Noncompressible veins are thrombotic.
- While dissecting the major target artery care should be taken not to injure adjacent nerves.
- Steal syndrome is more common when fistula is created above elbow level; when fistula is done with graft than vein; and in diabetic, Steal syndrome may cause gangrene of fingers or entire hand. In such situation access fistula may require to be ligated to save the hand. Otherwise interval ligation of artery distal to fistula level is done with revascularisation of artery distally using another graft from artery above the level of fistula to artery below the level of ligation.
- Possible sites of future access should be preserved and cannulas or venous catheters should be avoided at such sites.
- Proper documentation with a diagram of the fistula is a must in all these patients.

PERITONEAL DIALYSIS ACCESS

Peritoneal dialysis catheter can be placed as an emergency temporary one done in ICU or open placement of the catheter done in operation theatre or laparoscopic assisted catheter placement or totally laparoscopic catheter placement.

In emergency and laparoscopy, trocar placement is blind. So risk of bowel injury should be taken into account.

Tenckhoff or Missouri swan neck catheter (has got intraperitoneal ball deeper to cuff to position underneath the peritoneum whereas cuff comes in front of the peritoneum) is used.

Open Method

With patient in supine position entire abdomen is cleaned and draped. Site for trocar and exit trocar should be marked before making incision by placing the catheter on the abdomen with curl end placing on the pubic symphysis going upward with inflow cuff above the umbilicus on the rectus and exit cuff trocar below the umbilicus lateral to the rectus muscle. Incision is deepened to anterior rectus sheath which is incised vertically and rectus muscle is split. Purse string suture is placed in the posterior fascia which is later incised in the centre of the purse string. Peritoneal dialysis catheter with a guidewire or a stylet is lubricated with jelly. Catheter white line should face anterior upward. Catheter is inserted into the abdominal cavity along the posterior surface of the abdominal wall towards the iliac crest and then towards pubic symphysis. Curl of the catheter is placed in the pelvis just deep to the pubic symphysis close to the abdominal wall. Guidewire is removed; heparinised saline is flushed into the catheter. Fluid should flow without interruption and one should able to instill, aspirate or siphon the fluid easily if catheter curl is placed properly (Patient is placed in reverse Trendelenburg position). Purse string is tightened around the catheter (Missouri swan neck catheter). A tunnel is created through rectus muscle and subcutaneous tissue to reach exit site. Catheter is passed through this tunnel. Cuff of the exit site of the catheter should be 1 cm proximal to the exit point. Upper wound is closed completely. Suture is placed around catheter at exit wound **(Fig. 11-106)**.

Patient can undertake dialysis at home. Patient cannot go for swimming and bath should be avoided. Shower can be used. Dialysis is done usually 2 weeks afterwards. Initial low volume dialysis is done increasing the volume gradually to therapeutic level.

OMENTOPLASTY

Indications

To improve circulation in peripheral vascular disease, to improve lymphatic drainage from the limb in case of lymphoedema, in revascularisation of the pharynx, cranial cavity.

Surgical Anatomy

Common hepatic artery → Gastroduodenal artery → Right gastroepiploic artery.

Coeliac artery *Omental vessels.*

Splenic artery → Left gastroepiploic artery

Omentum has got 4 layers of omental arcades with rich lymphatics. By retaining one of the pedicles either right or left gastroepiploic arteries, omentum is mobilised for adequate length to maintain the circula-

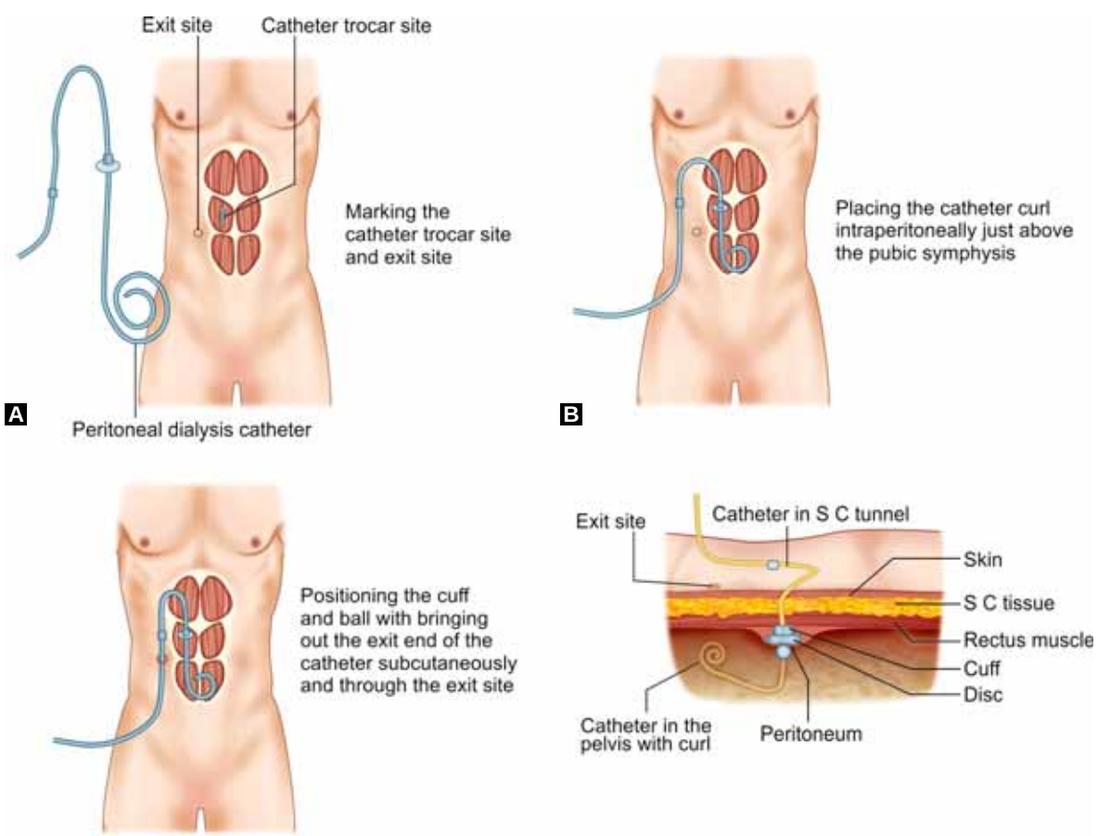

Exit site
Catheter trocar site
Marking the catheter trocar site and exit site
A
Peritoneal dialysis catheter
Placing the catheter curl intraperitoneally just above the pubic symphysis
B
Positioning the cuff and ball with bringing out the exit end of the catheter subcutaneously and through the exit site
Exit site
Catheter in S C tunnel
Skin
S C tissue
Rectus muscle
Cuff
Disc
Catheter in the pelvis with curl
Peritoneum

Fig. 11-106: Technique of peritoneal dialysis (open method).

tion. It controls the ischaemia, promotes the wound/ulcer healing and reduces the pain. It can also be used in upper limb ischaemia. It can be used in bilateral lower limb diseases as two pedicles. But if patient continues to smoke these omental vessels may acquire the disease (TAO) and recurrence of symptoms can occur.

Procedure

Preoperative antibiotic is given. Under general or epidural anaesthesia, entire abdomen and entire lower limb is cleaned and draped. Through upper midline incision abdomen is opened. Omental vessels/arcades are assessed. Omentum is separated from colon through avascular plane. Omentum is also carefully separated from mesocolon through omental bursa. Gastroepiploic arcade along the greater curvature is identified. Branches entering the stomach from gastroepiploic arcade are carefully ligated using 3 zero vicryl. One of the pedicles usually right is retained as pedicle to perfuse the arcade. Omentum is lengthened with careful planning. Bleeding and haematoma formation within omentum should be avoided as much as possible. Cauterisation should be minimum only if at all using bipolar cautery **(Fig. 11-107)**.

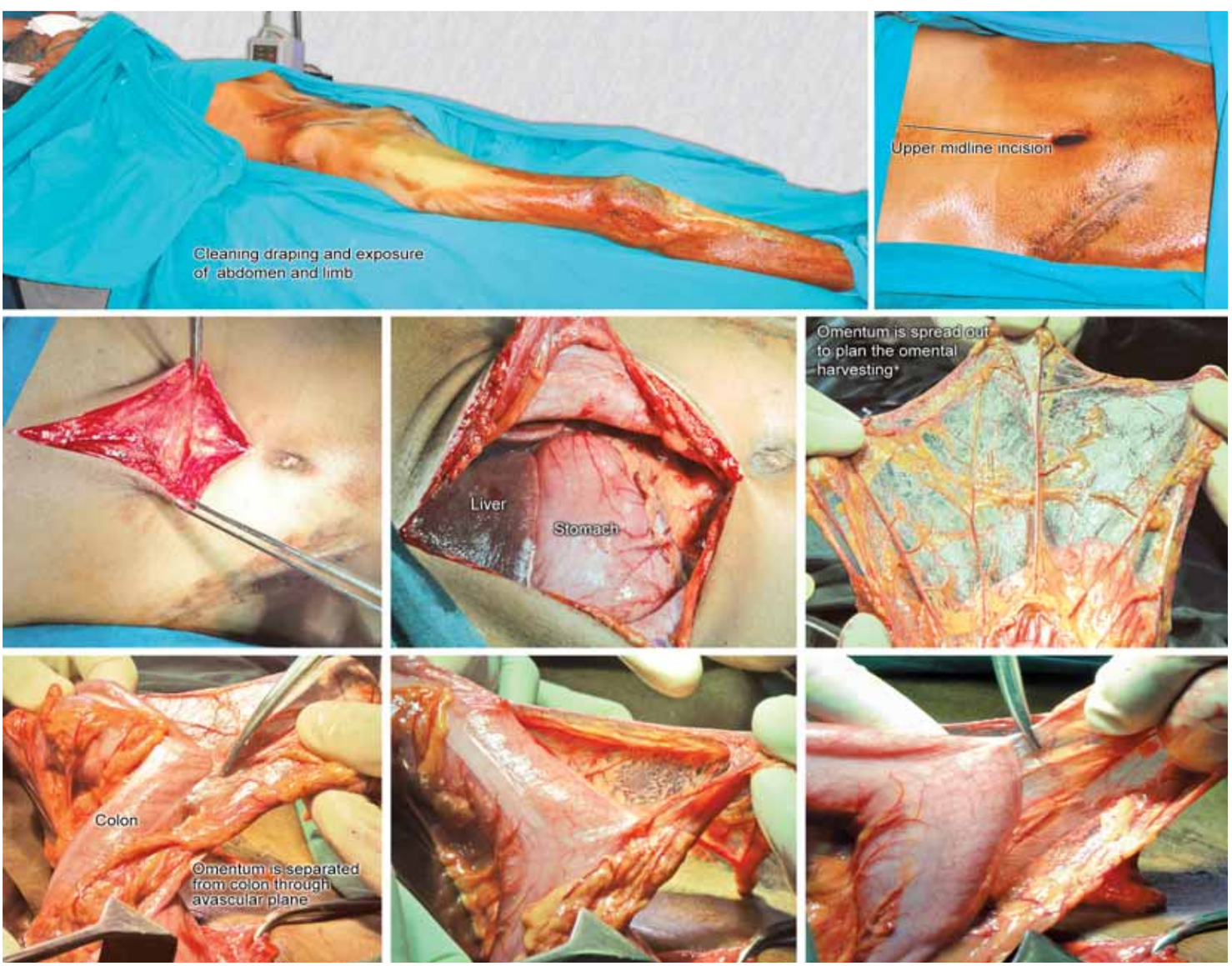
Incision is made just above the groin which is deepened across abdominal wall muscles and peritoneum to reach abdominal cavity. Mobilised omentum is brought out of the groin wound into the subcutaneous plane. Multiple transverse incisions are made in the limb downwards to reach the lower part of leg. Subcutaneous tunnels are created to pass the omentum. In the calf/leg deep fascia is opened to bury the tip of the omentum into the muscle. Abdomen is closed in layers. In the limb only skin is sutured without injuring the omental pedicle in the subcutaneous plane.

Patient is kept nil orally for 24 hours.

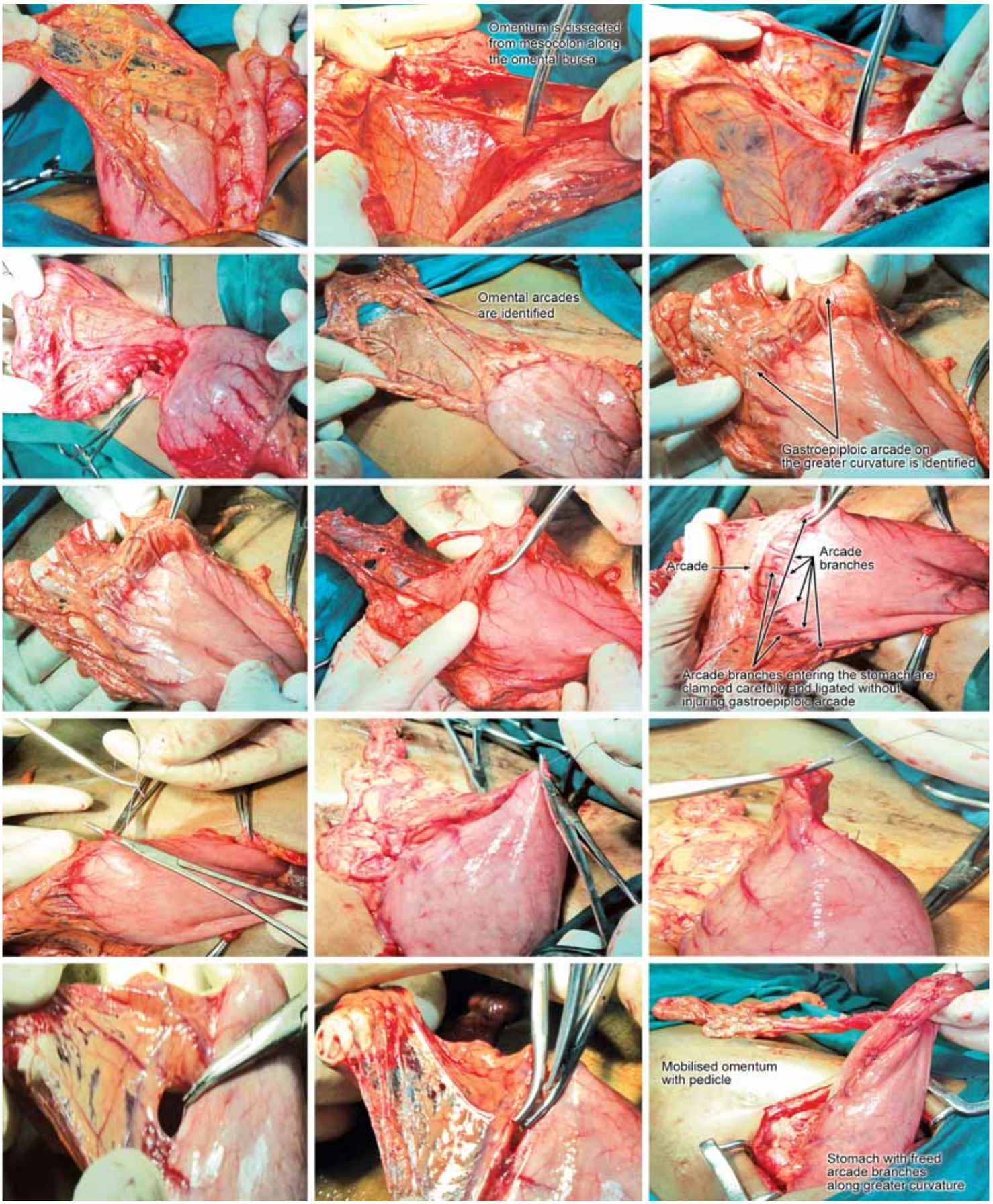
Doppler study at regular period will reveal the perfusion in the omentum.

Complications

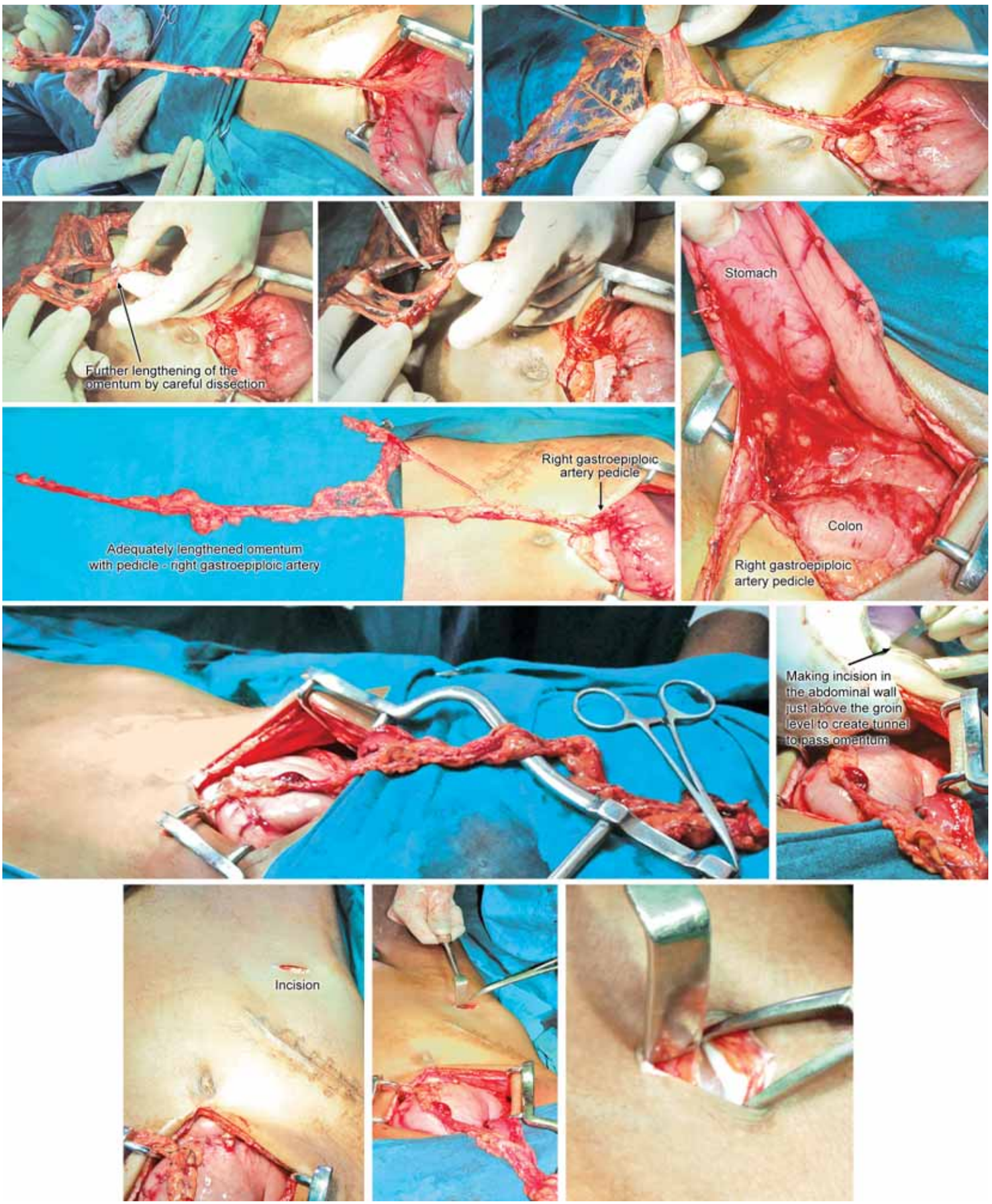
Abdominal sepsis can occur due to removal of omentum from the abdominal cavity. Patient is observed for peritonitis (primary) and septicaemia. It is treated usually with proper antibiotic therapy. Incisional hernia, adhesions, intestinal obstruction can occur. Wound infection in the limb and cellulitis, thrombosis of the omental vessels and failure of the procedure can also occur **(Fig. 11-108)**.


Cleaning draping and exposure of abdomen and limb
Upper midline incision
Liver
Stomach
Omentum is spread out to plan the omental harvesting*
Colon
Omentum is separated from colon through avascular plane

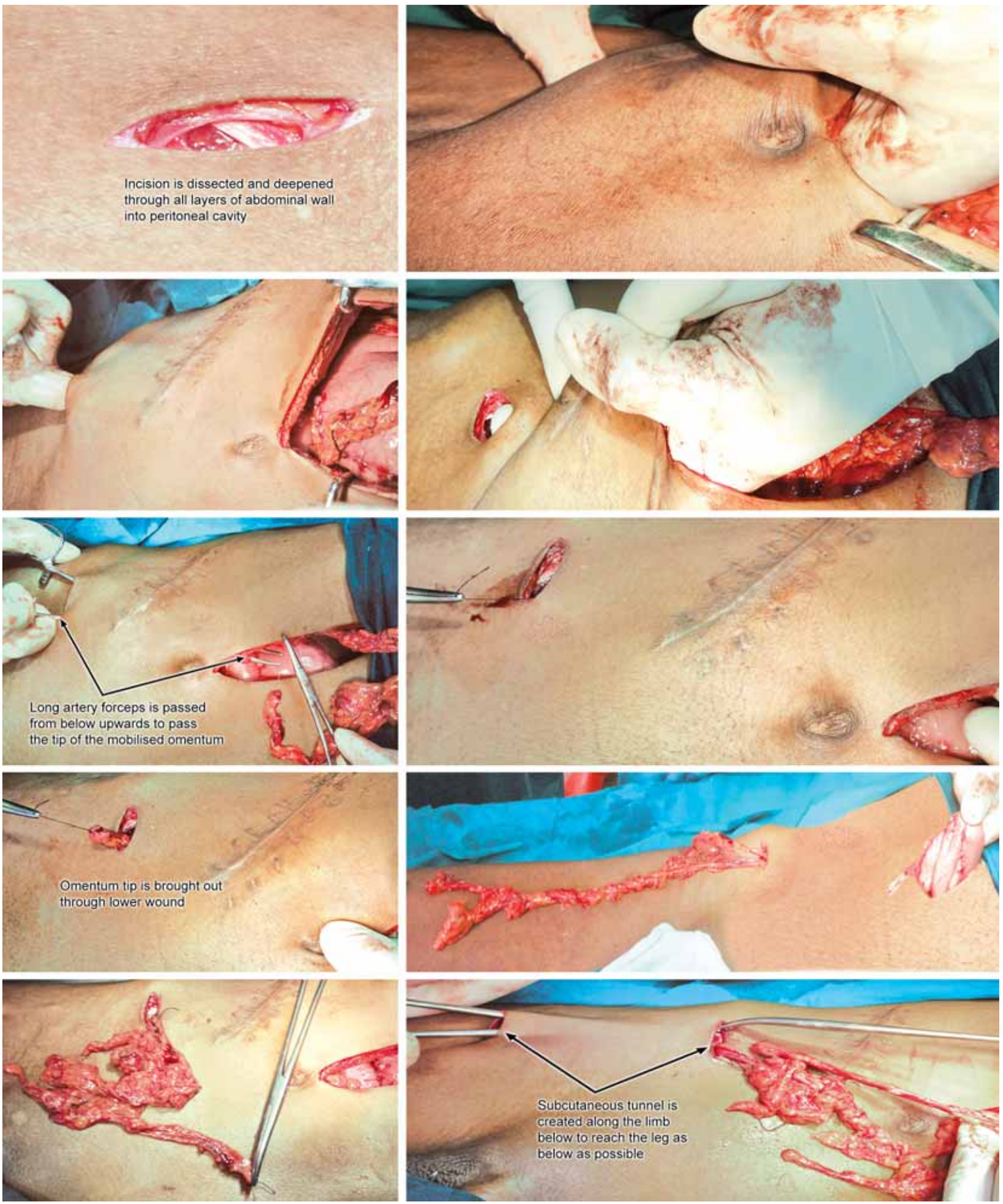
Figs 107(1)


Omentum is dissected from mesocolon along the omental bursa
Omental arcades are identified
Gastroepiploic arcade on the greater curvature is identified
Arcade
Arcade branches
Arcade branches entering the stomach are clamped carefully and ligated without injuring gastroepiploic arcade
Mobilised omentum with pedicle
Stomach with freed arcade branches along greater curvature

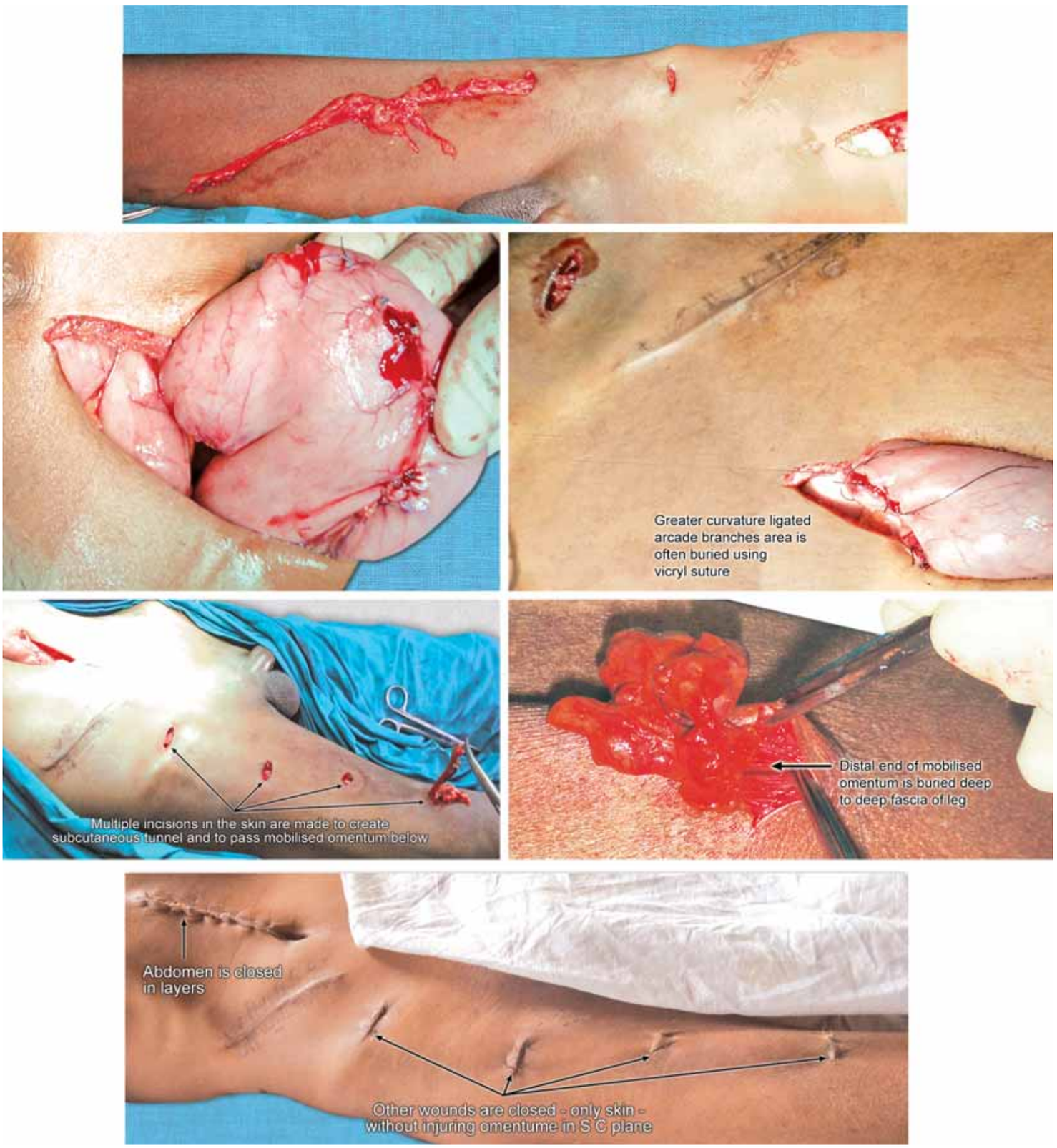
Figs 107(2)


Further lengthening of the omentum by careful dissection
Stomach
Right gastroepiploic artery pedicle
Adequately lengthened omentum with pedicle - right gastroepiploic artery
Colon
Right gastroepiploic artery pedicle
Making incision in the abdominal wall just above the groin level to create tunnel to pass omentum
Incision

Figs 107(3)


Incision is dissected and deepened through all layers of abdominal wall into peritoneal cavity
Long artery forceps is passed from below upwards to pass the tip of the mobilised omentum
Omentum tip is brought out through lower wound
Subcutaneous tunnel is created along the limb below to reach the leg as below as possible

Figs 107(4)


Greater curvature ligated arcade branches area is often buried using vicryl suture
Multiple incisions in the skin are made to create subcutaneous tunnel and to pass mobilised omentum below
Distal end of mobilised omentum is buried deep to deep fascia of leg
Abdomen is closed in layers
Other wounds are closed - only skin - without injuring omentume in S C plane

Figs 107(5)

Figs 11-107(1 to 5): Technique of omentoplasty.

Fig. 11-108: Hernia after omentoplasty along the upper medial part of thigh with colon as content. On percussion it was resonant. Barium enema X-ray showed colon in the hernial sac.

Chapter

12

Surgery in Venous Diseases

VENOUS DOPPLER

With the patient standing; the Doppler probe is placed at saphenofemoral junction and later wherever required. Basically by hearing the changes in sound, venous flow, venous patency, and venous reflux can be very well identified. A *uniphasic signal* means flow is in one direction. A *biphasic signal* means flow in both forward and reverse direction suggesting incompetence. Reversal can often be better appreciated by releasing a tourniquet applied earlier at saphenofemoral junction. An *audible whoosh signal > 0.5 sec* on performing the Valsalva manoeuvre with probe kept at the SFJ suggests incompetence.

Venous Doppler in varicose veins

- To find out DVT- very important
- To find out sapheno-femoral, sapheno-popliteal incompetence
- To find out perforator incompetence
- Uniphasic signals signify flow in one direction – normal; Biphasic flow signifies reversal flow with incompetence.

DUPLEX SCAN

Duplex scan is a highly reliable U/S Doppler imaging technique (Here high resolution B mode ultrasound imaging and Doppler ultrasound is used) which along with direct visualisation of veins, gives the functional and anatomical information, and also color map. Examination is done in standing and lying down position and also with *Valsalva manoeuvre*. Hand held Doppler probe is placed over the site and visualised for any block and reversal of flow. DVT is very well identified by this method. All patients with varicose vein should be assessed preoperatively by ultrasound with *proper venous mapping (Venous haemodynamical mapping; VHM; Cartography)*—i.e. marking on the patient's limb manually using permanent marker under ultrasound guidance. All surgeries should be done with on table ultrasound guidance. Post-operatively, all patients should be assessed using ultrasound for result, and for residual venous diseases. VHM is done in standing; in warm room with adequate time **(Figs 12-1 to 12-4)**.

Air Plethysmography

Patient is initially in supine position with veins emptied by elevation of leg. Air filled plastic pressure bladder (inflatable polyurethane cuff filled with air) is placed on calf to detect volume changes. Minimum volume is recorded. Patient is turned to upright position and venous volume is assessed. Maximum venous volume divided by time required to achieve maximum venous volume gives the *venous filling index (VFI)*. VFI is a measure of reflux. *Ejection fraction* is volume change measured prior and after single tiptoe manoeuvre, which is a measure of calf pump action. *Residual venous fraction* is an index of overall venous function which is venous volume in the leg after ten toetip manoeuvres divided by venous volume prior to manoeuvre. Patients with *increased VFI and diminished ejection fraction will benefit from surgery* **(Fig. 12-5)**.

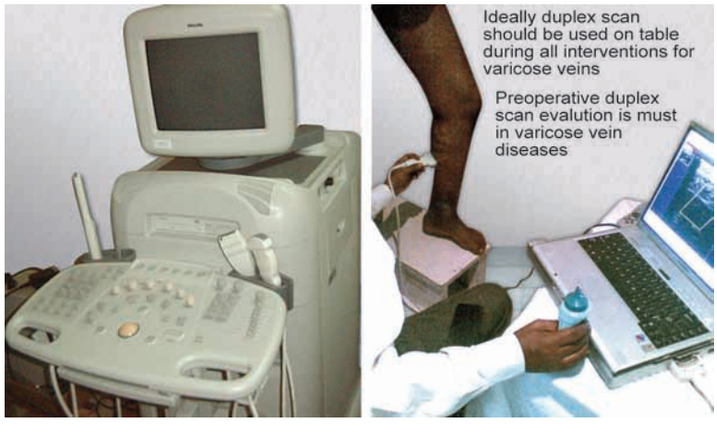

Ideally duplex scan should be used on table during all interventions for varicose veins
Preoperative duplex scan evalution is must in varicose vein diseases

Fig. 12-1: Duplex scan (with Doppler) machine used for varicose veins and DVT. Preoperative duplex scan, marking of veins and on table duplex scan is a must in managing varicose vein diseases.

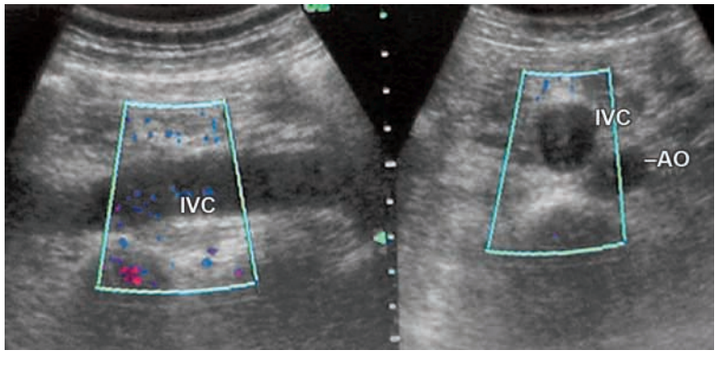


Fig. 12-2: U/S showing IVC thrombosis

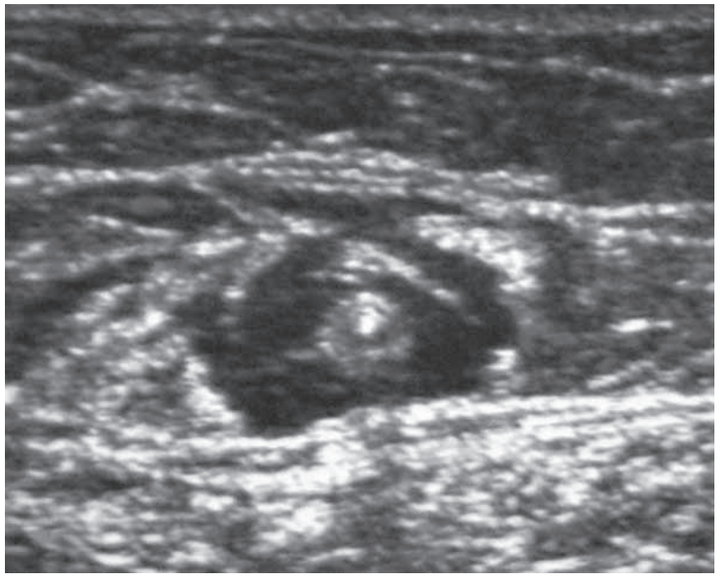


Fig. 12-3: Saphenous eye – as seen in US duplex scan.

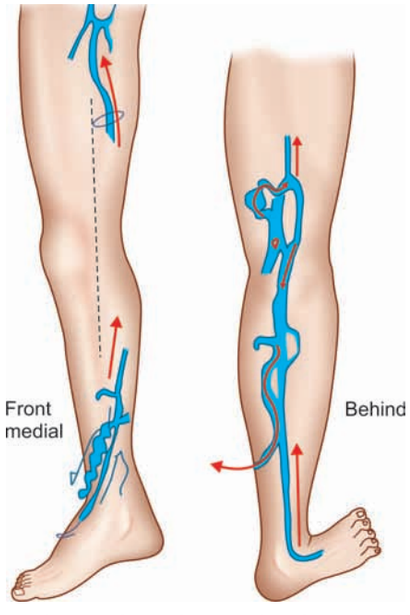


Fig. 12-4: Venous haemodynamic mapping (VHM) of the lower limb.

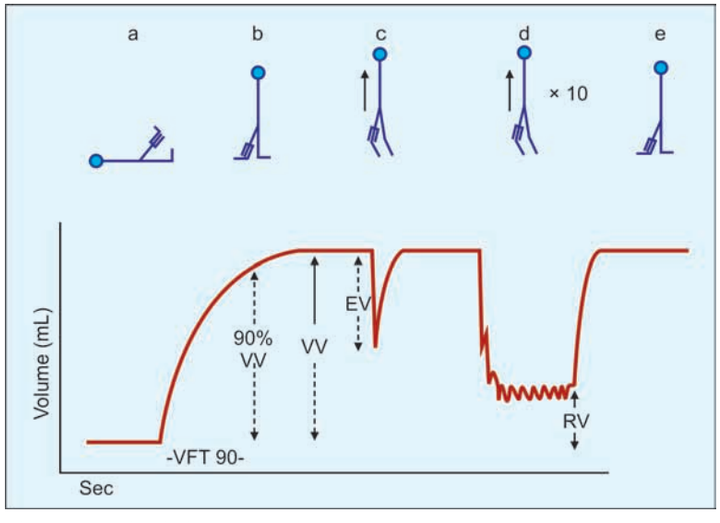


Fig. 12-5: Air plethysmography.

Venography/Phlebography

Ascending venography was a very common investigation done earlier to Doppler period.

A tourniquet is tied above the malleoli and the vein of dorsal venous arch of the foot is cannulated. Water soluble dye injected flows into the deep veins (because the applied tourniquet prevents its flow into superficial veins). X-rays are taken below and above the knee level. Any block in deep veins, its extent, perforator status can be made out by this.

Note: In the presence of Duplex scan ascending venography is not a necessary investigation. If DVT is present, surgery or sclerotherapy are contraindicated.

Descending venogram is done when ascending venogram is not possible and also to visualise incompetent veins. Here contrast material is injected into the femoral vein through a cannula in standing position. X-ray pictures are taken to visualise deep veins and incompetent veins.

Phlebography

- Ascending phlebography defines obstruction
- Descending phlebography identifies valvular incompetence
- Regularly not required to be done

Levels of Investigations

Level I – History, examination with Trendelenburg test, hand held Doppler scanner.

Level II –Noninvasive – Duplex scan, air plethysmography.

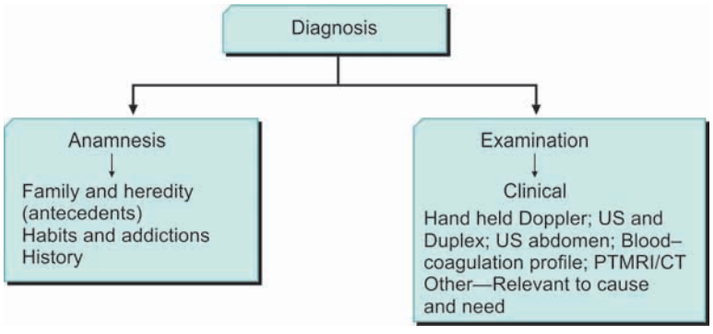
Level III – Invasive and complex imaging – descending and ascending venography; venous pressure measurement; CT scan; venous helical scanning; MRI.

Note:

Advanced CEAP classification is used now rather than basic CEAP. VCSS (Venous Clinical Severity Scoring) is also useful.

Table 12-1: VCSS system

	None – 0	*Mild – 1*	*Moderate – 2*	*Severe – 3*
Pain	None	Occasional; no restriction of daily activity	Daily that only interferes with daily activity	Daily pain that prevents from working
Varicose veins	None	Few scattered branch vein varicosities; > 5 blue telangiectases on the inner part of foot – ankle flare	Multiple varicosities of calf or thigh	Multiple varicosities of both calf and thigh
Inflammation	None	Perimalleolar area	Lower 1/3rd calf	More than lower 1/3rd of calf
Induration	None	Perimalleolar area	Lower 1/3rd calf	More than lower 1/3rd of calf
Active ulcer duration	No active ulcer	< 3 months	3-12 months	> 12 months
Other parameters similarly				



SURGICAL ANATOMY OF LOWER LIMB VEINS (FIG. 12-6)

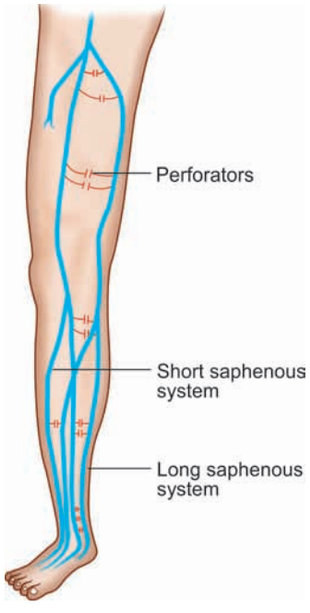


Fig. 12-6: Anatomy of lower limb veins.

Superficial Venous System

It is located in the saphenous compartment which is between subcutaneous plane and deeper aponeurotic plane. GSV and SSV are in this plane.

Great (Long) saphenous vein (GSV): It runs from the medial end of the dorsal venous arch up along the anteromedial aspect of the leg and thigh until it empties into the femoral vein. There is one valve at the junction – is called as *ostial / terminal* valve and reflux through it is called as *ostial reflux*. One more valve proximal to the main junctional tributary veins is called as *preterminal valve*. More than 50% reflux occurs at preterminal valve (*preterminal reflux*).

Small (Short) saphenous vein (SSV): It runs from the lateral end of the dorsal venous arch up along the posterolateral aspect of the calf until it passes through the popliteal fossa behind the knee and empties into the popliteal vein just above the knee.

Tributaries are located in the subcutaneous plane which joins the saphenous system. Superficial circumflex vein (often joins AAGSV), superficial external pudendal vein, superficial inferior epigastric vein, anterior vein of the leg, posterior arch vein of the leg (joins GSV), posterolateral venous chains of leg – are different tributaries. Long intersaphenous communicating vein often exists between cranial extension of SSV to join GSV and can be varicose and pathological and is called as *communicating vein of Giacomini- Cruveilhier*. *Anterior accessory great saphenous vein (AAGSV, Anterolateral vein of thigh)* is communicating vein into the GSV anteriorly and laterally. AAGSV communicates into GSV usually just proximal to preterminal valve (60%); often at confluence (39%); rarely onto femoral vein (1%). In many patients with varicose veins, it is this vein which is diseased than GSV. It often receives superficial circumflex vein before joining the GSV **(Fig. 12-7)**.

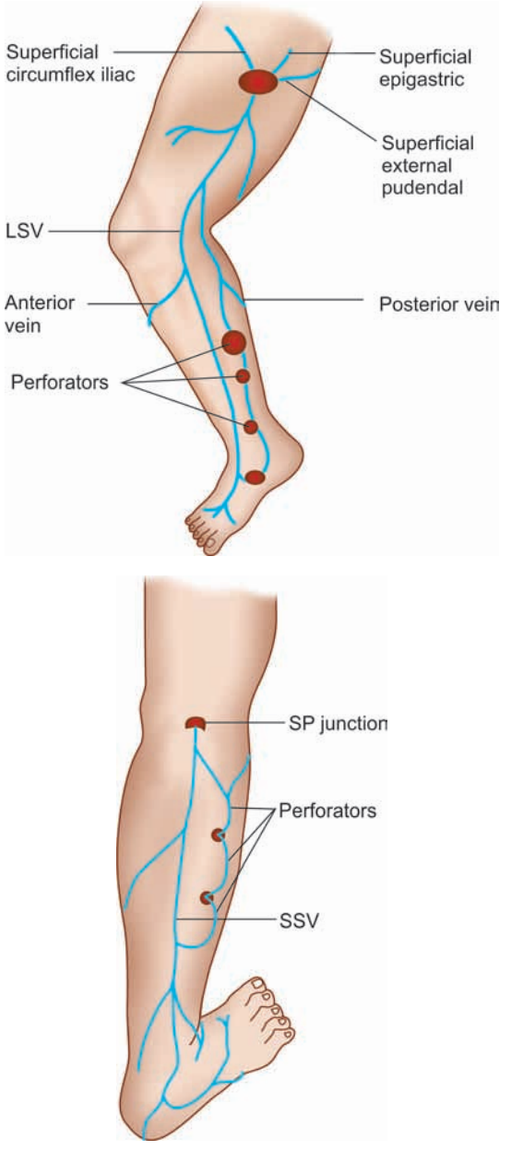


Fig. 12-7: Great saphenous vein (GSV/LSV), small saphenous vein (SSV) and perforators.

Perforator system of veins (communicating veins): They pass through the deep fascia carrying blood from superficial to the deep system. One way flow of blood is maintained through valves. Incompetence of these valves leads to appearance of superficial varicosity during exercise.

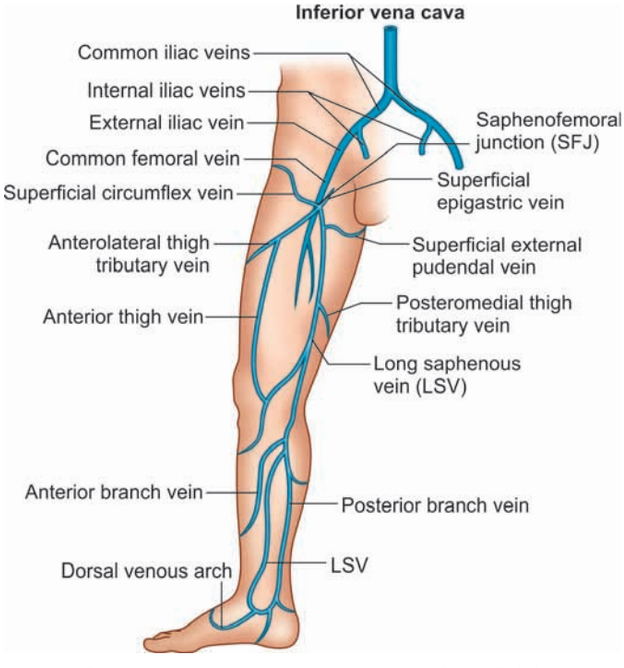
Deep venous system: It comprises femoral and popliteal veins; pairs of venae commitantes of the tibial, posterior tibial and peroneal arteries (total 6 venae commitantes, soleal and gastrocnemius veins join

to form popliteal vein); valveless blood lakes within the calf muscles communicates with superficial system via saphenofemoral junction, mid-thigh perforators, short-saphenopopliteal junction and calf perforators.

The calf muscle pump: It is often referred to as "*peripheral heart*". Its inflow into a segment of deep vein is through intake valves of the perforating veins and segment of deep vein below. Its outflow is through outflow valve to the deep vein segment above. It has got soleal veins (blush up the blood) and gastrocnemial veins (*Gilot*) (push up the blood) to have effective motor venous return **(Fig. 12-8)**.

DIFFERENT TYPES OF PERFORATORS

Para Achillean (*Bassi);* **Ankle perforators**; (*May or Kuster*); **Lower leg perforators** between deep veins and posterior arch vein *(Cockett*): I (posteroinferior to medial malleolus), II (10 cm above the medial malleolus), III (15 cm above medial malleolus); **Gastrocnemius perforators** between GSV and deep veins - upper proximal paratibial



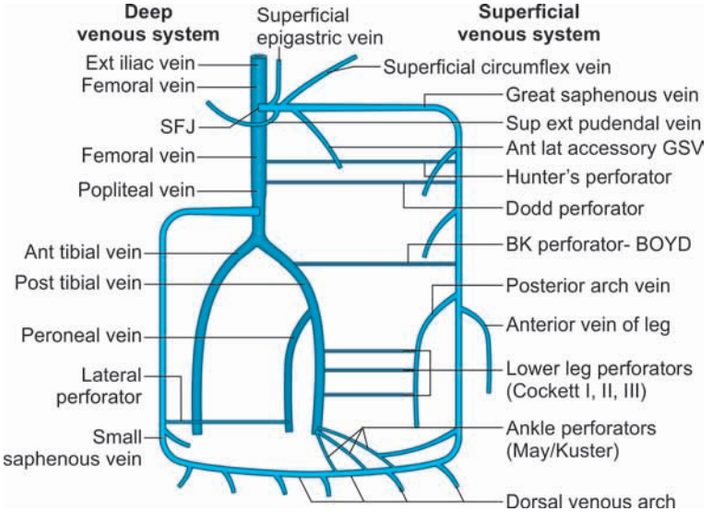


Fig. 12-8(1)

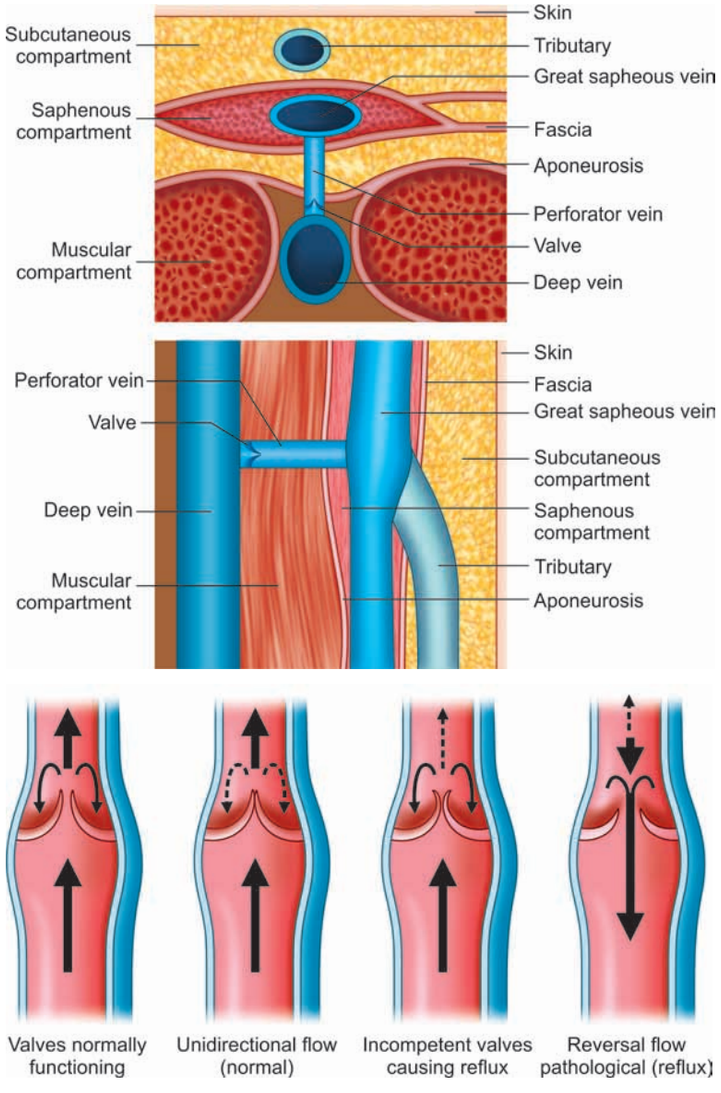


Fig. 12-8(2)

Fig. 12-8: Diagrams showing venous anatomy of the lower limb. Also note the functioning of the valve in the vein.

*(Boyd)-b*elow knee; **Lower and medial paratibial** (*Sherman)*; *24 cm perforator* between deep veins and GSV; **Mid-thigh perforator** between deep vein and GSV *(Dodd);* **Hach perforator in the posterior thigh***;* **Hunter`s adductor canal perforator** in the thigh **(Fig. 12-9)**.

PHYSIOLOGY OF VENOUS BLOOD FLOW IN LOWER LIMB

Veins are thin walled vessels with collapsible walls that assume an elliptical configuration in collapsed state and circular configuration in the filled state. Venous valves are abundant in the distal lower extremity and the number of valves decreases proximally, with no valves in superior and inferior venacava.

Factors affecting venous return are – (a) Arterial pressure across the capillary increases the pumping action of vein; (b) *Calf musculovenous pump*: During contraction phase of walking, pressure in the calf muscles increases to 200-300 mm Hg; This pumps the blood towards the heart; During relaxation phase of walking, pressure in the calf falls and so it allows blood to flow from superficial to deep veins through

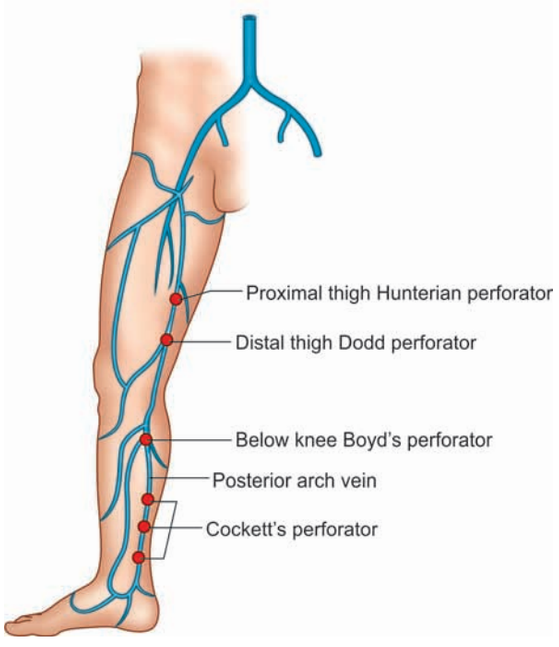


Fig. 12-9: Diagram showing different perforators.

perforators; Normally while walking, pressure in the superficial system is 20-30 mm Hg at the level of ankle; During walking, foot pump mechanism propels blood from plantar veins into the leg; (c) Gravity. Pressure in the vena cava where it enters the right atrium is very low (-5 mm Hg) which allows rapid filling of vena cava from high pressure peripheral veins.

Factors responsible for venous return: Negative pressure in thorax; Peripheral pump—calf muscle; *Vis-a-tergo* of adjoining muscle; Non-refluxing valves in course of veins.

VENOUS PATHOLOGY

Venous pathology develops when venous return is impaired. It can be of *deep, superficial or mixed types*. It can be due to primary muscle pump failure, venous obstruction, and venous valvular incompetence. It may be segmental or affecting the entire leg. Here venous wall shows increase in collagen and reduction in elastin. *Causes of primary muscle pump failure are* - muscle wasting, neuromuscular disease, deep fasciotomies, local vein valve failure. It leads to nonreduction of postambulatory pressure; causes increased hydrostatic pressure and thus decreased arterial inflow. Present concept is inflammatory pathology of the venous wall and valve. Present theory is a changed concept from top to bottom with segmental pathophysiology. So VHM (venous mapping) is essential prior to surgical intervention.

Incompetence can be of *three types* – perforator; superficial and deep.

Perforator incompetence is reversal of normal flow across the perforators. Normal flow is from superficial veins to deep veins. Perforator valve failure causes deep to superficial reflux causing congestion and venous hypertension. It causes transmission of extreme high pressure (150–200 mm Hg) generated at the deep veins into the superficial veins. This high pressure reflux *(hydrodynamic reflux*) causes distal valvular incompetence of the superficial venous system causing varicosity and its problems. Problems here are more rapid and progressive than just superficial vein incompetence.

Superficial vein incompetence is the most common form of the venous disease. It shows retrograde flow (*hydrostatic reflux*) due to malfunctioning valves. It is the tributaries which commonly become incompetent and diseased as it is in subcutaneous plane with less support and also has thin muscle layer in the wall. Here effects are slow and gradual.

Deep incompetence may be isolated incompetence of deep veins or may be associated with incompetence of superficial venous system. Here blood pumped out in normal volumes but extremity refill includes normal arterial inflow and also pathological reflux. Venous refill is rapid with normal or elevated ambulatory venous pressure **(Fig. 12-10)**.

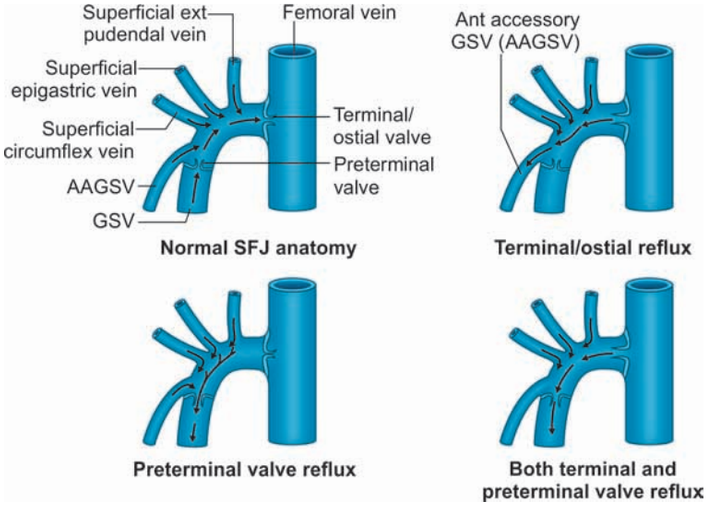


Fig. 12-10: Great saphenous vein anatomy at its saphenofemoral junction showing reflux.

MANAGEMENT OF VARICOSE VEIN DISEASE

One has to remember that varicose vein is a disease with progressive deterioration. Surgeon should not jump to do surgery to every patient with varicose vein. Selection of the case for surgical intervention is very important. It is done to relieve significant symptoms, reverse or reduce skin changes, to promote healing of the ulcers. Cosmesis and treating the asymptomatic uncomplicated varicose veins for prophylaxis are also the mentioned indications, but surgeon should be careful and should clearly discuss with the patient properly the drawbacks of interventions.

Venous mapping *is mandatory* prior to surgery. *Duplex scan with Doppler should be used always during all intervention procedures for varicose veins* **(Figs 12-11 and 12-12)**.

Contraindications for Surgery

DVT is an *absolute contraindication* for surgery.
Pregnancy, females taking contraceptive pills and recent episode of superficial thrombophlebitis are *relative* contraindications.

Indications for interventional procedures –
Complaints which are relevant like pain, discomfort;
Complications;
Cosmesis.

Endovenous ablation can be thermal or chemical. Thermal ablations (TA) are – radiofrequency (RFT) or laser ablation. Chemical are liquid

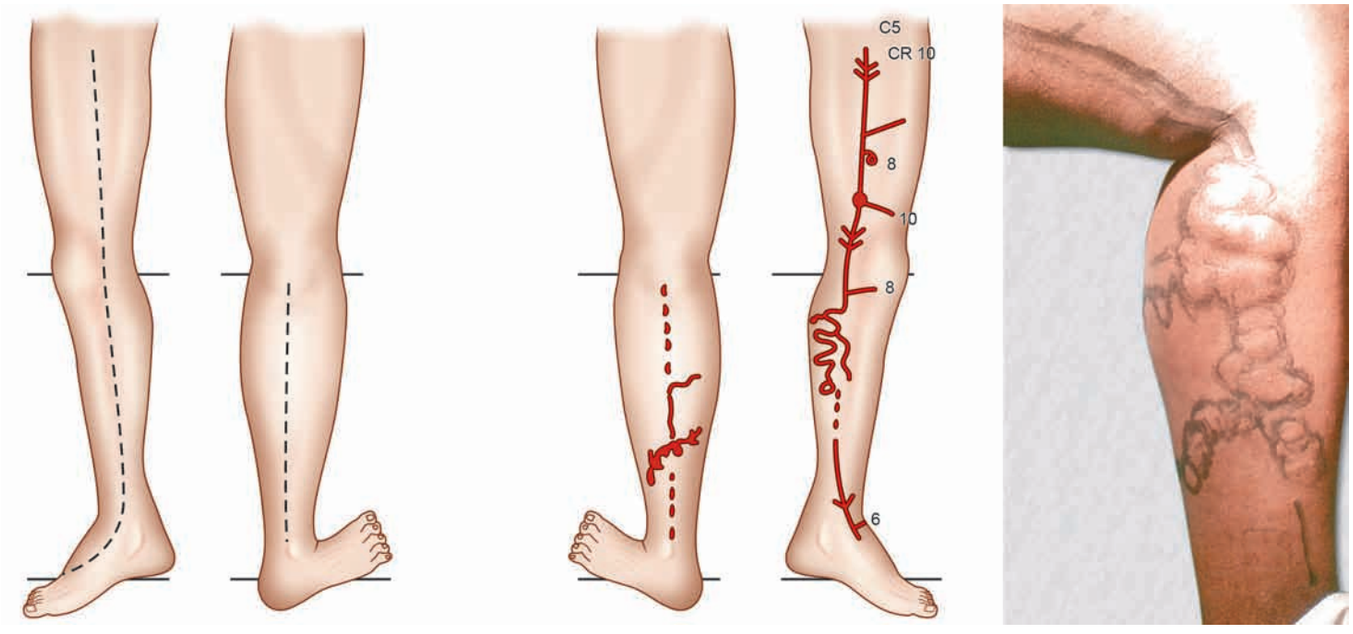


Fig. 12-11: Venous mapping should be done prior to any intervention to varicose veins. It is done using US scan with patient in *standing position*.

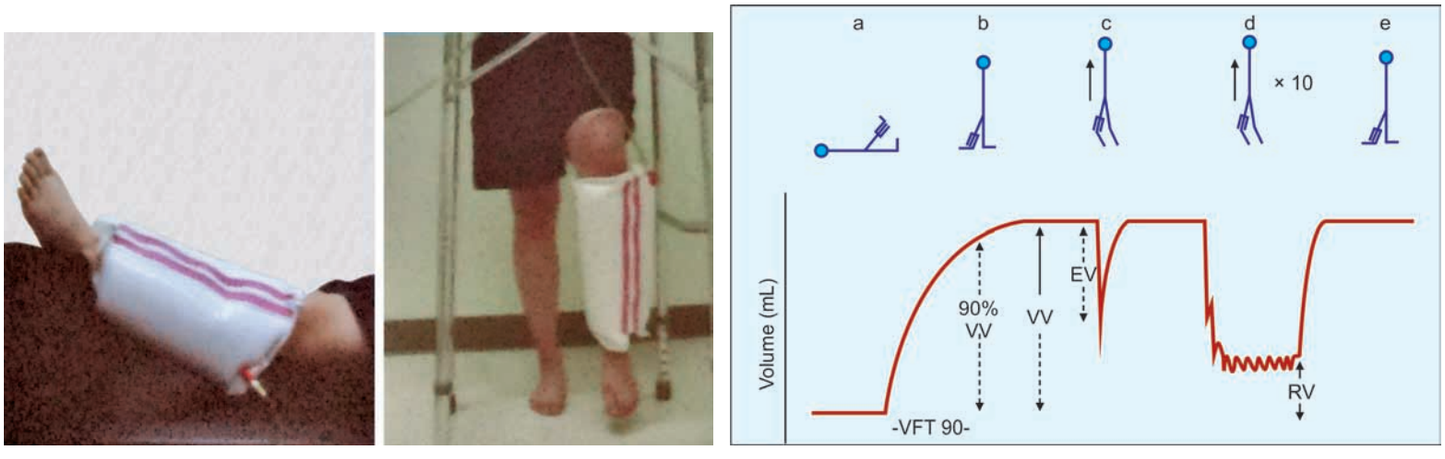
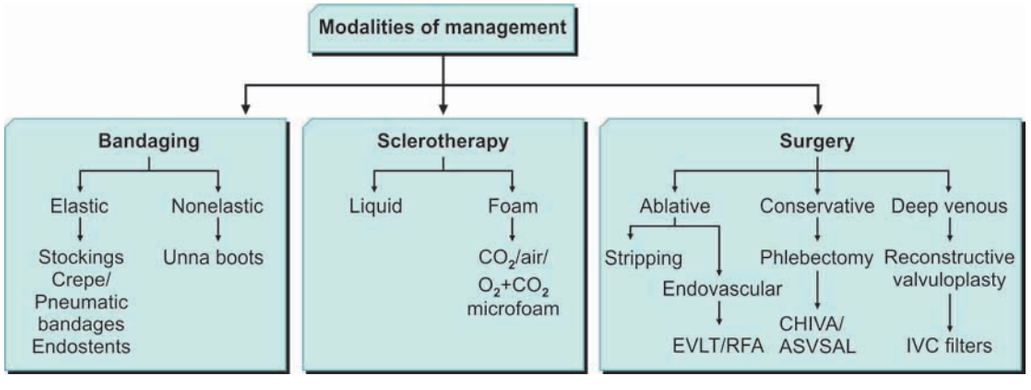


Fig. 12-12: Air plethysmography.



or foam sclerotherapy (FS). Venous mapping is mandatory for all mapping. Presently recommendation is all endovenous therapies should be done under US guidance. FS is simpler than TA. TA and FS both are effective, simple and safe. TA is more effective for vein > 5 mm. FS is appropriate for recurrent and complex varicosities.

TRENDELENBURG OPERATION (SAPHENO-FEMORAL CROSSECTOMY) AND/OR STRIPPING

It is *juxta femoral flush ligation* of long saphenous vein (flush with femoral vein) after ligating named (superficial circumflex, superficial external pudendal, and superficial epigastric vein) and unnamed tributaries. Anomalies of GSV should be remembered. Double saphenous vein is the commonest anomaly occurring near SFJ.

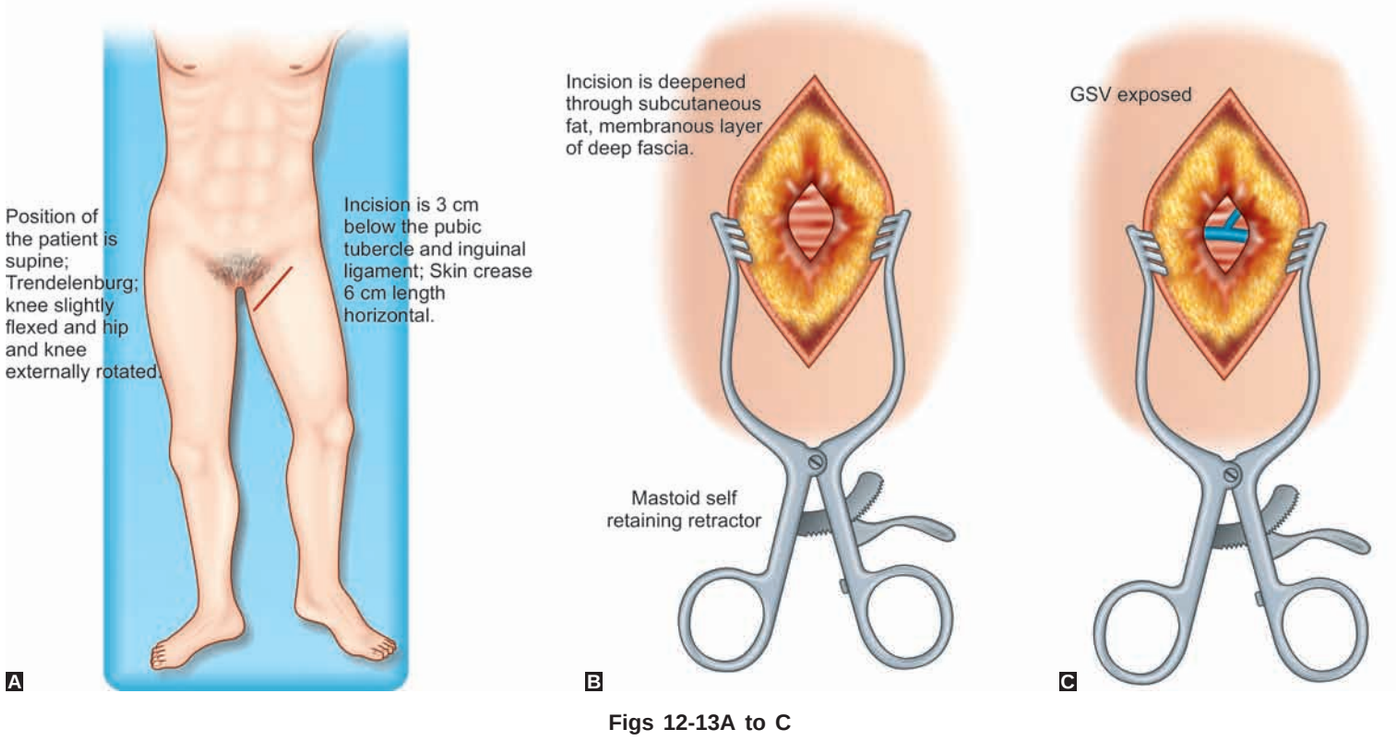
Procedure

It is done under spinal/epidural/general anaesthesia. Just prior to giving anaesthesia all dilated veins and perforators should be marked with proper marker in standing position. Marking can be done using Duplex scan with Doppler. It is ideal to use Doppler with duplex scan during procedure also.

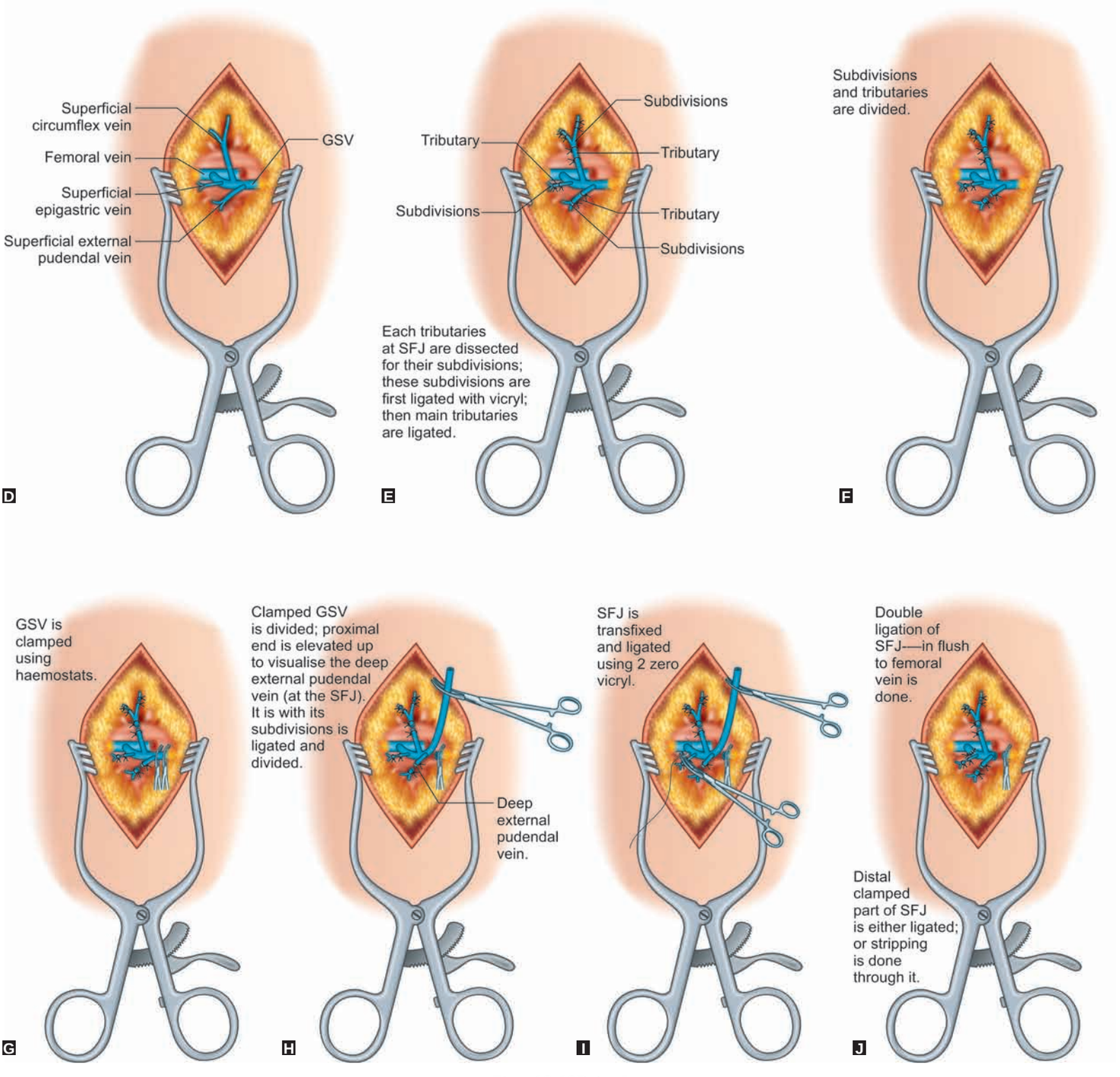
Entire limb, groin and perineum from ankle is cleaned and draped. Patient is placed in supine position with knee slightly flexed and rotated externally. Saphenous opening is marked which is 3-4 cm below and lateral to pubic tubercle. Horizontal incision of 6 cm length is placed at this point at the crease. Subcutaneous fat, membranous layer of superficial fascia (Scarpa's fascia) is incised. GSV is identified on the medial side of the wound. Wound edges are retraced. Dissection is done proximally to identify the cribriform fascia and saphenofemoral junction (SFJ). Once SFJ is delineated, SFJ is dissected all round and femoral vein is identified in deeper plane. Femoral vein is medial to femoral artery. Colour of femoral vein differs from that of GSV. A small external pudendal artery often may cross between femoral vein and GSV. Feeling the femoral arterial pulsation may be beneficial to identify the femoral vein. Care should be taken not to injure the femoral vein. There is a possibility of developing inadvertent tear at SFJ causing severe bleeding. In such situation blind application of the haemostat should be avoided. First head end is lowered to reduce the venous pressure; firm pressure over the site using a mop facilitates proper identification of the site of bleed which is ligated using polypropylene sutures. Superficial external pudendal, superficial external (circumflex) iliac, superficial epigastric veins are identified and dissected until they reach to their further tributaries. These smaller tributaries are dissected individually, ligated and divided. Other unnamed tributaries along the length of 3 cm of GSV from SFJ are also dissected, ligated and divided. All these smaller tributaries are ligated using 3 zero / 2 zero vicryl. Finally main named tributaries are ligated. Often it is done after transecting the GSV away from tributaries level and lifting the divided proximal end of the GSV. Once three main tributaries are ligated, proximal GSV is lifted to visualise the deep external pudendal vein which joins femoral vein or SFJ on medial side. This vein is carefully dissected, double ligated and divided. Avulsion of this vessel may occur causing torrential bleeding from the femoral vein. Femoral vein is dissected carefully adjacent to SFJ for 2 cm proximally and distally. Anatomical variations should be considered in all patients while dissecting which are not common **(Figs 12-13A to J)**.

GSV is transfixed and ligated using 2 zero vicryl suture on the wall of the femoral vein as a flush but without creating any kink to the vein and also one should not allow to form a blind pouch by doing ligation little distal to the SFJ which may later create *saphena varix*. Additional simple ligature is also placed **(Figs 12-14A to I)**.

Lower part of the wound is retracted to expose the posteromedial deep external pudendal vein and other tributaries of GSV which are


Position of the patient is supine; Trendelenburg; knee slightly flexed and hip and knee externally rotated.
Incision is 3 cm below the pubic tubercle and inguinal ligament; Skin crease 6 cm length horizontal.
A
Incision is deepened through subcutaneous fat, membranous layer of deep fascia.
Mastoid self retaining retractor
B
GSV exposed
C

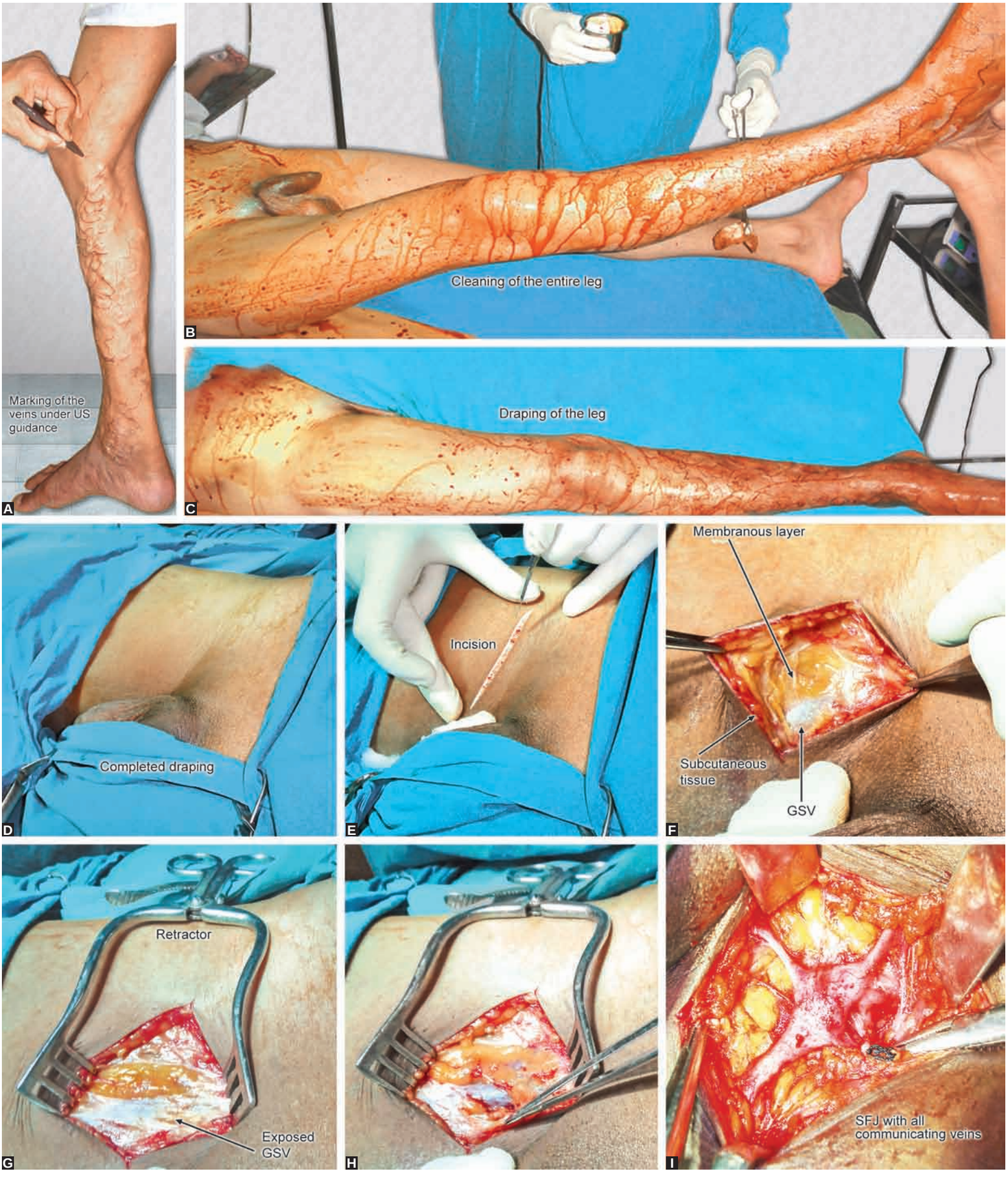
Figs 12-13A to C


Superficial circumflex vein
Femoral vein
Superficial epigastric vein
Superficial external pudendal vein
GSV
D
Tributary
Subdivisions
Subdivisions
Tributary
Tributary
Subdivisions
Each tributaries at SFJ are dissected for their subdivisions; these subdivisions are first ligated with vicryl; then main tributaries are ligated.
E
Subdivisions and tributaries are divided.
F
GSV is clamped using haemostats.
G
Clamped GSV is divided; proximal end is elevated up to visualise the deep external pudendal vein (at the SFJ). It is with its subdivisions is ligated and divided.
Deep external pudendal vein.
H
SFJ is transfixed and ligated using 2 zero vicryl.
I
Double ligation of SFJ—in flush to femoral vein is done.
Distal clamped part of SFJ is either ligated; or stripping is done through it.
J

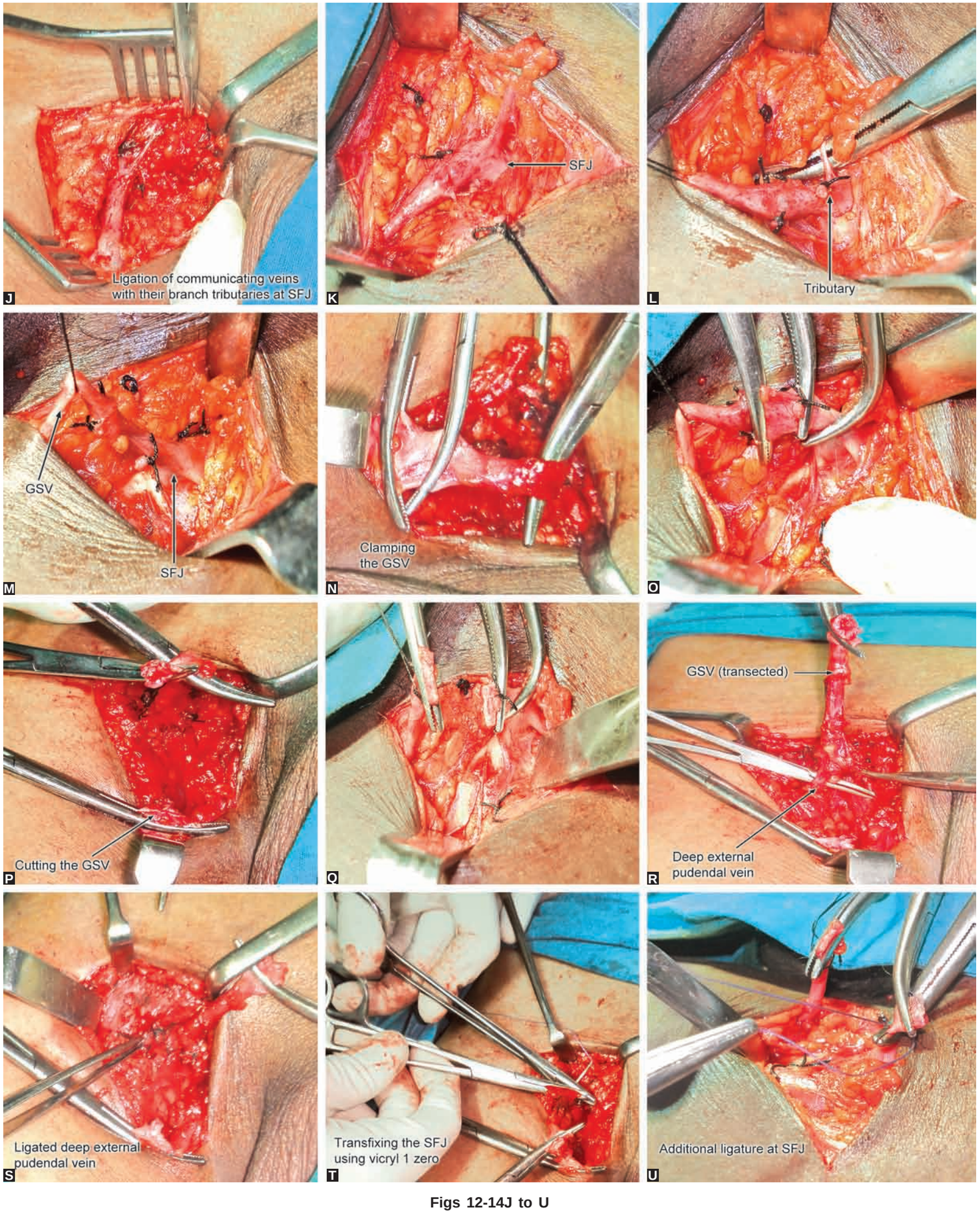
Figs 12-13D to J

Figs 12-13A to J: Diagram showing steps of saphenofemoral flush ligation.

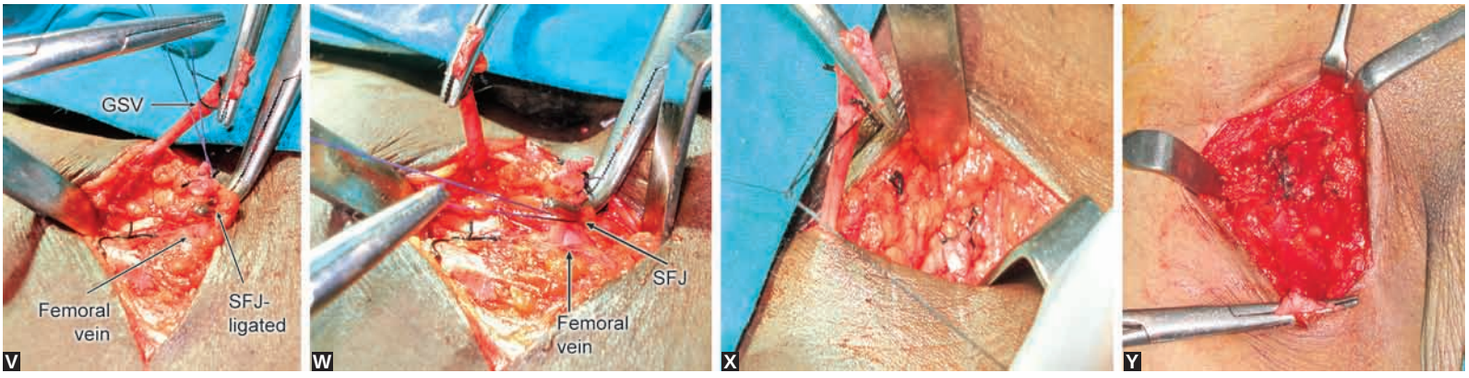
securely ligated. Remaining tributaries up to the middle of the calf (or up to 4 cm/hand breadth below the knee joint line to include Boyd's perforator) are addressed either by stripping or by series of small incisions along the line of GSV (ablation). Stripping the GSV below the mid-calf will likely to injure the saphenous nerve causing *saphenous neuralgia*. Stripping *should preferably be done* from above downwards after passing stripper from below upwards. *Many advocate* stripping of the vein from below upwards and is said to be technically easier with keeping limb elevated. But here injury to saphenous nerve and stripper entering the deep system are likely complications to occur even though incidences are low. *Stripping avulses all significant thigh perforators.* It is advisable to complete all planned procedures like foam sclerotherapy/multiple avulsions and close the skin wounds with stripper placed ready for stripping; at the end vein is stripped with limb in elevated position. Immediately after stripping the vein soft cotton pads and roller dressing pads are



Figs 12-14A to I



Figs 12-14J to U



Figs 12-14V to Y

Figs 12-14A to Y: Saphenofemoral flush ligation for varicose veins—operative steps.

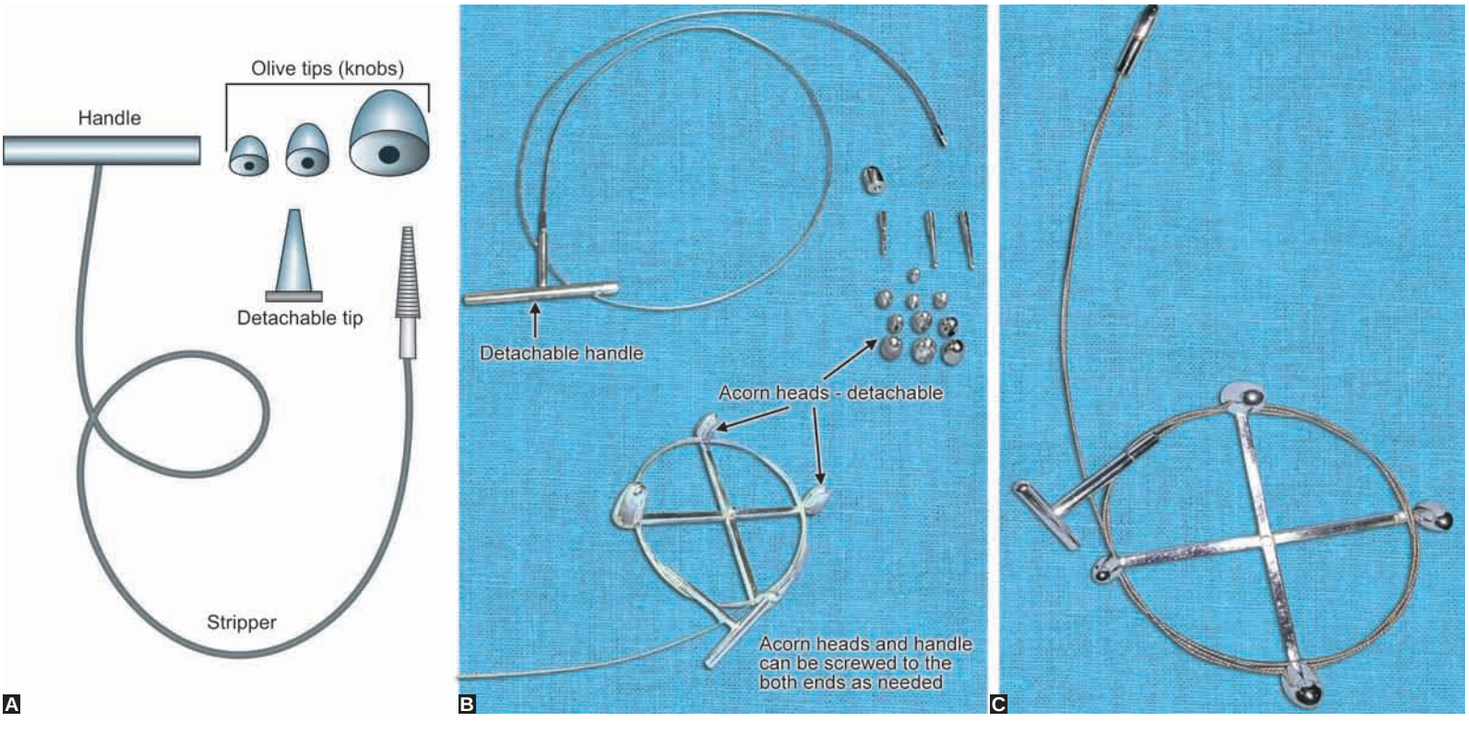
placed from toes to groin and bandage and crepe bandage or stockings are placed. Stripping is done in elevation to prevent haematoma formation. Limb should be kept in elevated position adequately (3 pillows) during postoperative period.

Two Types of Stripping Techniques

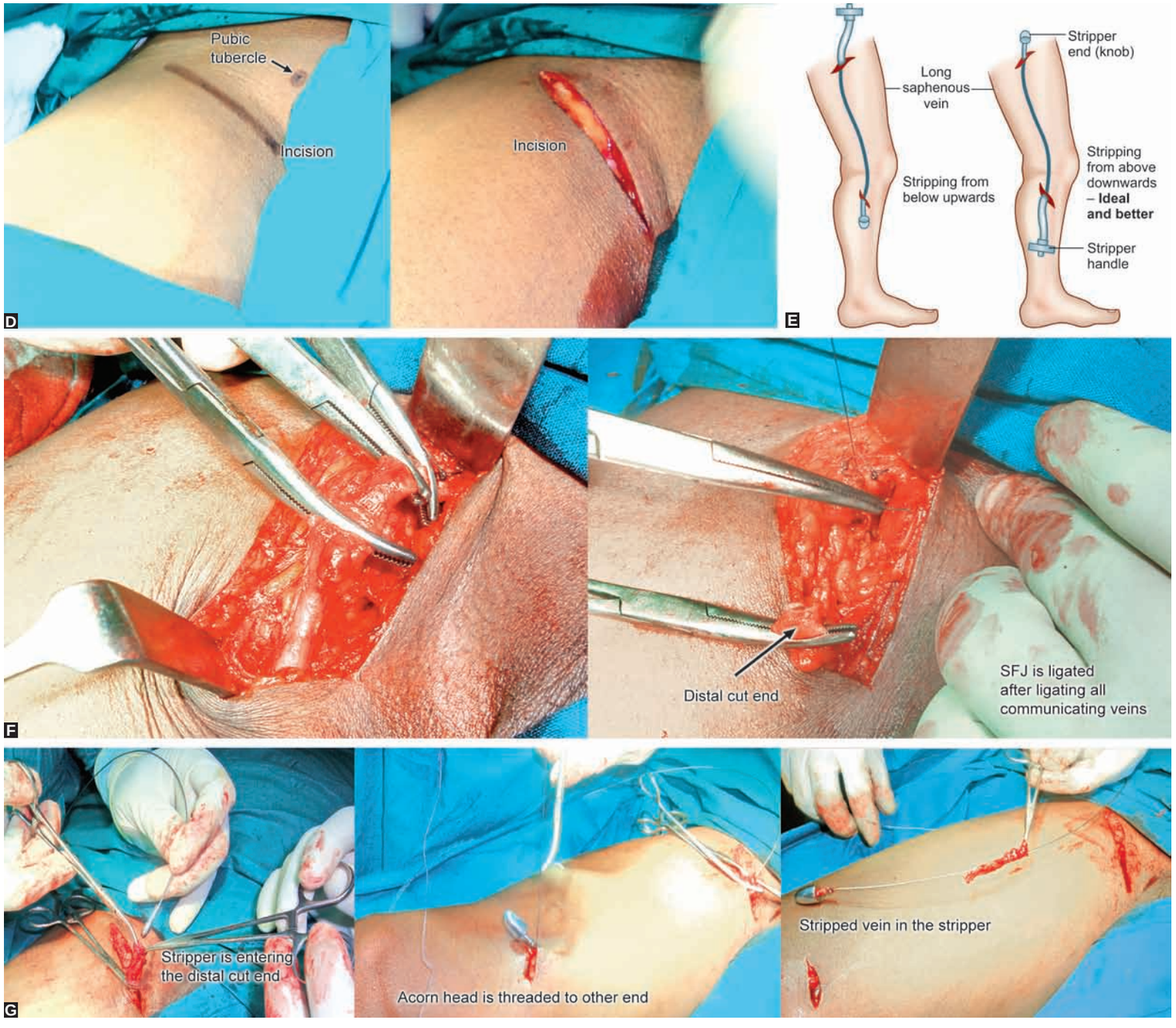
Extraluminal collision technique using Myer's stripper (Acorn head stripper, 73 cm long) is practiced since long time; but it damages the adjacent tissue, causes infection, postoperative pain and discomfort and haematoma along the stripped tract with possibility of revascularization of the tract haematoma.

Invagination technique is better with less damage to adjacent tissue. *Codman's stripper* is used for invagination technique. Stripping avulses the vein and obliterates the tributaries.

A small transverse incision is made at mid-calf level along the line of GSV. Vein is identified and dissected. Saphenous nerve which is very close to the vein should be separated and should not be injured. Vicryl ligature is passed to distal part of the isolated vein. After ligating it, the ends of the ligature are lifted using haemostat. Proximal to this, an additional 2 or 3 zero vicryl ligatures are passed around and temporarily held with two haemostats without tying. Proximal to ligature vein is held by two haemostats and anterior part of the vein is incised between two haemostats. It is better to place two 3 zero vicryl stitches instead of two haemostats and vein is incised between these two ties. Olive tip of the Myer's stripper is passed through the vein from below upwards towards groin crease wound. Depending on surgeon's choice *acorn head* is threaded into the lower end if stripping is done from below upwards (practiced by many surgeons) or acorn head is threaded to upper end if stripping is done from above downwards (*technically ideal*) **(Figs 12-15 and 12-16)**.



Figs 12-15A to C



Figs 12-15D to G

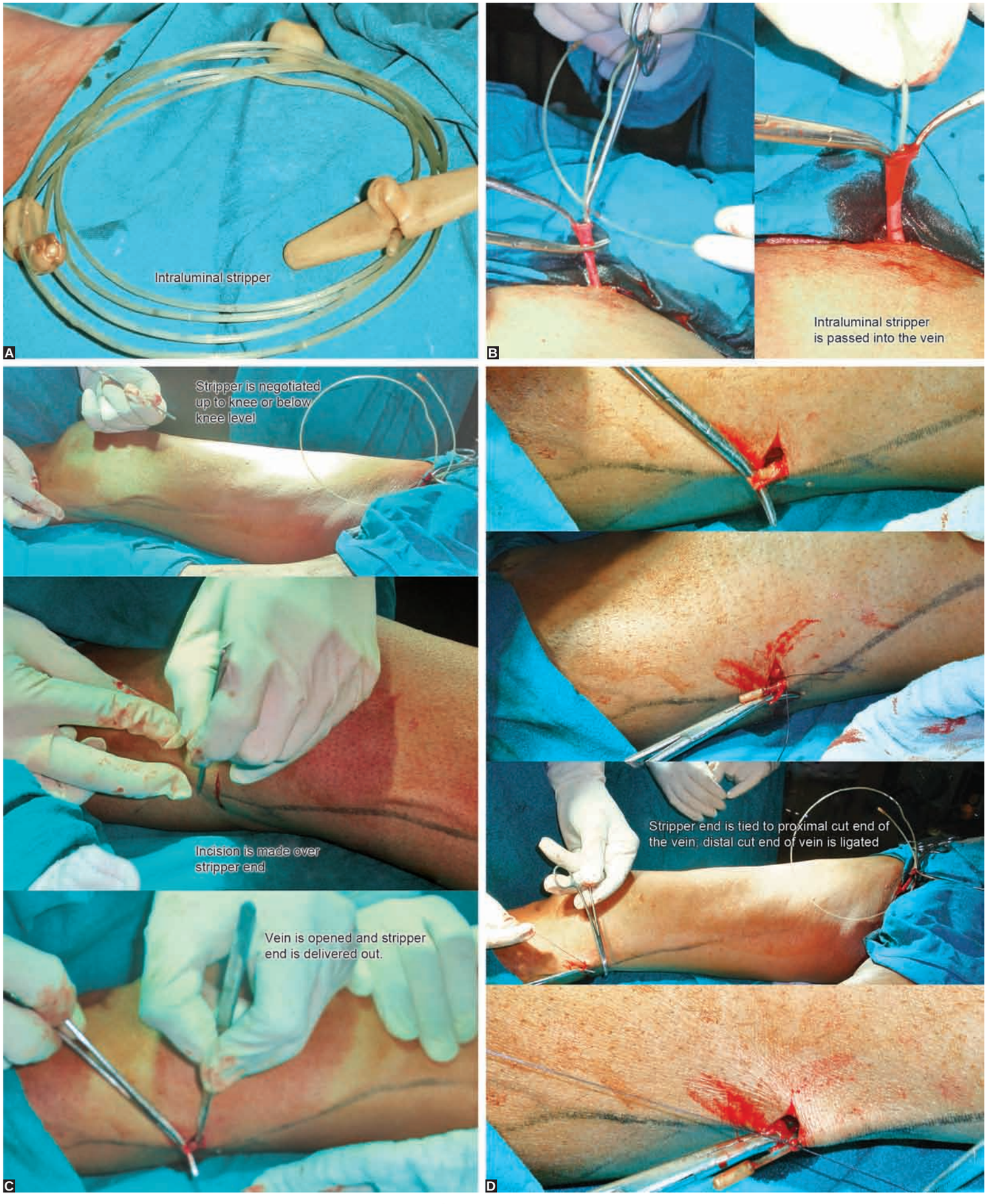
Figs 12-15A to G: Technique of extraluminal stripping of the varicose vein using Myer's stripper.

Proximal vicryl ligature in the mid-calf wound vein is ligated around the threaded acorn head of desired size. Wound is closed over the acorn head. Cleaning and soft dressing pads (roller dressings are placed to the wounds and leg) along with elevation of the limb is done. An elastic crepe bandage is applied from toes to groin up to the level just below the groin wound. Groin wound is also closed in two layers except for the part where stripper end with handle is coming out. With full elevation stripper is pulled with jerky movements from below upwards towards groin wound. Stripper with vein will come out. Part of the groin wound which is left open is sutured.

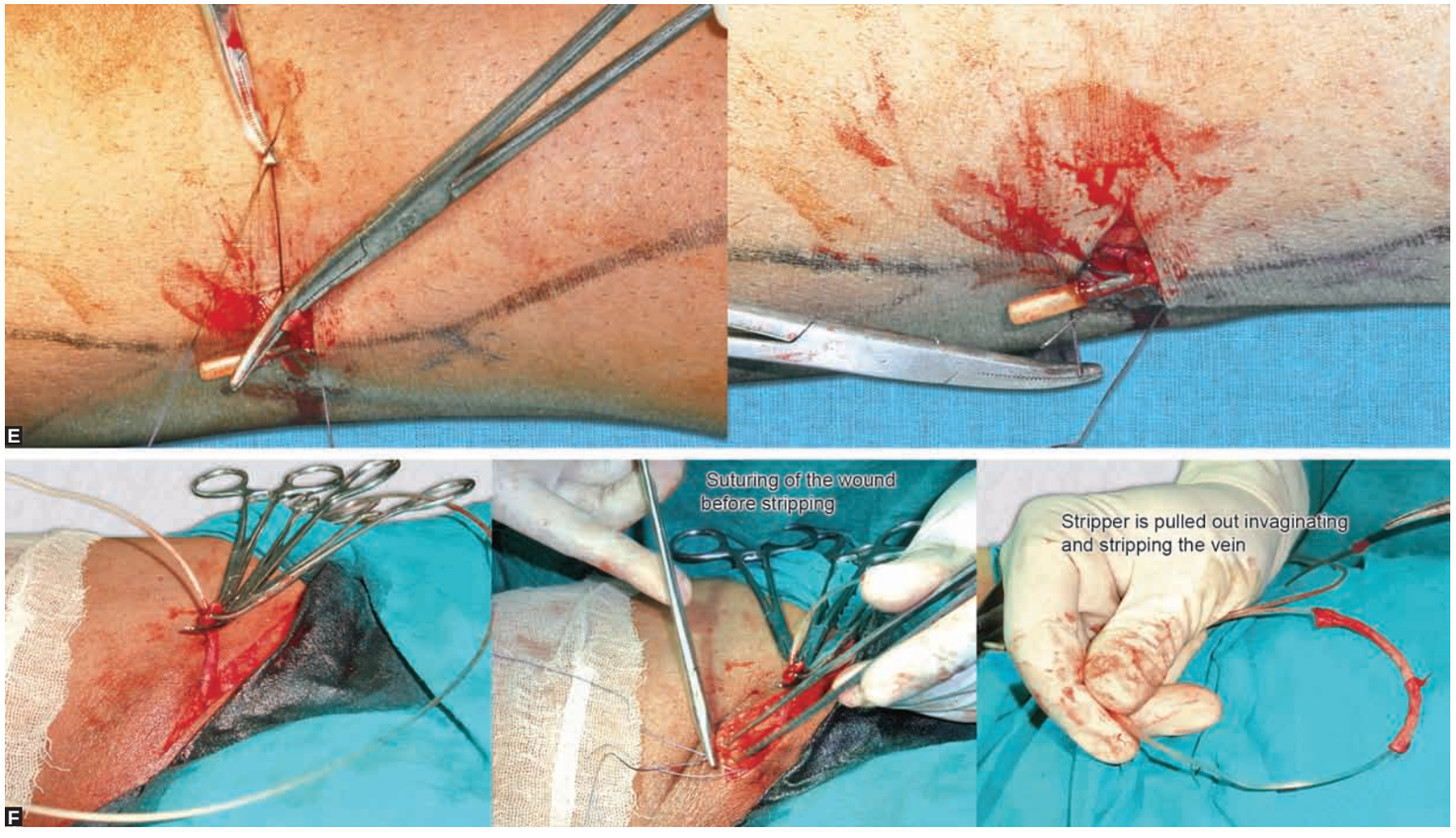
Problems with SFJ Ligation and/or Stripping

Often it is not possible to pass the stripper to entire required length of the vein. In such occasion stripper with olive tip is passed until resistance develops and a small incision is made on it to expose the vein. The vein is opened and stripper is further guided along the vein or stripping of this segment is done and later next segment of the vein is stripped in 2-3 parts.

Bruising, discomfort, pain, haematoma and oedema of leg can occur. Usually they resolve spontaneously in few days; rarely do they require drainage. Elevation and stockings are essential needs.


Intraluminal stripper
A
Intraluminal stripper is passed into the vein
B
Stripper is negotiated up to knee or below knee level
Incision is made over stripper end
Vein is opened and stripper end is delivered out.
C
Stripper end is tied to proximal cut end of the vein, distal cut end of vein is ligated
D

Figs 12-16A to D



Figs 12-16E and F

Figs 12-16A to F: Intraluminal stripping of the varicose vein – operative steps. It is better than Extraluminal stripping but chances of neovascularisation are more due to exposure of the endothelium during invagination.

Multiple leg ulcers adjacent to lower part of the shin is possible especially if stripping is done in lower leg and at ankle, as here, GSV is close and adherent to skin.

Saphenous neuralgia even though mentioned, its incidence is less than 1%. It occurs when stripping is done from distal to proximal. It is more common if stripping is done up to ankle level. Ideally stripping should not be done below the midcalf level. Saphenous neuralgia is hyperesthesia and burning sensation along the distribution of the saphenous nerve – along lower medial part of leg, ankle and foot. Saphenous nerve is a branch of the posterior division of the *femoral nerve* which pierces the deep fascia along the medial side of the knee between sartorius and gracilis and descends *downwards in front* of the GSV. *Small areas of numbness and tingling* along the distribution are common occurrence but it is tolerable and acceptable to the patient.

DVT after varicose vein surgery and stripping can occur. Elevation and stockings prevent formation of DVT. It is advisable to have prophylactic heparin therapy 5000 units subcutaneously 6th hourly especially in patients who are in high risk group like those who are on oestrogen therapy.

Infection, cellulitis, abscess and limb oedema are other complications which are treated accordingly.

Recurrence of the disease is common (30%). It is not due to any technical default but is due to progression of disease itself by *neoangiogenesis and revascularisation*.

Other complications - Injury to femoral vein, inadvertent ligation of femoral vein, thrombosis of femoral vein, haematoma in groin wound are basically technical complications. It can be prevented by proper identification of vein and branches, haemostasis and taking proper care while ligation.

Wound *infection* in groin is common due to close proximity to perineum, more fat in subcutaneous area and lymphatic disruption. Often *lymph ooze* can occur for short periods.

Oesch Pin Stripping

Oesch pin stripping (perforate invaginate) is better as postoperative pain and haematoma formation are less common. But there is a possibility of inverted endothelium triggering neoangiogenesis and recurrence. SFJ is dealt as usual. Oesch pin stripper has got a bend near the tip and an eye at proximal end. Bent tip is passed through the vein from above downwards up to midcalf or just below the knee level. Through a small incision tip is brought out through the skin. Thick vicryl (No. 1) is passed through the eye of the stripper. Vicryl is tied around the proximal part of the vein, keeping suture long. Tip of the stripper is pulled down to invert the vein which will be extracted through the lower incision. Wound at SFJ is closed. Steri-strip is placed to lower small incision **(Fig. 12-17)**.

Groin Reoperation for Recurrent Disease

Recurrence after SFJ ligation is due to incomplete disconnection at SFJ and neovascularisation. Recurrence also can occur whenever stripping of the distal part of GSV is not done which may create a new communication between common femoral vein and GSV. Recurrence

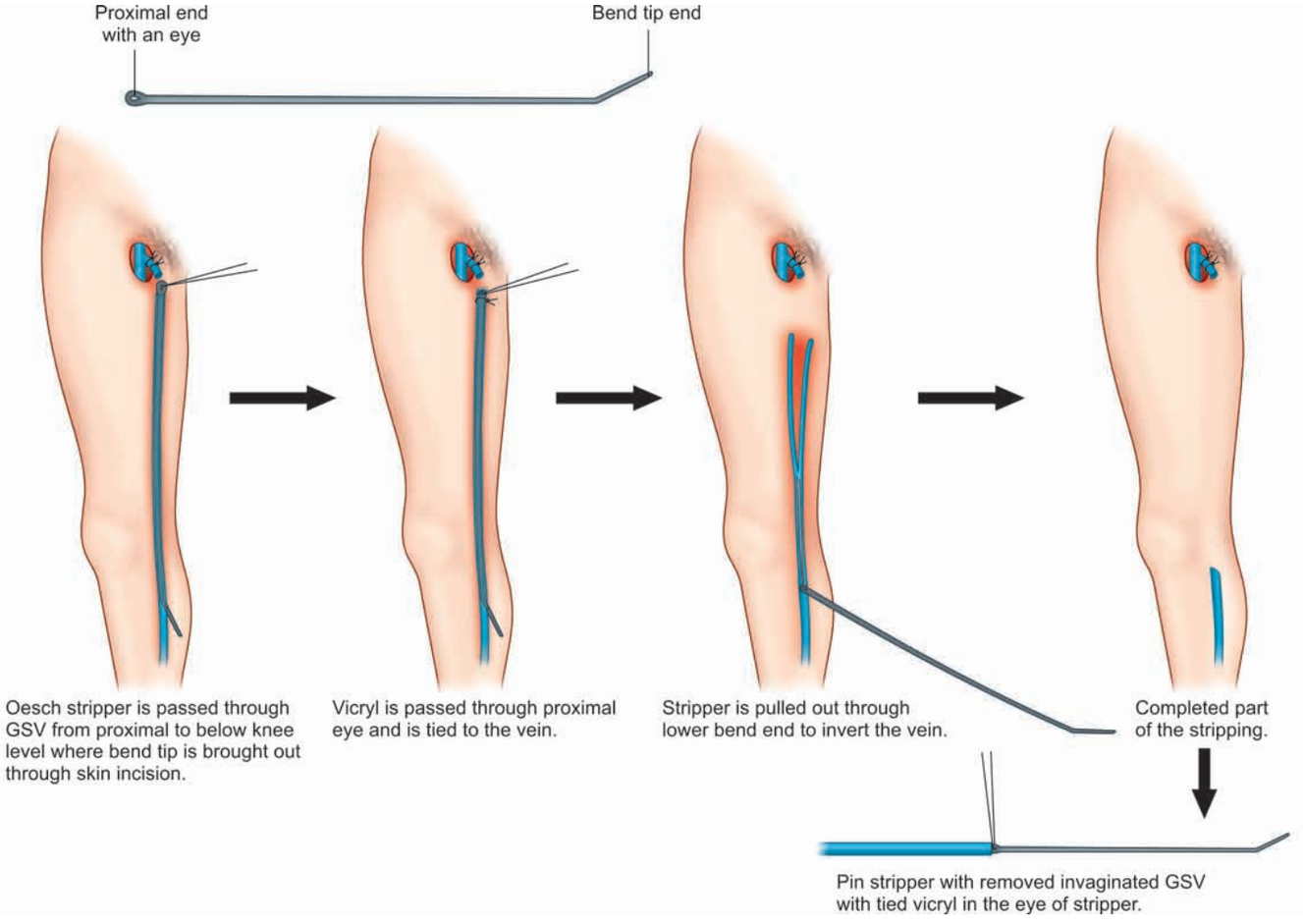

Proximal end with an eye
Bend tip end
Oesch stripper is passed through GSV from proximal to below knee level where bend tip is brought out through skin incision.
Vicryl is passed through proximal eye and is tied to the vein.
Stripper is pulled out through lower bend end to invert the vein.
Completed part of the stripping.
Pin stripper with removed invaginated GSV with tied vicryl in the eye of stripper.

Fig. 12-17: Diagram showing technique of Oesch pin stripping.

also can occur through a mid-thigh perforator. If SFJ is not ligated in flush or tributaries in groin are left in situ recurrence reflux at groin can occur. Neovascularisarion occurs always in front of the femoral vein and these vessels are adherent and thin walled. Duplex scan and varicography are ideal investigations for assessing recurrent diseases **(Fig. 12-18)**.

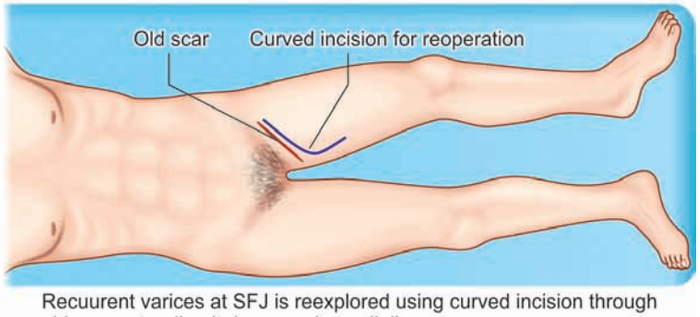

Old scar
Curved incision for reoperation
Recuurent varices at SFJ is reexplored using curved incision through old scar extending it downwards medially.

Fig. 12-18: For reoperation at saphenofemoral junction a curved incision placed with vertical part at medial side of thigh.

Incision for groin SFJ reexploration is done through same transverse scar or through a vertical incision or combination of both. Vertical incision gives better exposure. First femoral artery is identified and then femoral vein is identified. Careful sharp dissection is ideal than blunt dissection as blunt dissection may cause significant obscuring of visibility of the field. Adequate length of the femoral vein is dissected from lateral and medial sides. All tissues with scar are ligated in front of the femoral vein to clear all tributaries and neovascularisation. SFJ is re-ligated flush with femoral vein. If GSV is not stripped in earlier surgery, it should be stripped properly up to mid-calf level.

Complications of reexploration of groin are – haemorrhage, haematoma/seroma formation, lymph ooze, infection, injury to femoral vein and DVT.

LIGATION OF SAPHENOPOPLITEAL JUNCTION AND STRIPPING OF SSV

It is needed if SSV varicosity is evident. Semiprone or prone position is needed. SPJ should be marked using duplex scan preoperatively. Variation of entering of the small saphenous vein into popliteal vein is common. It may enter high up more proximally above the level of knee joint in 25% of patients. In 15% of patients SSV joins GSV. Transverse incision is placed in the popliteal fossa 2-3 cm above the transverse skin crease. Deep fascia is opened vertically; SSV is identified; one superficial tributary will be present which runs in middle from back of the thigh which often may connect above to posteromedial thigh vein or may connect through a perforator vein into deep femoral vein. SSV entering the fossa is identified. It is accompanied with sural nerve which should be dissected and safeguarded. Sural nerve arises from tibial nerve at middle of the popliteal fossa leaving the fossa at

its inferior angle to supply the skin of the lower half of back of leg and entire lateral part of the foot till tip of little toe. SSV is dissected up to the SPJ if there is no variation. It is always ideal to ligate the SPJ at junction. If variation is present it is often difficult to reach SPJ. In such situation many advocate ligation in the popliteal fossa deep to deep fascia to proceed further for stripping of the varicose vein. Gastrocnemius veins instead of normal draining into the popliteal vein may drain into the SSV and in such situation these veins should not be ligated as ligation may cause troublesome venous claudication and discomfort in the calf. Stripping of the SSV is easier. It is ideal to use intraluminal stripper to reduce injury to sural nerve. Stripping is done from above downwards even though many surgeons strip the vein from below upwards. Stripping of the SSV obliterates the midcalf perforator vein which reduces the recurrence.

SUBFASCIAL LIGATION

It is ligation of perforator where it enters the deep fascia (deeper to deep fascia). It is done for perforator incompetence. Perforators are marked prior to procedure using duplex scan. Different approaches are available to tackle perforators **(Fig. 12-19)**.

Fig. 12-19: Dodd (mid thigh) and Boyd (below knee) perforators.

Subfascial Ligation of Cockett and Dodd

Perforators are clearly marked prior to surgery by Fegan's clinical method or ideally using duplex Doppler scan. Multiple small transverse incisions are made on the sites of perforators. Perforators are ligated deep to deep fascia using vicryl **(Fig. 12-20)**.

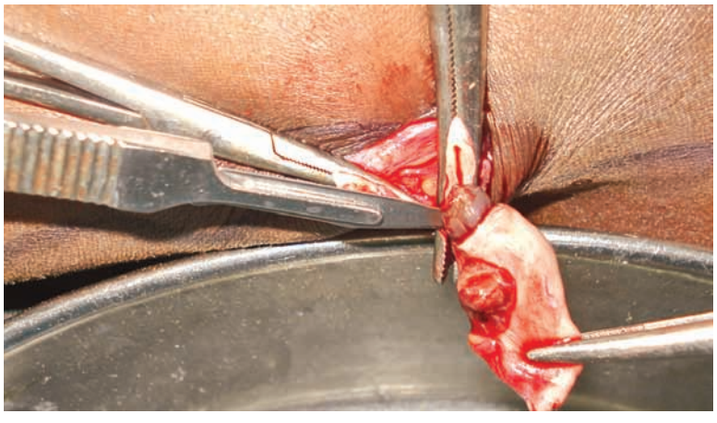


Fig. 12-20: Cockett and Dodd perforator ligation using small multiple transverse incisions.

Subfascial Ligation of all Perforators by Linton's Vertical Approach (1938)

Here vertical incision is made on the medial side of the calf at the anterior margin of the soleus little away from tibia. Often incision over the ankle is divided like in an inverted 'Y' or a posterior 'stocking seam' incision. Skin, subcutaneous tissue and deep fascia are incised without raising any flaps under the skin. Perforators passing across gastrocnemius and deep fascia will be clearly seen. All perforators are identified, ligated using vicryl and divided. Deep fascia is closed using vicryl. Problem with this procedure is lengthy scar which is cosmetically poor even though wound heals well **(Fig. 12-21)**.

Stab Avulsion of the Perforator (Multiple Phlebectomies)

Multiple *small vertical* incisions are made over all marked varicose veins in the leg. Veins are identified. Using vein hook or mosquito artery forceps vein ends are held and gently avulsed using rotation and pulling movements. Often it needs 50-70 incisions to clear the veins. Usually there is no need to suture the wounds as they get closed naturally. Steri-strip placing is sufficient. Postoperative compression bandage is a must. During hook avulsion of the vein, care should be taken not to injure the common peroneal nerve near the neck of fibula, tibial nerve near medial malleolus, saphenous nerve in medial part of leg, and sural nerve on the lateral part of the calf **(Fig. 12-22)**.

Subfascial Endoscopic Perforator Surgery (SEPS)

A special telescope is introduced deep-to-deep fascia through a single small vertical incision at proximal leg selecting healthy skin. Technique is done under tourniquet. Endoscope is advanced down along the medial border of the tibia. Perforators travelling in subfascial vein are identified and fulgurated using bipolar cautery or clips can be applied into the perforators. It is recommended in chronic venous insufficiency (CVI). But its limitation is difficulty in getting 'lift off' the skin in cases with severe lipodermatosclerosis to identify the perforators.

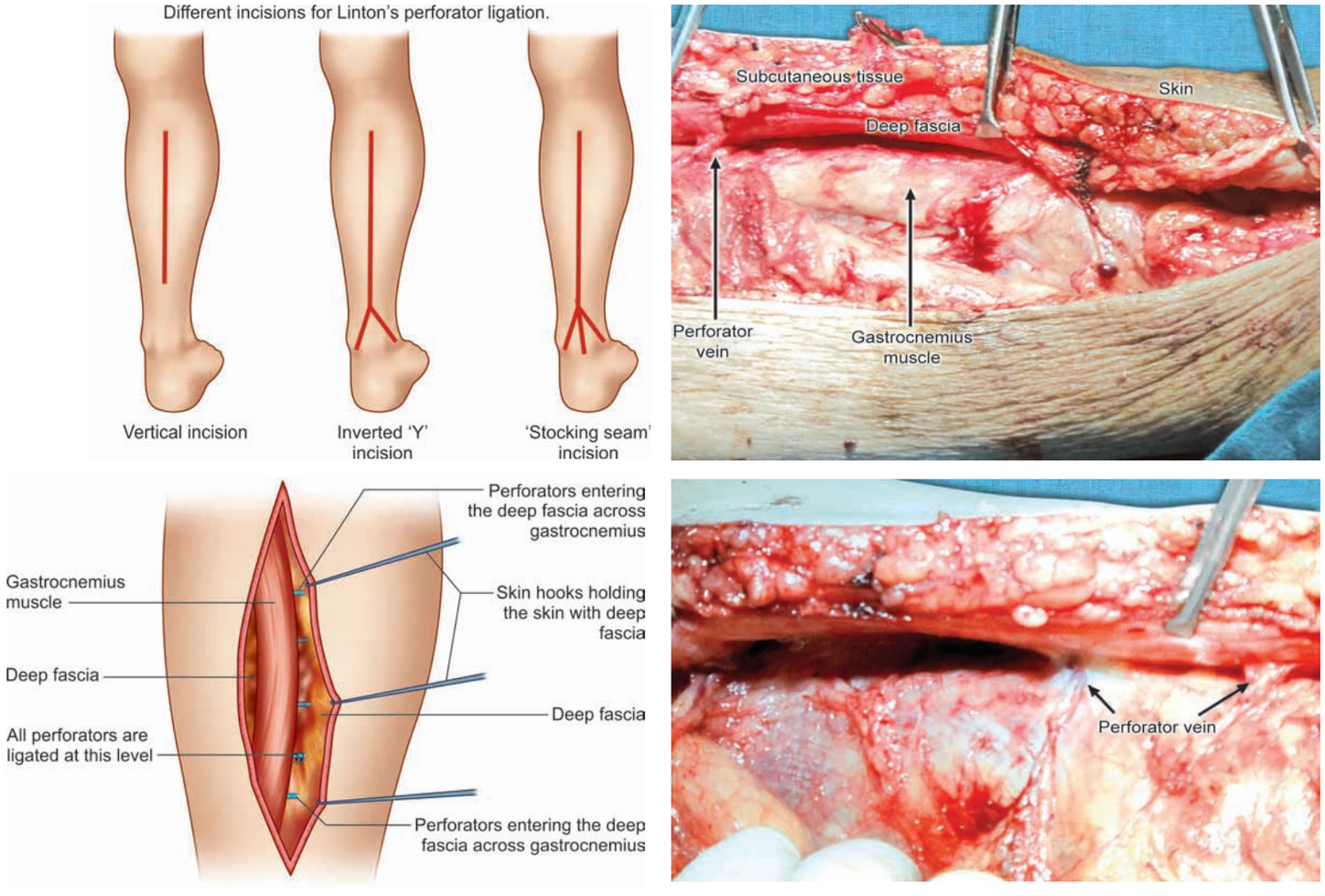


Fig. 12-21: Linton's vertical approach for subfascial ligation of perforators.

Fig. 12-22: Stab avulsion of the vein and perforators (Multiple phlebectomies). It is becoming popular and shows good result.

Complications are – infection, haematoma formation, neuralgia **(Fig. 12-23)**.

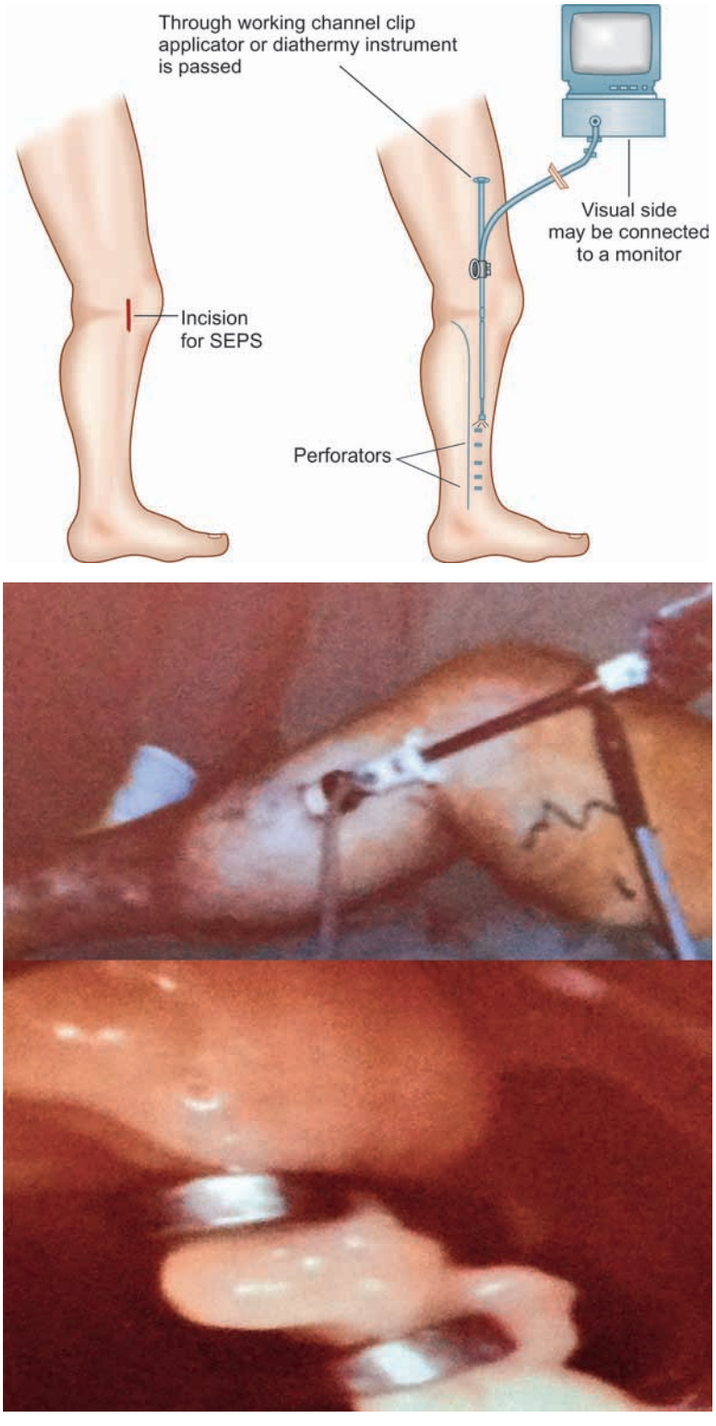

Through working channel clip applicator or diathermy instrument is passed
Visual side may be connected to a monitor
Incision for SEPS
Perforators

Fig. 12-23: Subfascial endoscopic perforator ligation surgery (SEPS).

AMBULATORY SELECTIVE VARICES ABLATION (ASVA/ASVAL) (Ablation Sélective Des Varices Sous Anésthesie Locale)

It is based on newer haemodynamic concept – antegrade haemodynamic evolution of saphenous vein incompetence from suprafascial compartment to great saphenous vein. Evolution of disease starts in collateral veins and their reflux leads into varicose reservoir. If varicose reservoir is abolished saphenous reflux will stop—a newer concept. Procedure is done under local anaesthesia (Ambulatory Selective Varices Ablation under Local anaesthesia/ ASVAL).

CHIVA: It is one of the methods used to achieve ASVA. (Cure Hemodynamique de'l Insufficiency Veineuse en Ambulatoire). *Pittaluga technique* is used (Dr Paul Pittaluga, A French vascular surgeon, founder of Riviera Vein Institute). Here attention has focused on surgical treatment of tributaries retaining the main trunk – ambulatory conservative haemodynamic management of varicose veins.

Saphenofemoral and saphenopopliteal junctions are identified and marked under US guidance. Individual gastrocnemius, intersaphenous, popliteal area veins are identified and marked; longitudinal 3 mm stabs are made using No. 11 blade; phlebectomy is achieved. Selective targeted diseased veins only are removed with preservation of healthy veins. Minimum pain, minimum haematoma, microincision and so minimum scar **(Fig. 12-24)**.

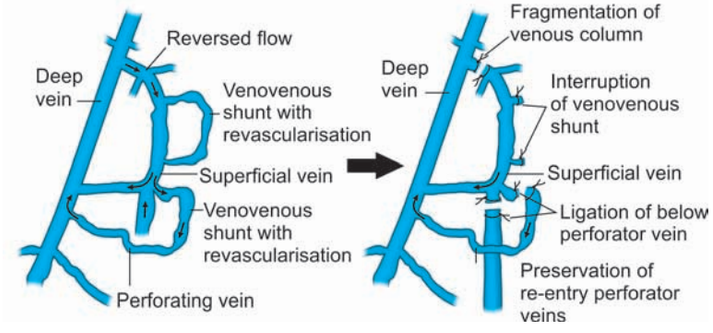


Fig. 12-24: CHIVA – Pittaluga technique.

ENDOVENOUS THERMAL ABLATION

Thermal ablation works by generating heat energy within the vein, which inflicts direct thermal damage to inner wall of the vein causing destruction of intima and collagen denaturation of media eventually leading to fibrosis and occlusion. Radiofrequency ablation (RFA) and endovenous laser ablation (EVLA) are two methods used. Thermal ablation is used for varicosities of great, short, accessory saphenous veins, perforating veins as well.

RADIOFREQUENCY ABLATION (RFA) METHOD (VNUS CLOSURE METHOD) (VNUS Medical Technologies Inc; Sunnyvale, CA, USA—By Goldman 2000)

Politowski described this method 50 years ago. Electric energy is converted into heat to denature the collagen tissue in the vein in a bloodless field.

VNUS closure system is the present RFA device used. This procedure is done under general or regional anaesthesia. A RFA catheter is passed into long/short saphenous vein near saphenofemoral or saphenopopliteal junction under US guidance. A special heater probe is inserted into the vein which obliterates 6 cm of vein at a time using 'pull-back' technique. The catheter has a central core for irrigation which prevents coagulum accumulation during the procedure. Temperature of 85°C is used for longer duration of time to cause

endothelial damage, collagen denaturation and venous constriction. Phlebectomy is done while withdrawing the catheter. Wall of the vein is destroyed through its full thickness. Vein forms a cord, which gets dissolved by macrophages and immune cells. Procedure is slow one as it will take 25 minutes to obliterate 45 cm vein **(Figs 12-25 and 12-26)**.

Newer generation device VNUS Closure FAST is used with high temperature of 120°C and can be done under general anaesthesia. In this, 45 cm of vein will be obliterated in 5 minutes. It has got VNUS Closure RFS Stylet to tackle perforator veins. It can be done under local anaesthesia. It is better than pull back technique. 7 cm segment is fired in 20 seconds. Catheter is passed 10 cm below the knee by percutaneous access under US guidance or by venesection. Nitroglycerine (NTG) spray may be used to dilate vein and make it easier to cannulate. RFA catheter is passed into the vein up to 2 cm below the SFJ. Tumescent anaesthesia is infiltrated – 10 cc per 1 cm vein length. Vein should be made 1 cm depth from the skin. Tumescent

Fig. 12-25: Set up required for radiofrequency ablation of varicose vein (VNUS – RFA).

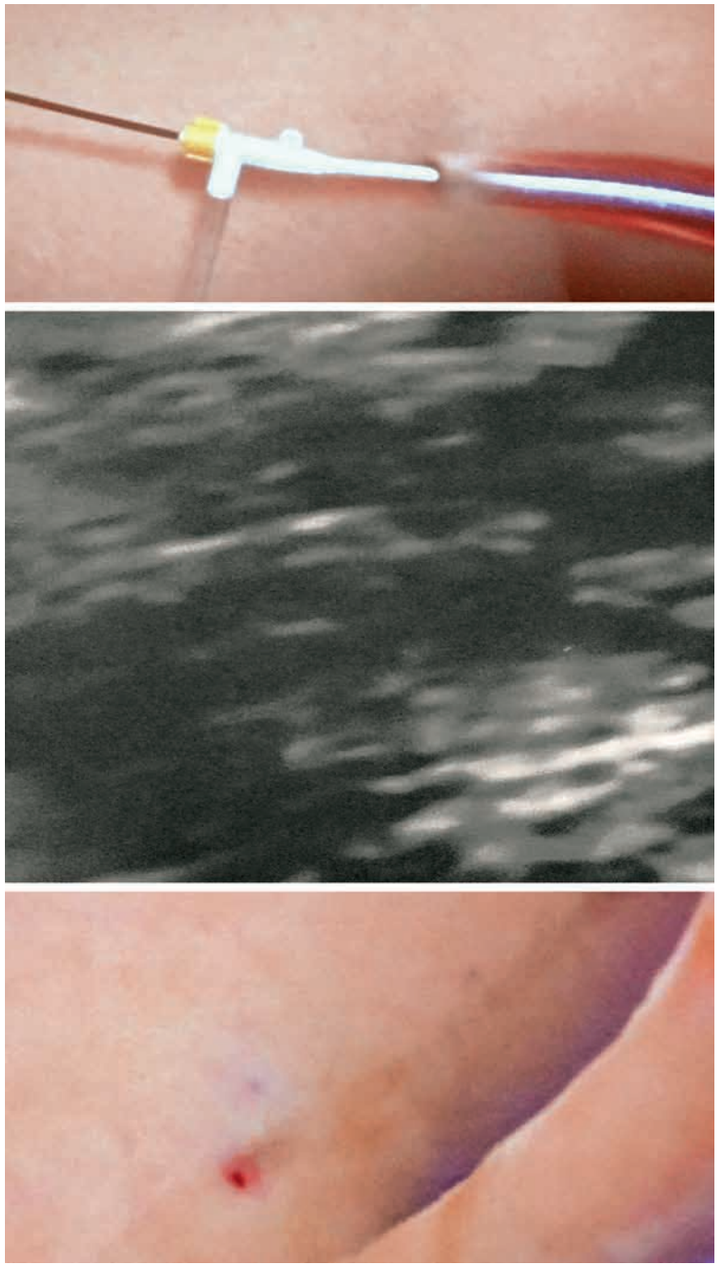


Fig. 12-26: Steps in VNUS RFA closure therapy.

creates thermal buffer around the vein; compresses and empties the vein. Initially patient is in reverse Trendelenburg position (Head up) until catheter is passed; then 15° Trendelenburg position is done (head down). RF is fired as 20 seconds for 7 cm segment length. During firing compression over the vein is achieved from outside (external pressure) by pressing with the US probe longitudinally and by pressing the vein line distal to the probe using two fingers. Above knee compression bandage (grade II – 30-40 mm Hg pressure) is applied for 2 weeks. Patient can walk in 1 hour. Running, jumping, straining and weight lifting are avoided for 2 weeks. Analgesics can be taken. Usually antibiotics and analgesics are not needed.

RFA is better in relation to pain, quality, speed of recovery and recurrence compared to open surgery. It is done as outpatient procedure; can resume work early; no hospitalisation; no scar; no sutures.

CELON RFITT – Celon Radio frequency induced thermal therapy with a bipolar applicator is still newer technique. Probe diameter is 1.8 mm which fits to 6 French sheath with a total length 120 cm and electrode length 15 mm. Vein wall is used as a conductor between both poles top reach a temperature of 650–950°C within the vein wall but applicator remains cold. Power (P) of 18–20 W and an applicator time (T) of ≥1.5 sec/cm is used.

Complication rates are 7% in RFA compared to EVLT (20%) but recurrence rate is more compared to EVLT.

ENDO VENOUS LASER ABLATION/ TREATMENT (EVLA/EVLT)

It causes direct and indirect thermal injury of the venous wall with endothelial denudation, contraction of collagen and fibrosis creating a nonthrombotic occlusion of the vein. EVLA is done for truncal varicosities and large branch veins and tributaries.

EVLA is first described by Bone in 1999. The Diomed 810 nm diode laser received US FDA approval in 2002. It is as effective as surgical stripping but with shorter recovery time and less side effects. Vein wall destruction occurs by conductive and convective heating. Direct contact, steam bubble and carbonisation occur. Thermal energy is absorbed by haemoglobin or water. Bare tipped, radial, jacketed, self centering tulip fibres are available. Single use/multiple uses fibres are also available. 400/600/1100 microns fibre size are available.

It is done ideally under *local anaesthesia* with US/duplex scan guidance. Spinal/general anaesthesia can be used. Vein should be marked with marker pen. It is done as an outpatient procedure or as day-care surgery. *System* contains endovenous generator with wavelengths of either 810 nm or 1064 nm, laser firing fibre, monitor showing all the needed parameters related to laser foot switch. Diode laser is used. Procedure is done under US guidance. Hyper Diode 1470 with atraumatic and 360° optical fibres are also now available for faster precise ablation **(Fig. 12-27)**.

Patient lies supine with diseased leg flexed, hip externally rotated and knee flexed. With aseptic precaution, under US guidance LSV is cannulated (18 G cannula) above or just below the knee at the level of Boyd's perforator; needle is removed keeping cannula in place; a 0.035" J guidewire is passed beyond SFJ; 18 G cannula is removed; 5- French introducer catheter/ sheath is passed over guidewire; tip is placed 1 cm distal to the junction; guidewire is removed; laser fibre is inserted into the catheter up to the tip of the catheter and catheter is withdrawn for 2 cm and laser fibre protrudes for 2 cm beyond the sheath / catheter. Catheter and laser fibre tip positions are confirmed using US. Vein can be cannulated at ankle also **(Fig. 12-28)**.

Tumescent anaesthesia (500 ml of cold saline, 30-50 ml of 1% xylocaine with adrenaline, 30 ml of 8.4% sodium bicarbonate) is prepared and injected along the entire length of the GSV to be fired. Injection is done manually using 50 cc syringe or tumescence pump or using as drip set. It should form a *cushion* surrounding the vein along its entire length to provide local anaesthesia, to give protection like a 'heat sink' preventing thermal damage of skin and soft tissues, to provide adequate venous compression to create complete apposition of the venous wall and so effective venous obliteration. Tumescent anaesthesia is given under US guidance.

Laser fibre is fired step by step using diode laser, 1-3 mm withdrawal in 2-3 seconds. Introducer sheath/catheter having mm markings on the surface with the laser fibre are slowly withdrawn. Intermittent pulsed mode firing or continuous mode firing set ups

Laser machine
Laser fibre with introducer sheath in place inside the GSV
Injecting the tumescent solution
Laser fibre tip inside the GSV near SFJ
Laser fibre connected to laser machine
Laser machine
Foot switch with connecting cable
Withdrawing and firing of laser through fibre
Technique of firing laser

Fig. 12-27: Laser machine and its setting to patient.

are available in the generator. Proximal thigh 14 mm Watts; lower thigh 12 mm Watts; knee and upper leg 10 mm Watts energy are used. Presently it is approved ablation of entire great saphenous vein even though up to midcalf level is commonly done by surgeons. But thermal injury to saphenous nerve is a possible problem. Once procedure is over, catheter is removed. Total obliteration of the vein should be confirmed using ultrasound. Pressure bandage is applied for 2 weeks **(Fig. 12-29)**.

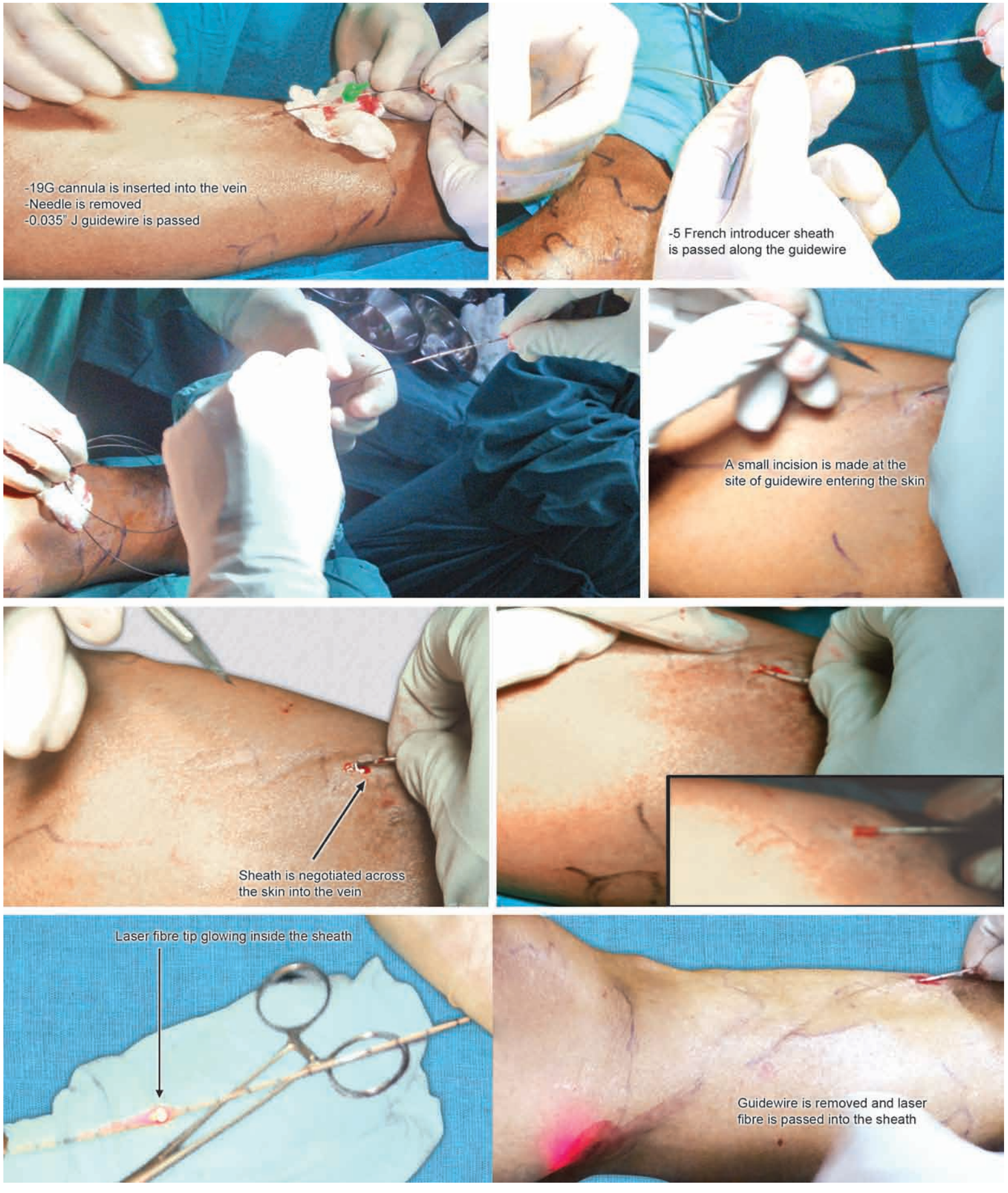

-19G cannula is inserted into the vein
-Needle is removed
-0.035" J guidewire is passed
-5 French introducer sheath
is passed along the guidewire
A small incision is made at the
site of guidewire entering the skin
Sheath is negotiated across
the skin into the vein
Laser fibre tip glowing inside the sheath
Guidewire is removed and laser
fibre is passed into the sheath

Fig. 12-28: Laser fibre insertion - initial procedure.

Cleaning and draping of the leg with proper marking of the vein
Vein should be marked properly
Cannulation of the vein and removal of the needle retaining the cannula
-19G cannula
Passing the guidewire under US guidance
0.035" J guidewire
Passing 5 F introducer sheath along the guide-wire into the vein under US guidance
Introducer sheath is inside the vein
Laser fibre passed through the sheath with tip placing 1-2 cm prior to SFJ. Laser tip should be projecting 1-2 cm beyond the end of the sheath US guidance is needed
Laser fibre tip 1 cm prior to SFJ
Laser fibre tip 1 cm prior to SFJ
Laser tip
Sheath with laser fibre

Figs 12-29(1)

Injecting tumescent solution around the vein close to laser fibre
Injecting tumescent solution around the vein close to laser fibre
Laser generator
Injecting tumescent solution
Laser fibre tip glowing red
Pulling the laser fibre every 3 mm with keeping firing for 3 seconds
Laser fibre tip glowing red
Finishing the laser firing
Laser fired area after completion

Figs 12-29(2)

Figs 12-29(1 and 2): Technique of endovenous laser treatment/ablation.

Heat produced (729°C – 1000°C at tip) by the laser produces steam bubbles with thermal damage of endothelium leading into occlusion of the vein. Laser energy acts on the blood within the vein rather directly through the wall and heats the blood and in turn heats the vein wall.

Advantages of EVLA are—minimally invasive; cosmetically acceptable; no large wounds or scars; done under local anaesthesia; done as day care procedure; easier to do the procedure; rapid recovery and rapid return to work; less chances of neovascularisation and so less chances of recurrence (2% in 2 years) as compared to surgery (30-40%). Technique has got 95% efficacy.

Disadvantages of EVLA are—inability to create flush occlusion allowing tributaries to open up to cause possible recurrence; cost factor, laser fibre kit costs 15,000 Rupees and is disposable; difficulty in cannulating the vein; multiple punctures often may be needed; need of duplex scan in operation theatre; need of trained surgeons to do venous duplex scan and Doppler. One should remember that it is not totally 'pain free'.

Complications of EVLA are—transient postoperative pain; skin ecchymosis; haematomas; thermal injury of the skin; DVT; residual varicosities; sensory disturbances if 1064 nm generator is used **(Figs 12-30 and 12-31)**.

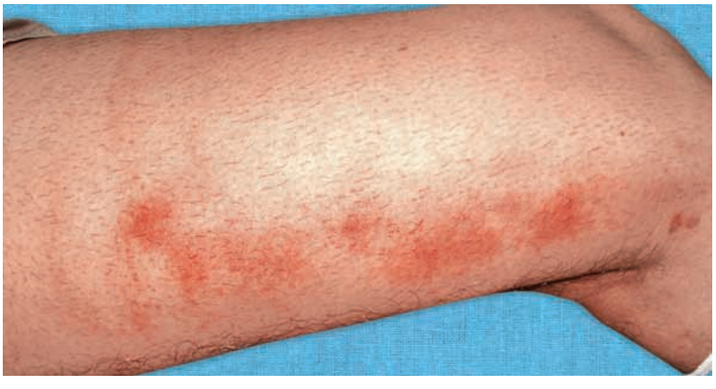


Fig. 12-30: Ecchymosis due to laser ablation of varicose vein.

Fig. 12-31: Wearing stocking is a must after any procedure. Wearing of stocking for minimum of 6 months is needed. It is better to advice to wear stockings during day time for life long to reduce recurrence and neovascularisation.

HEAT ABLATION FOR CLOSURE OF INCOMPETENT PERFORATOR VEIN (ICPV)

Mark Whiteley has invented thermoablation device which is passed into the incompetent perforator to occlude the vein by heat – Transluminal Occlusion of Perforating Veins (TRLOP) or Percutaneous Ablation of Perforators (PAPs). Technique is useful in recalcitrant venous ulcers.

Complications of PAPs are—paraesthesia, DVT, infection.

TRIVEX METHOD

Under subcutaneous illumination and local anaesthesia, a large quantity of fluid is injected percutaneously to identify the underneath superficial veins. Tumescent anaesthesia created causes hydrodissection. Trivex resector and illuminator are placed under the skin. Resector gently extracts veins by suction and morcellation. Further stages of tumescence flushes all blood and delivers vasoconstricting solutions. Solution is passed through 18 gauge needle to clear all blood underneath. Method is cosmetically acceptable; removes all sized veins; achieves good pain relief; with minimal complications like bruising, induration which gets resorbed eventually; can be used when there are venous ulcers.

OTHER METHODS

Transilluminated phlebectomy is done by passing transilluminating light under the skin and passing a rotating blade through another small incision. Veins are grasped and removed by rotating movements.

Ambulatory phlebectomy is done through tiny small incisions using special phlebectomy instruments. *Ramelet's hook* is used. It has sharp harpoons to grip the perivenous collagen tunica externa of the vein to grip and lift. Ambulatory phlebectomy is very useful OP procedure with minimal pain, safety, effectiveness and complications mainly useful in vein collaterals, reticular/perineal/foot and small perforators.

Electrodessication using weak electric current through a fine needle directly into the spider veins (telangiectasis) is also used.

Obliteration of saphenous veins with hyperheated steam is simple and cost effective which is designed by Milleret et al (France). Here water is pressurized at 600 atmospheres which is forced through a narrow tube into the needed vein to cause coagulation and sealing of the vein. Vapour once condenses turns into harmless water.

Cryostripping of the vein is also tried. Cryo probe is used only in part of the therapy while stripping.

INJECTION SCLEROTHERAPY FOR VARICOSE VEINS (FEGAN'S)

Sclerosants are injected into the vein to achieve complete sclerosis of the venous wall. It is used since 100 years as *liquid sclerotherapy.*

It is *indicated* in uncomplicated perforator incompetence; in managing reticular and thread veins; recurrent varicosities; isolated varicosities; in aged and unfit patients. Presently it is said that all types of varicose veins are amenable to sclerotherapy. It is very useful in managing spider veins less than 3 mm. In veins more than 3 mm sclerosant may get washed away.

Contraindications for sclerotherapy are—saphenofemoral incompetence, deep venous thrombosis; huge varicosities – may precipitate DVT; peripheral arterial diseases; hypersensitivity/immobility; pregnancy; venous ulcer – relative contraindication.

Sclerosants used are **sodium tetradecyl sulphate 3% or polidocanal 1%** or sodium morrhuate or ethanolamine oleate.

Sclerosants cause aseptic inflammation, perivenous fibrosis, endothelial obliteration.

Procedure – A 23 gauge needle is inserted into the vein; vein is emptied; 0.5 to 1.0 ml of sclerosant is injected into the vein with limb in elevated position; immediate compression is applied to prevent thrombosis; complete endothelial apposition and sclerosis is achieved. Injection is started at ankle level and later proceeded upwards. Compression stockings for 6 weeks should be used. Repeated sessions of injections with 2-4 weeks intervals can be given. It is called as *macrosclerotherapy*.

Microsclerotherapy: Very dilute solution of sclerosing agent like STDS, polidocanal is injected into the thread veins and reticular veins followed by application of compression bandage (30 G needle). Dermal flare will disappear well by this method.

Note: Sclerotherapy can be – liquid or foam. Foam type may be with air or with CO_2.

Foam Sclerotherapy by Tessari

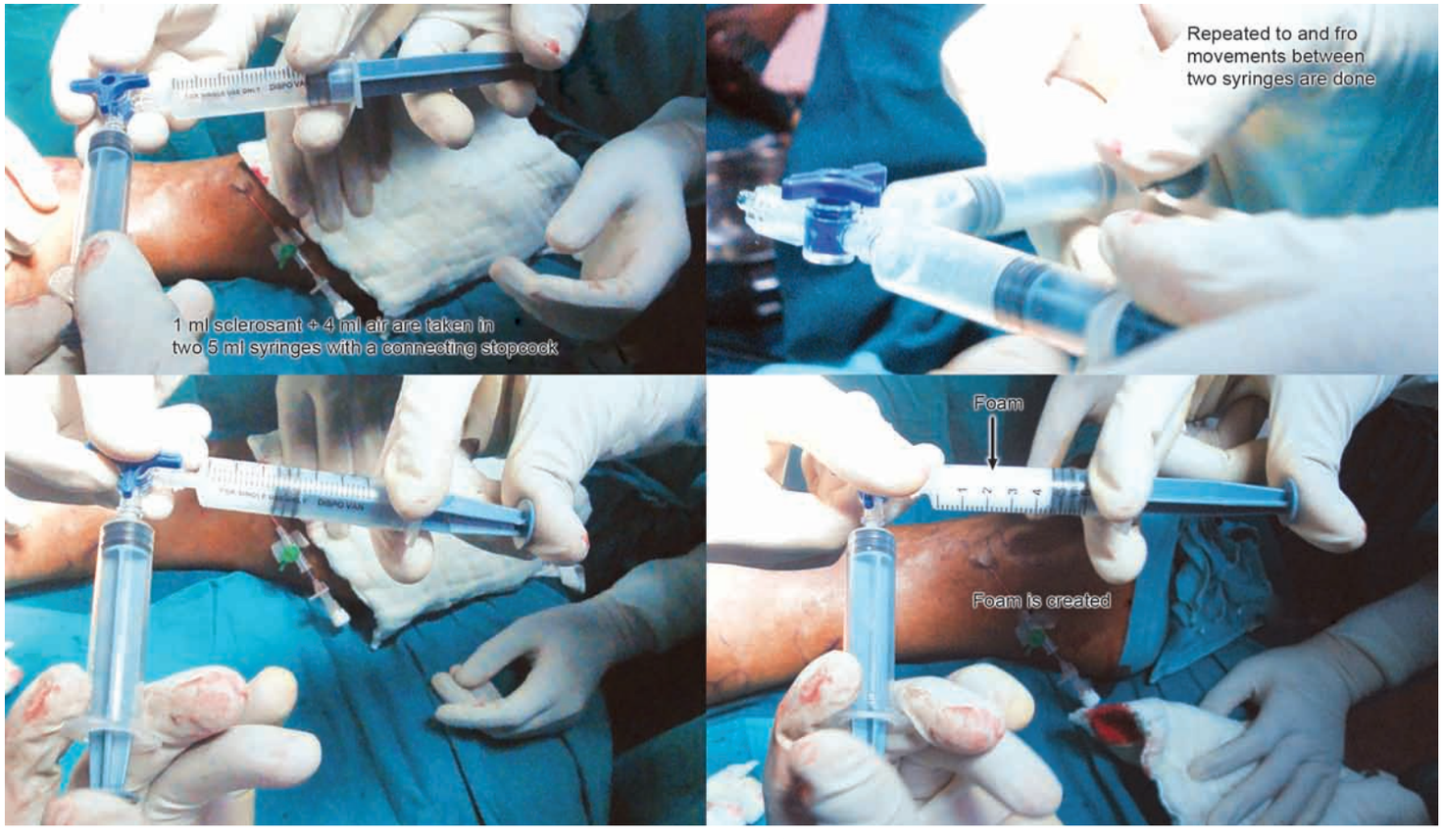
Cabrera introduced foam sclerotherapy using CO_2 in 1997. In 2000, Tessari started creation of foam from liquid sclerosant through three way stopcock and two syringes. It is simple, affordable, safe, efficient and repeatable. Foam fills the vein, stays longer and also causes spasm prolonged contact with the endothelium exposes subendothelium and causes fibrosis of venous wall. Thick consistency of foam makes it easier to treat large and bulging veins.

Foam displaces blood but never dilutes it; foam doesn't get mixed with blood and so won't get deactivated; causes wider area of chemical ablation of trunk veins. Gas embolism is a rare complication.

STD taken in a syringe is passed rapidly in to another syringe which contains air that results in formation of foam. This foam in much larger quantity is injected in to the superficial vein. Air gets absorbed between foam and endothelial lining is destroyed. Foam is created by different methods. Entire procedure is done under US guidance even through foam sclerotherapy without US guidance is also accepted method.

One of the methods which is followed by many is as follows – 1 ml of STDS is taken in a 5 ml syringe; 4 ml of air is taken in another 5 ml syringe; both syringes are connected through a stopcock; by repeated to and fro movements between two syringes air gets mixed with sclerosant causing soap like foam. Usually 12-15 strokes are needed to create optimum foam. Large quantity of foam can be created by using 20 ml syringe using 4 ml of STDS in one and 16 ml of air in another 20 ml syringe to create 20 ml foam. Maximum sclerosant used is 6 ml for one sitting with 30 ml foam. Response to treatment is assessed by ulcer healing, disappearance of symptoms, US showing disappearance of varices. Leg should be raised during injection to prevent air embolism. Immediate stockings should be applied and should be continued for 6 weeks. Even though DVT can develop, its incidence is less. Foam which is dense gets coaxed into venous wall and so unlikely to flow to distant; so DVT and air embolism usually will not occur **(Fig. 12-32)**.

Foam minimises thrombosis by pushing the blood out of the site of the vessel where action is needed. Polidocanol or sodium tetradecyl sulphate is used for foam sclerotherapy.


1 ml sclerosant + 4 ml air are taken in
two 5 ml syringes with a connecting stopcock
Repeated to and fro
movements between
two syringes are done
Foam
Foam is created

Figs 12-32(1)

Figs 12-32(2)

Figs 12-32(1 and 2): Technique of foam sclerotherapy. Stockings and elevation of the limb is important in post-procedure period.

In small veins, magnifying glasses can be used to cannulate the vein. US guided foam sclerotherapy is standard which makes visualisation of foam and its passage.

Pharmaceutical microfoam is available now. It is low density uniform small bubbles of 100 μm. it is generated from O_2/CO_2 gas mixing with low nitrogen and gas gets absorbed in blood faster minimising gas embolism. Incidence of gas embolism is very less with this microfoam compared air based manually created foam.

Complications are—anaphylaxis, headache, transient blindness, stroke, air embolism are rare but specific to foam sclerotherapy. Thrombophlebitis, DVT, skin discolouration, skin necrosis is other complications.

Advantages are—cheap, easier, anaesthesia is not needed, done on day care/OPD basis, can be combined with other procedures for varicose veins.

Echosclerotherapy

Sclerotherapy is done under duplex ultrasound image guidance.

Transillumination Microsclerotherapy *(vein – lite)*

It is better to image the veins using light generated by halogen bulb with high quality fibre with uniform illumination over the skin and passing 30 gauge needle for microsclerotherapy.

Catheter Directed Sclerotherapy

It was devised at Miami Vein Clinic, with specific catheter for sclerotherapy. This catheter has got side holes all around the specific length for uniform contact of venous wall with the foam. It also has got a balloon at the tip which after inflation blocks the SFJ thus preventing embolisation of foam. It has got three external ports one for balloon inflation; one for bladder valve port; one for injection. This technique is under trial **(Fig. 12-33)**.

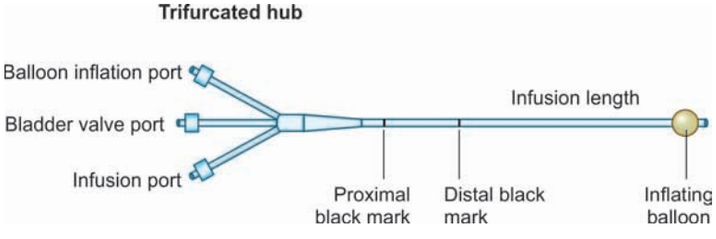


Fig. 12-33: Catheter directed sclerotherapy.

Remember about sclerotherapy

- Current place of sclerotherapy is mainly for recurrent varicosities and thread/telangiectatic veins
- Sodium tetradecyl sulphate (STDS) is most commonly used sclerosant
- Hyperpigmentation is common after STDS
- Anaphylaxis is common after sodium morrhuate
- Anaphylaxis is least with polidocanol
- Extravasation (presence of pain/irritation/burning) should be avoided as it will cause skin necrosis
- Postsclerotherapy walking immediately after injection for 30 minutes with elastic bandage in place prevents/minimizes the chances of DVT
- Compression bandage should be worn for minimum period of 6 weeks
- Sclerotherapy can be – macrosclerotherapy; microsclerotherapy; echo (ultrasound guided) sclerotherapy; foam sclerotherapy; transilluminated sclerotherapy

Note

- Non-chromate glycerin is better for sclerotherapy of telangiectatic veins.
- 5 ml syringe should be used.
- Ideally finer needle should be used; 30 gauge is better.
- Light and magnification if used it will be better in telangiectatic sclerotherapy.
- Liquid sclerosant is better for smaller veins less than 3 mm.
- Injection should be felt rather than flash back in hub.
- Injection should be stopped if there is white pallor formation in the skin.
- Leg should be elevated while injecting.
- Larger and deeper veins should be injected first before smaller and superficial veins.
- Trapped blood source should be evacuated.
- 3 way stopcock should be used to create foam.

MANAGEMENT OF VENOUS ULCER

Venous ulcer is a complication of chronic venous hypertension occurring around ankle in *Gaiter's* zone. (Gaiter – French – a covering of cloth/leather around ankle and lower leg). 80% of leg ulcers has got venous component. Prevalence of ulcer increase with age and in females. Recurrence of venous ulcer is 60–70%. It is due to CVI, obesity, DVT, phlebitis, trauma. There is abnormal wound healing mechanism in terms of matrix formation with disrupted cell formation. Venous leg ulcer (VLU) limits work, causes pain, immobility, social and psychological impairment.

Treatment strategy consists of—compression; elevation, adequate walking; control of bacterial burden, improvement in nutrition, wound care by dressing; skin grafting. Apligraf application produce more cytokines and growth factors to promote wound healing in venous ulcer. Compression is always better; high compression is better than low; multicomponent system is more effective than single component system. Ulcer is treated initially with *Bisgaard's method*; later by split skin grating. Graft can be taken from same side thigh. It should be combined with definitive procedure for varicose veins **(Fig. 12-34)**.

COMPRESSION THERAPY FOR VARICOSE VEINS

- Compression reduces the venous wall tension; prevents reflux; controls the venous over distension; decreases ambulatory venous hypertension; improves microcirculation; improves filtration and exchange dynamics.
- Compression diverts the blood towards deep veins through perforating veins; prevents the outward flow of blood in perforator incompetence; improves the efficacy of calf muscle pump. Compression reduces the oedema and improves the venous and lymphatic drainage; improves venous elasticity; improves the microcirculation and more important is that it prevents further damage of the venous wall.
- Compression may be elastic/inelastic/combination of elastic and inelastic (*Unna boot*)/multilayered (four layered) compression system which can provide sustained high compression for several days—usually up to a week / intermittent pneumatic compression. Unna boot is three layered paste gauze compression dressing containing calamine, zinc oxide, glycerin, sorbitol, gelatin and aluminium silicate which has mainly inelastic inner component with partly elastic outer layer wrap.
- *Inelastic type* is used for continuous use in severe chronic venous disease. *Elastic type* is used as self applied at day time. Elastic types are – short stretch < 70%; medium stretch 70-140%; long stretch > 140%.
- Recommended pressure in mild varicose veins, pregnancy and postoperative period is 20 mm Hg; in symptomatic varicose veins and after sclerotherapy it is 30 mm Hg; in venous ulcer and post-phlebitic leg it is 40-45 mm Hg; in phlebolymphedema (venous oedema with lymphatic oedema which is more dangerous) it is more than 45 mm Hg.
- Skin maceration, excoriation, dryness, infection, ulceration and failure are the complications of compression therapy.

Remember

- Compression improves rate of ulcer healing.
- Supplementation of phlebotonic drugs in conjunction with compression therapy is accepted.
- Inelastic compression causes more improvement (reduction) in venous filling index (VFI) than elastic compression. But elastic compression is more commonly used because it is better accepted.
- Multilayered bandage system is most effective.
- Ankle – arm pressure index less than 0.6 is contraindication for compression therapy as it may precipitate ischaemic ulcer formation.
- Exercise may improve the muscle–pump action.

Compression garments standard

British standard

- Class I: 14-17 mm Hg
- Class II: 17-24 mm Hg
- Class III: 24-35 mm Hg

International (European) standard

- Class I: 20-30 mm Hg
- Class II: 30-40 mm Hg
- Class III: 40-50 mm Hg
- Class IV: 50-60 mm Hg

Compression Bandages

- *Type 1*—Light weight confirming stretch bandages. These comprise light weight elastomer with high elasticity but little power. It is used to retain dressings.
- *Type II* (Short stop)—Light support bandages. Minimal stretch. Exhibit limited elasticity but tends to lock out on minimal extension. In ambulant patient with CVI they form an essentially inelastic covering to the leg which will exert pressure during calf systole but not during diastole. They are unsuitable for control of oedema.
- *Type III* (Long stop)—are extensible elastic and powerful to a varying degree **(Fig. 12-35)**.

SURGICAL TREATMENT FOR DEEP VENOUS THROMBOSIS AND VENOUS THROMBOEMBOLISM (VTE)

Palma Operation

In iliofemoral thrombosis, common femoral vein below the block is connected to opposite common femoral vein using opposite great saphenous vein **(Fig. 12-36)**.

Venous ulcer
Multiple window cuts are made in the graft
Scraping and preparing donor area
Split skin graft
Donor area
Graft (SSG) is placed over the recipient bed
Graft is fixed to recipient bed edge by clips/sutures
Graft has taken up well

Fig. 12-34: Split skin grafting can be used to cover the venous ulcer after treating the varicose veins.

May – Husni Operation

When popliteal vein is blocked popliteal vein below the block is anastomosed to great saphenous vein as end-to-end bypass **(Fig. 12-37)**.

Venous Thromboembolism (VTE)

Incidences in DVT

- 20% of hospitalised patients; 50% of orthopaedic surgery patients; 1% of adult population after 40 years; 40% of patients undergoing abdominal or thoracic surgeries; one out of 100 DVT patients will die of pulmonary embolism.
- 5% of pulmonary embolism forms chronic thromboembolic pulmonary hypertension with right ventricular failure.
- More than 50% of DVT leads into chronic venous insufficiency (CVI).
- 30% DVT recurs 10 years after discontinuation of the anticoagulant therapy.
- Post-thrombotic syndrome (PTS) occurs in 50% of DVT patients with leg oedema, pain, nocturnal cramping, venous claudication, skin pigmentation, dermatitis and ulceration on the medial side of the lower leg.
- VTE can be provoked or unprovoked (idiopathic).

Fig. 12-35: Stages of applying crepe bandage immediately after intervention procedure. Elevation of the limb is also equally important.

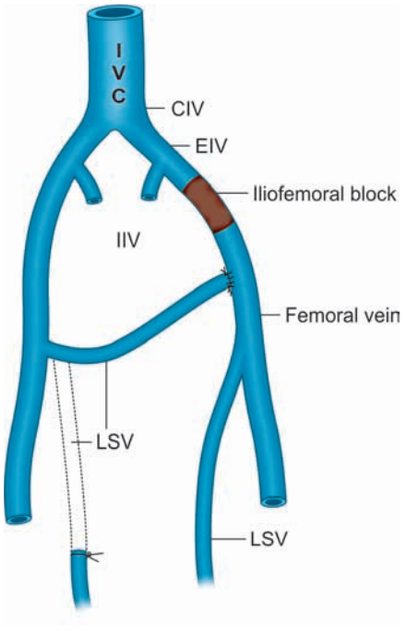


Fig. 12-36: Palma operation for iliofemoral block. Using opposite great saphenous vein femoral vein is connected to other femoral vein.

Well's criteria for DVT probability is based on – active ulcer; paralysis/recent immobilisation; bedridden for > 3 days; recent surgery within 1 month time; swollen leg; tenderness along deep veins; calf girth difference > 3 cm; pitting oedema; others.

SMART tool – Surgical and Medical Assessment of Risks for Thrombosis.

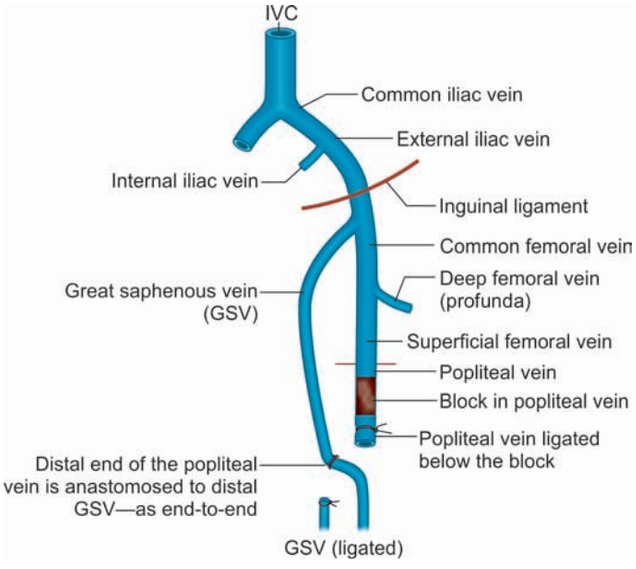


Fig. 12-37: May – Hunsi operation.

DVT risk can be :

Low risk – < 10% (minor surgery in mobile patients); *moderate risk* – 10-40% (general; gynaecologic/urologic surgeries) – needs LMWH or mechanical thrombophylaxis if there is high bleed; *high risk* – 40-80% (hip / knee arthroplasty, fractures, major trauma) needs LMWH, mechanical thrombophylaxis. Dose of LMWH is full dose (5000 units) 2 hours prior to surgery, then half or full dose for 10 days.

High risk can be brought down to 5% by prevention and prophylaxis.

Calf vein thrombosis is defined as any clot involving the deep veins of the calf that did not extend to the popliteal veins. Calf has got three paired veins – posterior tibial, anterior tibial and peroneal. Calf also has got two unpaired muscular veins – soleal and gastrocnemial. Peroneal veins are commonly involved. Isolated calf muscle vein thrombosis (ICMVT) occurs when thrombosis is confined only to muscular veins; when thrombosis present in paired calf veins, it is called as deep calf vein thrombosis (DCVT). If both paired veins and muscular veins are involved then it is called as isolated distal deep vein thrombosis (IDDVT). Its prevalence is 5-30%. Incidence of propagation of thrombus from deep veins to proximal vein is 5-30%. But post-thrombotic syndrome is not common in IDDVT (calf). Thromboembolism is more common once thrombus extends to proximal vein. Present recommendation is – ultrafraction heparin intravenously or LMWH subcutaneously for 10 days; then vitamin K antagonist (Warfarin) for 3 months. INR should be maintained between 2.0 to 3.0 (2.5). Extended therapy for 6 months may be done depending on the risk factors.

Noncompressible clot in compression ultrasound (duplex) is very useful method of evaluation.

In a confirmed case, thrombectomy may be needed using Fogarty catheter.

Catheter directed thrombolysis (CDT) can be done after cannulating (5F or 6F, US guided, multihole catheter) popliteal vein to reach clot area under ultrasound and also fluorescence guidance and injecting tissue plasminogen activator (tPA) and reteplase into the clot (intraclot). Short saphenous vein or post-tibial veins are also can be used.

IVC filters are used when anticoagulation has failed (recurrent pulmonary embolism), anticoagulation has caused bleeding, when anticoagulation is contraindicated (intracranial haemorrhage).

Pulmonary embolism causes acute dyspnoea, haemoptysis, chest pain, shock, right ventricular dysfunction, severe respiratory distress and death. Well's and modified Geneva criteria are used. CT angiogram is very useful. Treatment is – Heparin, thrombolysis, catheter directed thrombolysis, surgical embolectomy with cardiopulmonary bypass.

Leg elevation, stockings and early ambulation are preventive measures. In confirmed DVT cases massage and hot fermentation are contraindicated.

Duration of anticoagulation in isolated calf vein DVT is 6 weeks; in provoked DVT it is 3-6 moths with risk factor it is with extended therapy of more than 6 months; unprovoked DVT duration is 3-6 moths, if 2nd episode extended therapy for > 6 months. For recurrent DVT it is for life long.

In patients with acute proximal DVT of limb, anticoagulant therapy (LMWH) alone is suggested over systemic/catheter directed thrombolysis or venous thrombectomy.

Thrombolysis is indicated in extensive thrombosis of iliofemoral or proximal sites, threatened limb viability, venous anatomical anomaly.

In pregnancy LMWH is used for DVT. Ultrafraction heparin, vitamin K analogue (Warfarin), direct thrombin (dabigatran) inhibitors and Anti-Xa (rivaroxaban, apixaban) are not used in pregnancy.

VTE treatment is categorised as – initial; long term; extended.

Chronic DVT

It leads into chronic venous insufficiency (CVI). It presents as non healing ulcer over malleoli and lower leg; lymphovenous oedema; ankle fibrosis; pigmentation; lipodermatosclerosis of leg; joint osteoarthritis; quadriceps and calf muscle wasting. It is evaluated by discharge culture study, Doppler study, CT/MRI of part; D dimer test; biomarkers P; selectin/CRP.

It is managed by elevation to reduce edema; compression devices; venous stenting; venous valve repair (valvuloplasty).

Venous ulcer is treated by – compression therapy – 40 mmHg multilayered (four) sustained graduated compression or 2 layered zinc oxide impregnated 25 mm Hg compression; debridement; infection control; colloid silver dressing.

Post-Thrombotic Syndrome (PTS)

PTS is late effect of DVT. It can occur in ileofemoral or femoropopliteal or calf vein DVT. But ileofemoral DVT is more commonly involved with PTS. Residual thrombus increases the risk. It develops in 50% of DVT patients as late effect usually in 2 years. Around 3% of PTS patients develop venous ulcers (post-phlebitis ulcers). It can occur in a DVT patient in spite of anticoagulation therapy. PTS is measured by Villalta scale and Ginsberg measures are used for the assessment of PTS. CEP, VCCS, Wildmer classification is used for chronic venous insufficiency (CVI) assessment. PTS incidence can be reduced by initial treatment of heparin/LMWH for DVT, Warfarin, and early ambulation with compression stockings. Active thrombus removal (thrombectomy) and thrombolysis should be done. US Duplex scan is diagnostic tool. Near infrared spectroscopy (NIRS) is also useful in early detection **(Fig. 12-38)**.

Treatment—drugs, elastic bandage and deep venous reflux surgery – valvuloplasty.

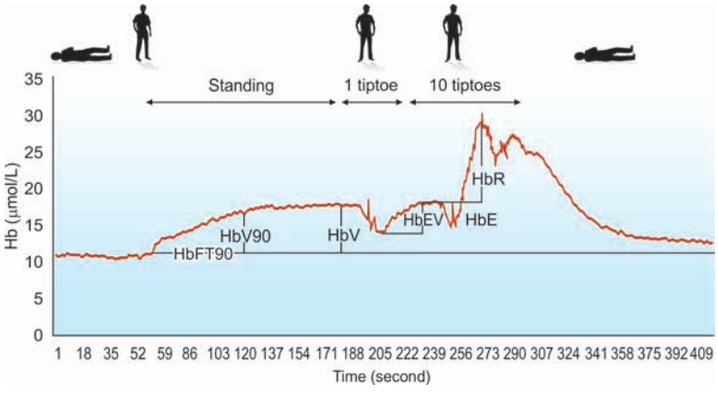


Fig. 12-38: Near Infrared spectroscopy.

IVC Filters

IVC filters are used to prevent dislodged thrombus from entering into right atrium. ACP 2012 (American College of Chest Physicians) and ACR – SIR 2010 (American College of Radiologists and Society for Interventional Radiologists) guidelines are used.

IVC filters are used in pulmonary embolism and DVT when anticoagulants are contraindicated and symptomatic pulmonary embolism with thrombotic load in the limb. IVC filters are indicated in recurrent DVT and pulmonary embolism despite therapeutic anticoagulation; may be useful in free floating thrombus in ileofemoral segment or IVC. IVC filter is indicated in pregnancy when anticoagulants are contraindicated and when there is extensive thromboembolism. If patient had recent history of VTE and he has to undergo some other surgery, then IVC filter is indicated. Chronic thromboembolic pulmonary hypertension needs IVC filters. Retrievable IVC filters are placed.

Prophylactic filters may be used in trauma like closed head injuries, spinal cord injuries, and multiple long / pelvic bone injuries. Infrarenal IVC thrombus, duplication of IVC, larger [pelvic mass prior to surgery if IVC mobilisation is needed, in pregnancy when filters are indicated—suprarenal IVC filters are placed. IVC filters are placed under Duplex US and fluoroscopic guidance **(Fig. 12-39)**.

Retrievable filters are commonly used now. Retrieving is done in 6-12 months or once chances of re DVT have become less. Retrieving is technically easy and safe.

Different filters are – Mobin Uddin; Greenfield; Bard, etc.

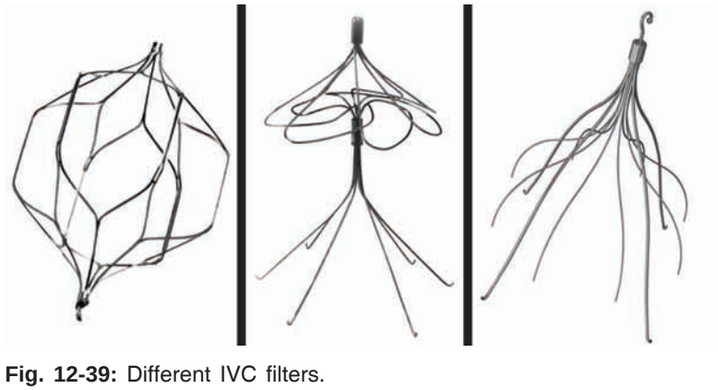


Fig. 12-39: Different IVC filters.

Chapter

13

Surgeries of Nerves, Muscles and Tendons

MUSCLE REPAIR

Longitudinal clean incision of the muscle can be left alone or loose 2 zero vicryl sutures are placed. But deep fascia in front should be sutured, muscle hernia can occur otherwise **(Fig. 13-1)**.

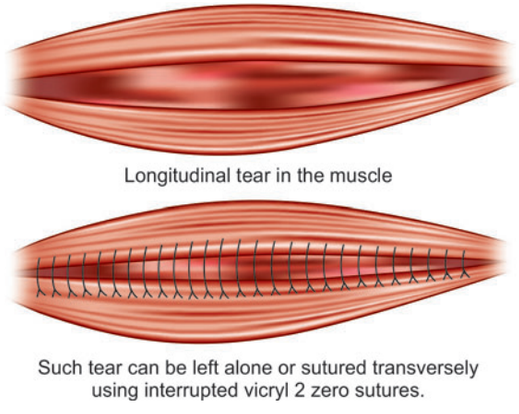

Longitudinal tear in the muscle
Such tear can be left alone or sutured transversely
using interrupted vicryl 2 zero sutures.

Fig. 13-1: Longitudinal muscle tear is simpler and safer.

It is *the transverse cut/incision* of the muscle which is *more* problematic. It should be sutured using *figure of eight sutures* using vicryl. Direct simple suturing will tear and will not hold. It is often ideal to take the bite of the *adjacent fascia* of the muscle to achieve a proper strength on suturing. Kocher's, horizontal, bucket handle incisions create horizontal cuts in the abdominal muscles. If transverse cut of muscle is not sutured, muscle fibres retract and may atrophy. *Partial transverse cut* may cause hypertrophy of remaining muscle fibres to compensate and function like earlier. Partially cut muscle retracts and forms a '*tumour like' swelling* which should be left alone without any surgical intervention. All *complete transverse cuts* in muscle need proper suturing using vicryl. 6 weeks of splintage is necessary **(Fig. 13-2)**.

MUSCLE DEBRIDEMENT (MUSCLE EXCISION)

When muscle is dead or badly infected, entire necrosed muscle should be excised until proper bleeding occurs. All unhealthy, pale, lusterless grey muscle tissues should be liberally excised. Excised muscle bed should be thoroughly irrigated and washed with warm normal saline. A corrugated drain should be placed before suturing. Only skin suturing

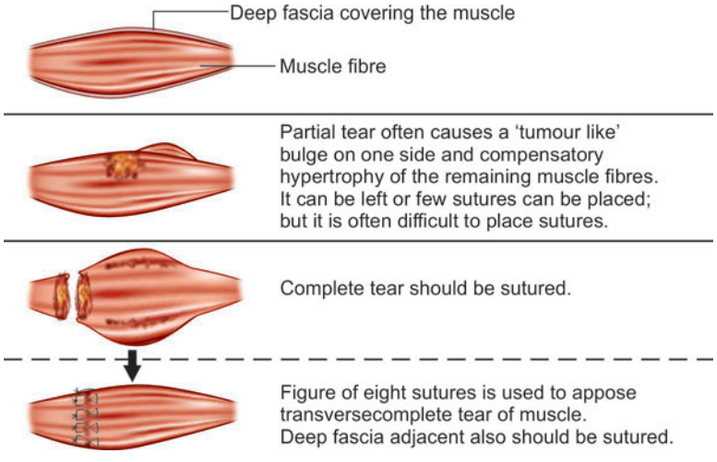

Deep fascia covering the muscle
Muscle fibre
Partial tear often causes a 'tumour like'
bulge on one side and compensatory
hypertrophy of the remaining muscle fibres.
It can be left or few sutures can be placed;
but it is often difficult to place sutures.
Complete tear should be sutured.
Figure of eight sutures is used to appose
transversecomplete tear of muscle.
Deep fascia adjacent also should be sutured.

Fig. 13-2: Transverse muscle tear is difficult to manage either partial or complete.

will suffice; if at all loose apposition sutures using interrupted vicryl 2 zero sutures can be used. One should not place continuous sutures in an infected bed. Proper adequate antibiotics, prevention of tetanus or gas gangrene is also important.

COMPARTMENT SYNDROME

It occurs due to oedema, haematoma deep-to-deep fascia, in muscular compartment. It is common after trauma, infection, burns. Fracture of bone with haematoma is also a precipitating cause. Pressure within the compartment increases causing poor perfusion of the tissues locally and distally often by blocking the main artery. It is common in *leg*, forearm, thigh and arm. Early emergency decompression by *fasciotomy* is needed. Pain which gets aggravated on muscle action; pallor; absence of distal pulse are typical features. *Lengthy deep multiple fasciotomy incisions* are needed. It releases the pressure, improves the perfusion, and reduces the oedema. Later secondary suturing is done once wound becomes clean and oedema subsides completely.

Fasciotomy in the Calf

It is done by a deep vertical incision placed behind the medial margin of the tibia to release posterior compartment; another deep vertical incision is placed 4 cm lateral to tibia to release anterior and peroneal compartments **(Fig. 13-3)**.

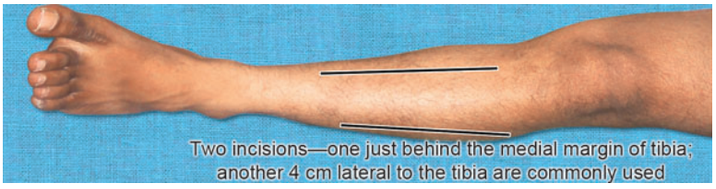


Fig. 13-3: Fasciotomy incision in the leg.

Often *flaps can be raised at the level of deep fascia* through a single lateral incision over the fibula (with elevation of flaps) to reach all four compartments of the leg **(Fig. 13-4)**.

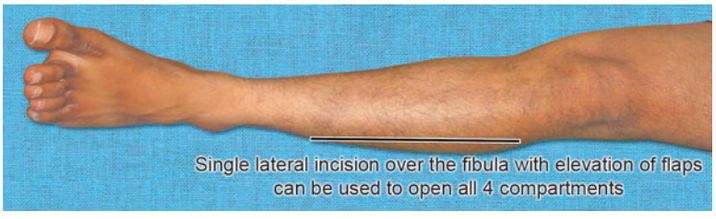


Fig. 13-4: Single lateral incision with elevation of the flap can be used to reach all compartments.

TENDON REPAIR

Tendon heals either by *intrinsic method* when there is no stress to tendon or by *extrinsic method* when there is stress to tendon. Extrinsic healing often causes fibrous mass called *tenoma* which may interfere the tendon gliding.

Tendon injury may be a clean incised injury, or laceration, or tendon rupture due to blunt force or tendon avulsion from the bone.

Flexor and extensor tendons of the fingers are commonly affected. Achilles tendon is commonly injured in the lower limb.

Tendon repair can be primary (within 24 hours); delayed (within a week after 24 hours); secondary (after one week).

Two types of tendon suturing are here.

(1) In Kessler method knot stays in the cut part of the tendon.
(2) In Goldner method knot comes away from cut ends of the tendon **(Fig. 13-5)**.

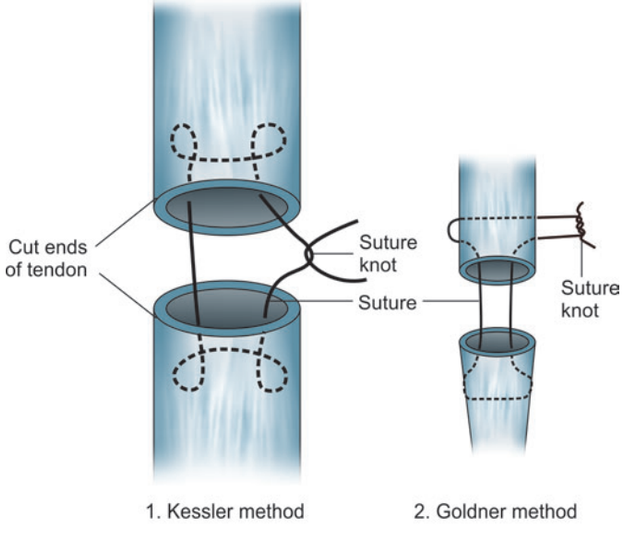


Fig. 13-5: Types of tendon suturing – 1. Kessler method. 2. Goldner method.

Suture material used for tendon repair is *polypropylene with round body needle*. 3 zero or 4 zero suture is used for smaller tendons; 2 zero is used for tendons like Achilles tendon. Absorbable sutures *should not* be used as with suturing, full tensile strength of the tendon is achieved only after 8 months of the injury. Silk is not used because it causes extensive tissue reaction. In olden days strips of fascia were used (now not used). *Continuous suturing* is done.

Postoperative splintage for 4-6 weeks is needed. Later passive and active exercises are started with proper advice of physiotherapy.

Complications are – infection, adhesion, stiffness and failure.

In avulsion injury of tendon, it is attached to bone by drilling holes in the bone through which tendon is passed. Often this tunneled tendon is buttressed with suture and a button which are removed after 4-6 weeks **(Figs 13-6 and 13-7)**.

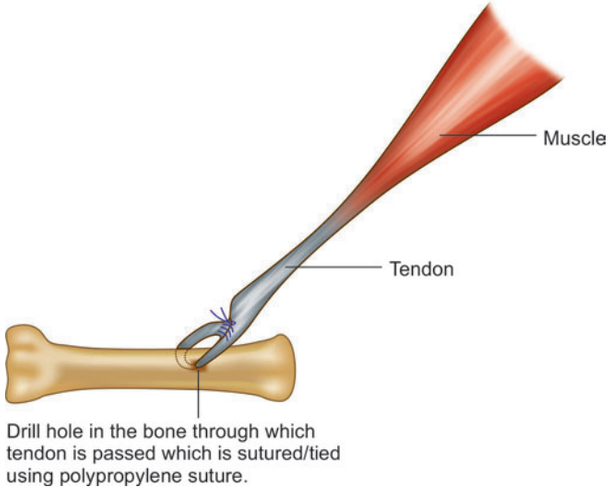


Fig. 13-6: Suturing of the avulsed tendon into the bone is done by passing tendon across the drilled holes in the bone.

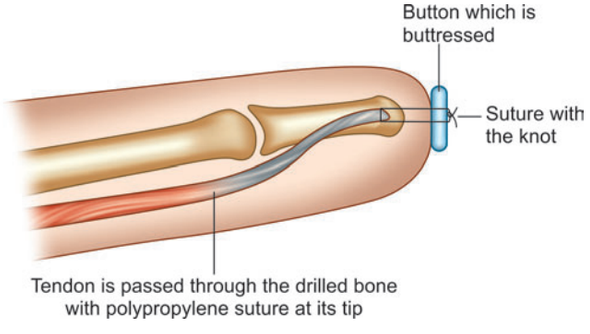


Fig. 13-7: Tendon is passed through the bone and buttressed using a button outside which is removed later.

TENDON RELEASE

It is done for stenosing tenosynovitis of finger (middle or ring) or thumb. Surgical release of the tendon is done, if steroid injection fails. Procedure can be done under local anaesthesia. Release of adjacent soft tissue is often required.

Either transverse or longitudinal incision can be placed over the site just distal to transverse palmar crease.

Similarly tendon release is done for de Quarvain's stenosing tenosynovitis.

TENDON TRANSFER

It is the transfer of one tendon from its existing site to another site where its function is required to have a new function required at the newer site (restore the lost function at the newer site). Function of the transferred tendon should be maintained by other tendons. Tendon should able to acquire the function at the newer site properly. Tendon should be strong enough to have a newer function and should have adequate amplitude of movements. For example, in ulnar claw hand, flexor digitorum superficialis (FDS of index finger) is transferred to lumbrical canal of the digits to have flexion at MCP joint and extension of proximal IP joint. Extensor indicis tendon can be used to replace extensor pollicis longus tendon **(Fig. 13-8)**.

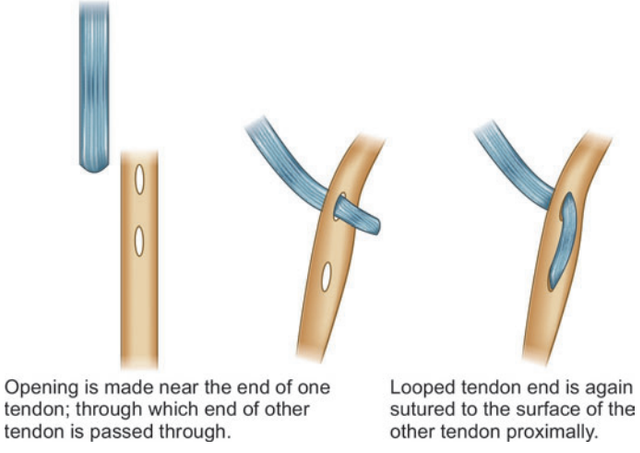

Opening is made near the end of one tendon; through which end of other tendon is passed through.
Looped tendon end is again sutured to the surface of the other tendon proximally.

Fig. 13-8: Method of suturing of the transferred tendon.

Examples

Paul Brand's operation is done for claw hand. Here extensor carpi radialis brevis is transferred with a graft to extensor hood through lumbrical canal. Graft is taken from Palmaris longus.

Stye Bunnell's operation is done for ulnar claw hand only. Here flexor digitorum superficialis is transferred to extensor hood.

Foot drop is corrected by tendon transfer using tibialis posterior muscle with intervening plantaris tendon graft. Tendon is inserted to cuboid and cuneiform bones. *Ober's and Barr's procedures* are different routes of transfer of the tendon into the cuboid and cuneiform bones.

TENDON GRAFT

When tendon suturing or transfer is not possible because of inadequate length, tendon of a muscle which is not functionally much useful (non-essential tendon) is taken as a graft to obtain required length. ***Common grafts used are*** palmaris tendon in forearm and plantaris tendon in leg.

Example - Extensor carpi radialis brevis (ECRB) is lengthened using tendon graft to transfer to lumbrical canals in claw hand.

Problems in tendon graft: Infection, adhesions, graft failure, stiffness of the part.

TENDON LENGTHENING

It is done when existing tendon is short or has become shortened by trauma/infection. It is commonly used in Achilles tendon, hand, forearm etc. Tendon is slit like a lengthy 'L' and is sutured with lengthening **(Fig. 13-9)**.

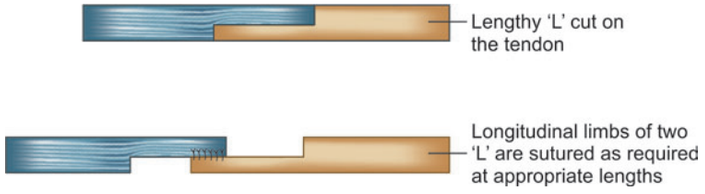


Fig. 13-9: Tendon lengthening technique.

NERVE REPAIRS

Types of Nerve Suturing

Epineurorrhaphy:
Only epineurium is sutured using interrupted sutures. It is commonly used.

Epi-perineurorrhaphy:
Initially perineural sheath and then epineurium is sutured. It is not commonly used.

Repair should be delayed if nerve is lacerated; *marker stitches (using silk)* are then placed at the cut end site to identify the nerve for suturing at a later period. Usually microscope or loup is used for nerve suturing **(Fig. 13-10)**.

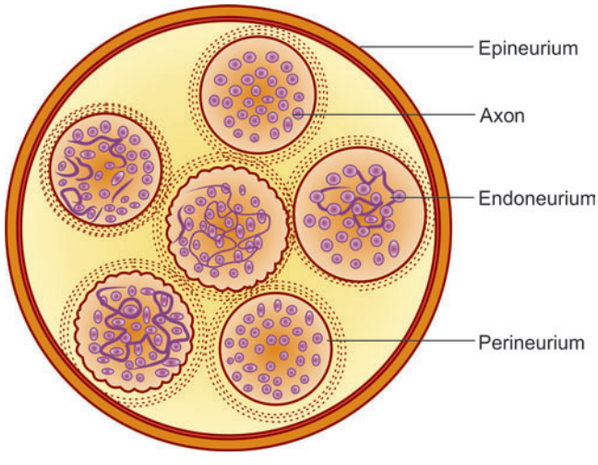


Fig. 13-10: Cross section of a peripheral nerve.

Note:

Incomplete injury usually does not require any suturing. Initial management is conservative. Though incised injury commonly transects the nerve; but possibility of nerve injury in blunt trauma should also be remembered. Proper clinical examination for nerve injury is essential.

All suspected nerve injury should be explored under anaesthesia, general or regional. Tourniquet can be used if there is no evidence of ischaemic injury.

Primary repair is done immediately after injury. Nerve ends are minimally trimmed very close using a blade. All fascicles of the nerve are

oriented correctly. Two stay sutures are placed to keep the orientation properly. Usually epineural suturing is done using 8 zero polypropylene interrupted sutures. It needs magnification. 6 – 8 sutures are placed for large peripheral nerve like median or ulnar nerve. For small nerve like digital nerve, only 2-3 sutures are placed **(Fig. 13-11)**.

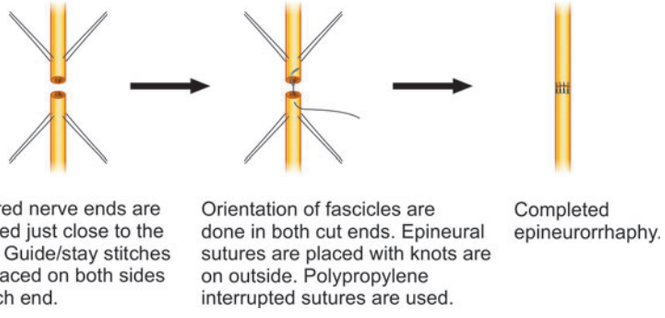

Severed nerve ends are trimmed just close to the ends. Guide/stay stitches are placed on both sides of each end.
Orientation of fascicles are done in both cut ends. Epineural sutures are placed with knots are on outside. Polypropylene interrupted sutures are used.
Completed epineurorrhaphy.

Fig. 13-11: Primary nerve repair.

Secondary repair is done at a later period. It is done in a preexisting scar tissue. Here first nerve ends, both proximal and distal are identified, carefully dissected adequately. Proximal neuroma and distal glioma are trimmed for 1 cm to expose the normal fascicles of the nerve ends. Often guide sutures of silk may be present which were placed earlier during exploration of the trauma. Once nerve ends are clean, it is sutured alike primary suturing with stay sutures, with proper alignment of fascicles, followed by epineural suturing. Here as epineurium is thicker, suturing is easier **(Fig. 13-12)**.

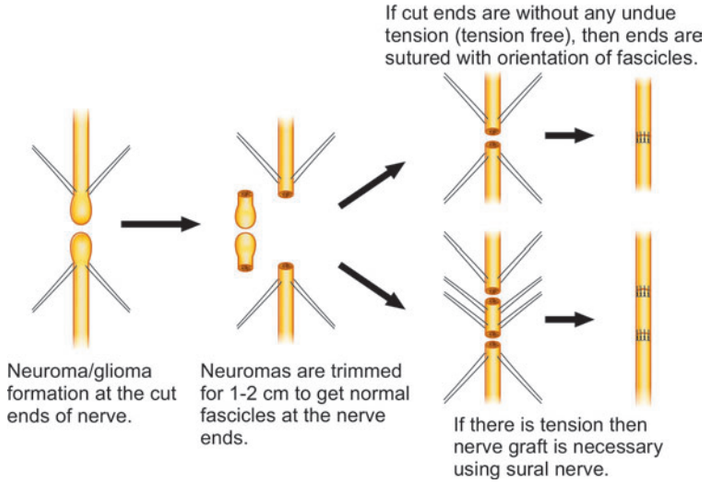

If cut ends are without any undue tension (tension free), then ends are sutured with orientation of fascicles.
Neuroma/glioma formation at the cut ends of nerve.
Neuromas are trimmed for 1-2 cm to get normal fascicles at the nerve ends.
If there is tension then nerve graft is necessary using sural nerve.

Fig. 13-12: Secondary nerve repair.

All nerve suturing should be done *tension free*. If there is tension, it should be corrected by various methods - relaxing incisions; transpositioning of the nerve (like of ulnar nerve in elbow joint); shortening of the bone; nerve graft - usually sural nerve is used for nerve graft (often saphenous nerve is used); positioning of the limb; doing initially *neurolysis* (release of the scar tissue adjacent to injury). Nerve graft is needed if gap is more than 2 cm between the cut ends.

Immobilisation of the part is a must for 3-6 weeks. Adjacent joint should be kept in flexed position; later extension is achieved slowly and gradually. Denervated distal part should be taken care of properly as there may be paralysis, loss of sensation, with possible development of contracture.

Prognostic factors in healing of the nerve injury –

Higher the lesion worse the prognosis (more the distance nerve has to grow means less chance of complete recovery); more the gap between the cut ends worse the prognosis; associated injuries alter the prognosis; children do better with nerve injury; type of the injury also decides the prognosis; technical precision also decides the outcome of the surgery.

If nerve suturing fails or cannot be done, then tendon transfer is done at a later period after 4-6 months.

Different Nerve Injuries

Facial nerve injury occurs during parotidectomy. It may be neuropraxia or complete injury. If it is neuropraxia, it is treated conservatively with steroid, tarsorrhaphy. If it is complete injury, it is repaired using nerve graft. Grafts used are great auricular nerve or hypoglossal nerve.

Recurrent laryngeal nerve injury is seen after thyroidectomy, oesophagectomy, tracheal surgery, mediastinal surgery. Its management is discussed in Chapter 15 'Surgery for Thyroid and Parathyroids'.

Radial nerve injury causes wrist drop. Its primary suturing is effective as it is mainly motor. But it takes a year time for recovery. So tendon transfer is often done.

Median and ulnar nerves can be damaged at wrist, forearm or at elbow. They are repaired primarily. If lacerated or crushed, guide stitches are placed and later secondarily repaired. Ulnar nerve when injured at the elbow is sutured in front of the elbow to reduce the tension.

Brachial plexus injury is complicated injury as it may be supraclavicular/infraclavicular; pre-ganglionic or post-ganglionic. It needs a combined, specialised, multidisciplinary approach.

Tibial and common peroneal nerves are also repaired using similar principles. *Sciatic nerve* suturing does not give good result even though it looks technically sound.

Autonomic nerves being non-myelinated, axonal growth will not occur and so nerve repair is not effective.

Classification of Nerve Injuries

Seddon's Classification

Neuropraxia: It is temporary physiological paralysis of nerve conduction. Here recovery is complete. There is no reaction of degeneration.

Axonotmesis: It is division of nerve fibres or axons with intact nerve sheath. There is reaction of degeneration distally with near complete recovery. Patient can present with sensory loss, paralysis of muscles or causalgia.

Neurotmesis: Here complete division of nerve fibres with sheath occurs. Degeneration occurs proximally up to the first node of *Ranvier* as well as distal to the injury. Recovery is incomplete even after nerve suturing. There is complete loss of motor and sensory functions with loss of reflexes. If the nerve is mixed type other than pure motor or sensory recovery is still poorer.

Sunderland's Classification

i. Conduction block—temporary neuronal block.
ii. Axonotmesis but endoneurium is preserved.
iii. Axonotmesis with disruption of endoneurium but perineurium is preserved.
iv. Here disruption of endo and perineurium has occurred but epineurium is intact.
v. Neurotmesis with disruption of endo, peri and epineurium has occurred.

TINEL'S SIGN

It is the clinical sign (*prognostic indicator*) used to assess the level of regeneration. It is elicited 3 weeks after the nerve injury (regeneration begins after the completion of nerve degeneration). Tapping over the course of the nerve is done *from distal to proximal* to elicit a sensation of `*pins and needles' or hyperaesthesia*. If sensation is felt at the site as well as distally along the distribution of the nerve that means *good recovery* can be expected. If sensation is felt only at the site of tapping, then result is *equivocal*. If no sensation is felt it means no recovery.

MANAGEMENT OF NERVE ENTRAPMENT/ COMPRESSION (NERVE RELEASE)

Nerve entrapment and specific nerve injury is commonly due to trauma, constriction bands, fibrosis. It is treated by steroid injections, surgical release of entrapped nerve. Examples are median nerve entrapment in carpal tunnel syndrome, meralgia paraesthetica of thigh, tardy ulnar palsy causing ulnar nerve compression.

Carpal Tunnel Syndrome

It presents with median nerve palsy. Median nerve is deep to flexor retinaculum which gets entrapped under the flexor retinaculum due to causes like trauma (lunate dislocation, malunited Colle's fracture), myxoedema, acromegaly. Flexor retinaculum is also called as *transverse carpal ligament* which extends laterally from trapezium and scaphoid, medially to pisifiorm and hook of hamate.

Flexor retinaculum maintains the concavity of the wrist. It is diagnosed clinically and confirmed by nerve conduction studies. Cervical rib and cervical spondylosis are the differential diagnosis **(Fig. 13-13)**.

Surgery is usually done under *local anaesthesia*. General or brachial block can be used. Tourniquet is commonly used. *Vertical crease incision* is made in the proximal part of the palm with convexity of the incision towards the ulnar side **(Fig. 13-14)**.

Skin incision is deepened. Palmar cutaneous branch of the median nerve should be preserved. Incision is deepened to identify the flexor retinaculum. *Entire length, both superficial and deep parts* should be cut properly. It is cut towards ulnar side of the wound. *Only skin* is sutured using interrupted nonabsorbable 3 zero polypropylene or polyethylene sutures.

Complications are incomplete fasciotomy and recurrence, nerve injury.

Using small proximal incision, endoscope can be passed to visualise and cut the entire flexor retinaculum – *minimal access surgery.*

Anterior Transposition of the Ulnar Nerve

Ulnar nerve is behind the medial epicondyle (behind common flexor origin). Medial epicondylitis causes tardy ulnar palsy. In such situation common flexor tendon is released from its origin; ulnar nerve is placed in front of the flexor origin; detached common flexor tendon is reattached to medial condyle. It is called as anterior transposition of ulnar nerve. It is also used in ulnar nerve injury. Elbow is immobilised for 3 weeks.

Meralgia Paraesthetica

It is entrapment neuropathy of lateral cutaneous nerve of thigh under the inguinal ligament. It arises from posterior divisions of lumbar plexus (L2, 3); runs over the quadrates lumborum and iliacus muscles; emerges behind the lateral part of the inguinal ligament; divides into anterior and posterior branches, supplying skin over anterolateral part of the thigh and anterior part of the gluteal region. Patient presents with loss of sensation at the area of distribution of the lateral cutaneous nerve of thigh (upper lateral part of the thigh). It is treated by reassurance and steroid injection. Nerve release is routinely not required **(Fig. 13-15)**.

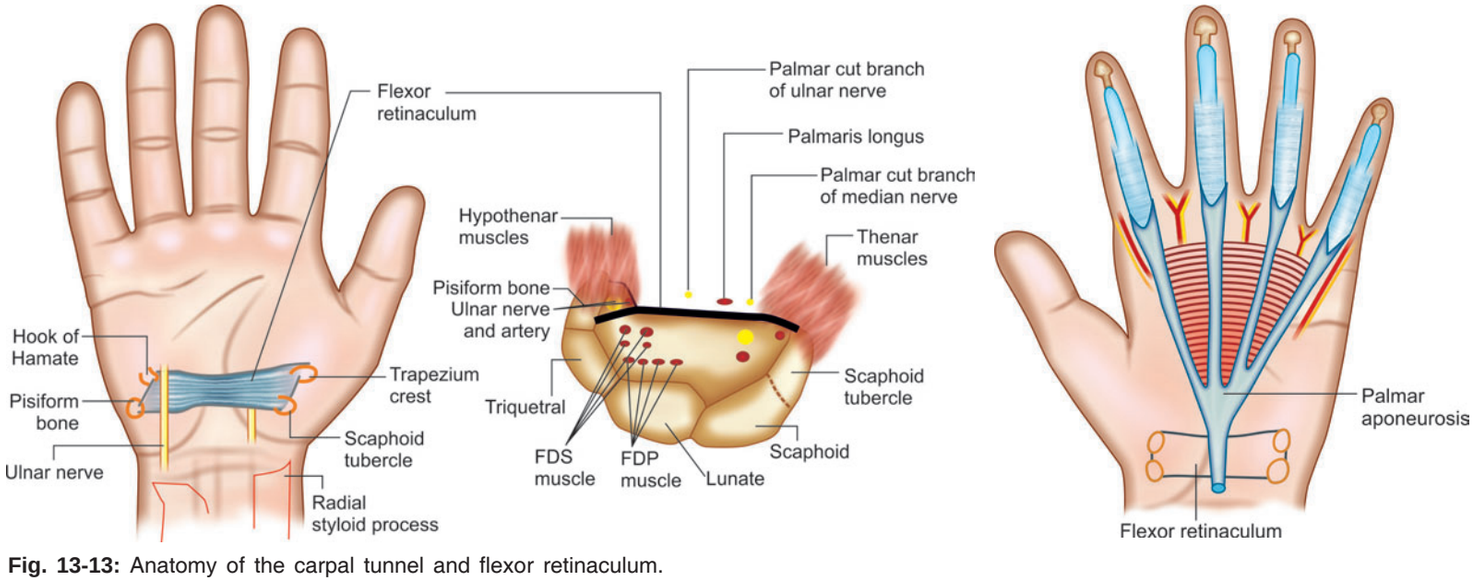


Fig. 13-13: Anatomy of the carpal tunnel and flexor retinaculum.

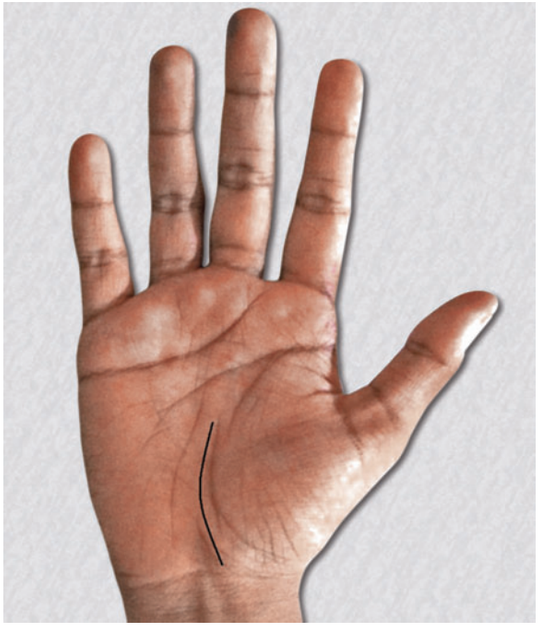


Fig. 13-14: Incision for carpal tunnel syndrome.

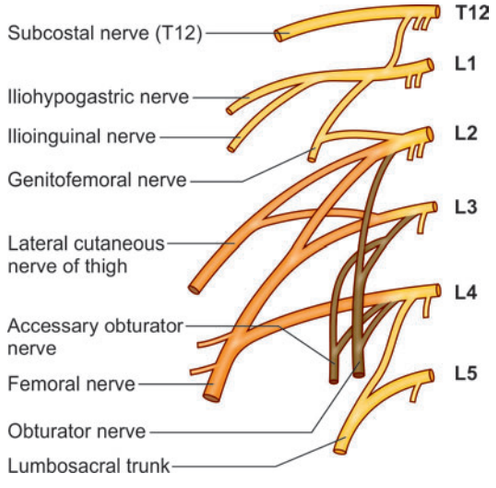


Fig. 13-15: Lumbar plexus showing origin of lateral cutaneous nerve of thigh.

LUMBAR SYMPATHECTOMY

Indications

It is mainly used to improve the healing of cutaneous ulcers in patients with vascular disease like TAO; in causalgia of lower limb (it is common in upper limb). Its benefits are temporary. It causes cutaneous vasodilatation by sympathetic blockage. It may also be used to improve the blood supply of skin flaps in amputations.

Contraindications

It is contraindicated in patients with bleeding disorders and patients who are on anticoagulants.

Principles

It is a pre-ganglionic sympathectomy. Ganglia L2 and 3 supply leg below the knee level. L1 supplies buttock and upper thigh. L1 lies under the crus of diaphragm. L4 lies under the common iliac vessels.

Procedure

General or spinal anaesthesia is used. Patient should be strapped to table in lateral tilt position. Incision is transverse or oblique at the level of the umbilicus extending obliquely downwards. External and internal oblique muscles are divided; transverse abdominis muscle is initially split from posterior part, then towards anterior part (as peritoneum is adherent to muscle in anterior part but free in posterior aspect and so to avoid opening of the peritoneum it is split from behind). Peritoneum is pushed medially by finger dissection. If peritoneum is opened it is closed using vicryl continuous sutures. It is swept in front of the psoas major muscle towards medially. Genitofemoral nerve and ureter are identified. Ureter along with peritoneum is retracted medially using Deaver's retractor. Additional Deaver retractor is used to tract the upper part of the wound. Self retaining retractor may be useful at this stage. IVC is visualised as a bluish structure. Its posterior aspect is gently dissected using peanut and fine dissections. One should not injure the lumbar veins which if injured may cause torrential bleeding and obscure the surgical field. On the left side sympathetic chain is behind the aorta, which is mobilised to reach the chain. Sympathetic chain is identified as stiff vertically placed structure behind the IVC/aorta in front of the vertebrae which can be felt by rolling the finger. *L2 is identified* as it is largest ganglion. L1 is high up behind the diaphragmatic crus and it should not be removed. L2, 3 and 4 are removed. L5 is often below which may or may not be removed. Chain is dissected off the vertebrae using scissor for adequate length and is cut using scissor. It is not necessary to ligate the chain on either side. After removal specimen chain is sent for histology for confirmation. Haemostasis is confirmed. Wound is closed in layers using 1 zero vicryl. Drain is usually not necessary unless there is bleeding **(Fig. 13-16)**.

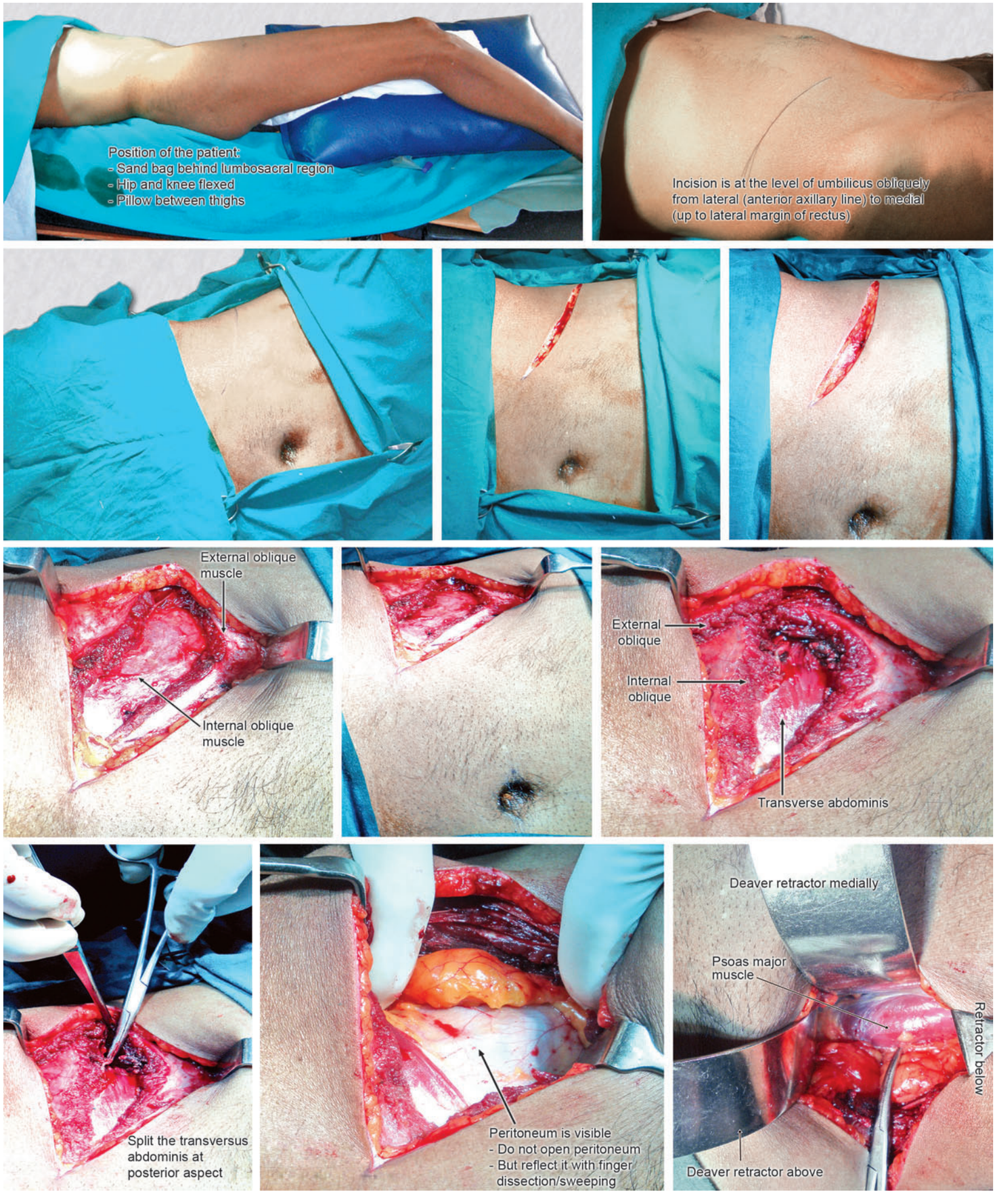
Postoperative Period

Patient is monitored for bleeding. Temperature of the limb is checked which will become warmer (becomes warmer immediately after sympathectomy). Sutures removed in 7-10 days.

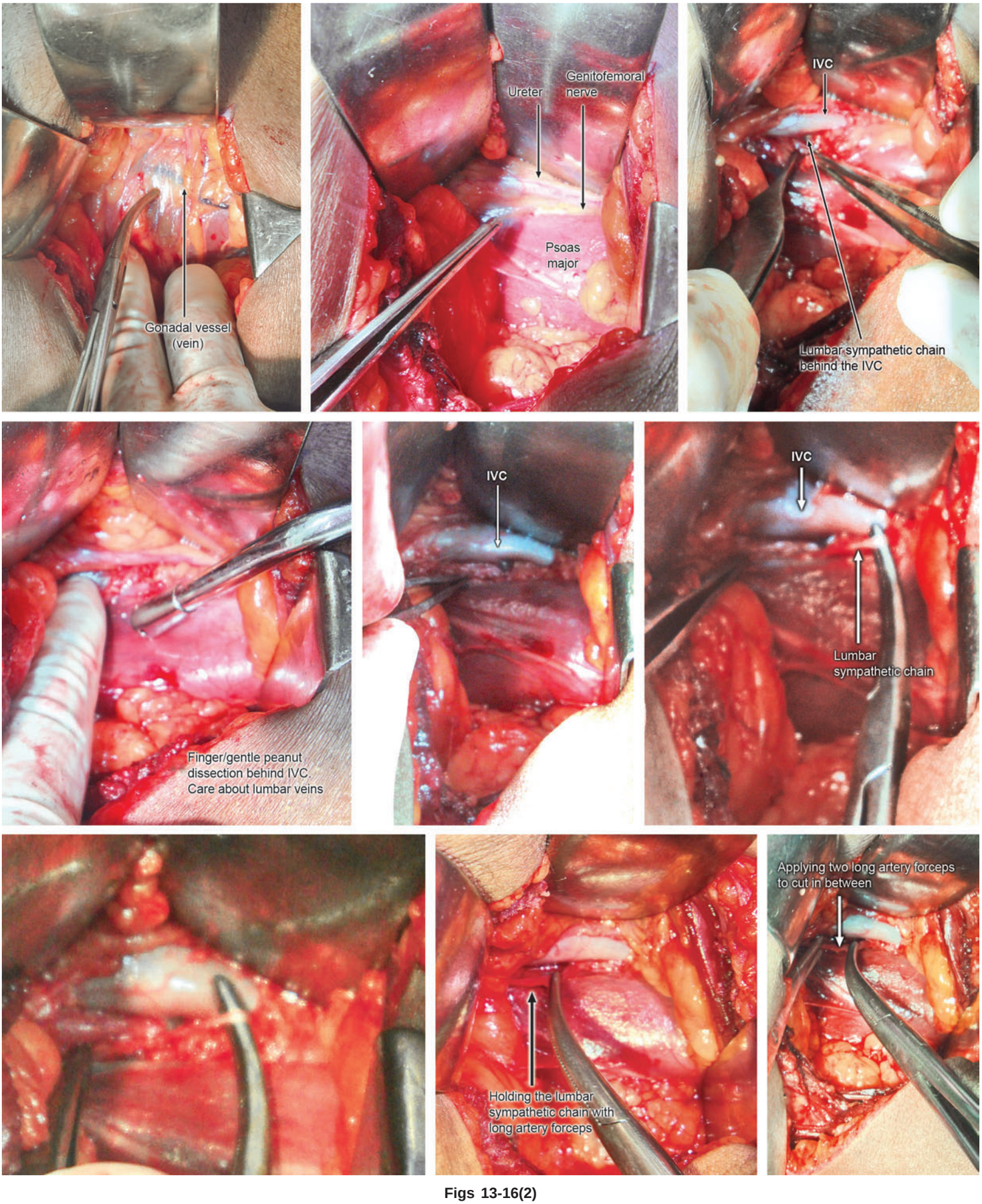
Problems and Complications

Often, reaching the sympathetic chain may be problematic. Injury to IVC (rarely aorta on left side) may be dangerous. If IVC is injured, it should be clamped using Satinsky clamp; and sutured using 4 zero polypropylene suture. Injury to peritoneum, bowel, and ureter can occur. Bleeding lumbar veins is quite difficult to tackle. Bipolar diathermy fulguration is useful. If it is identified it can be ligated gently. Often it is ligated during surgical dissection itself to avoid bleeding. Spasm of spinal cord vessel and spinal cord ischaemia and paraplegia can develop rarely. If L1 ganglia of both sides are removed, ejaculatory failure can develop (dry ejaculation). Haematoma formation, wound infection are other complications.

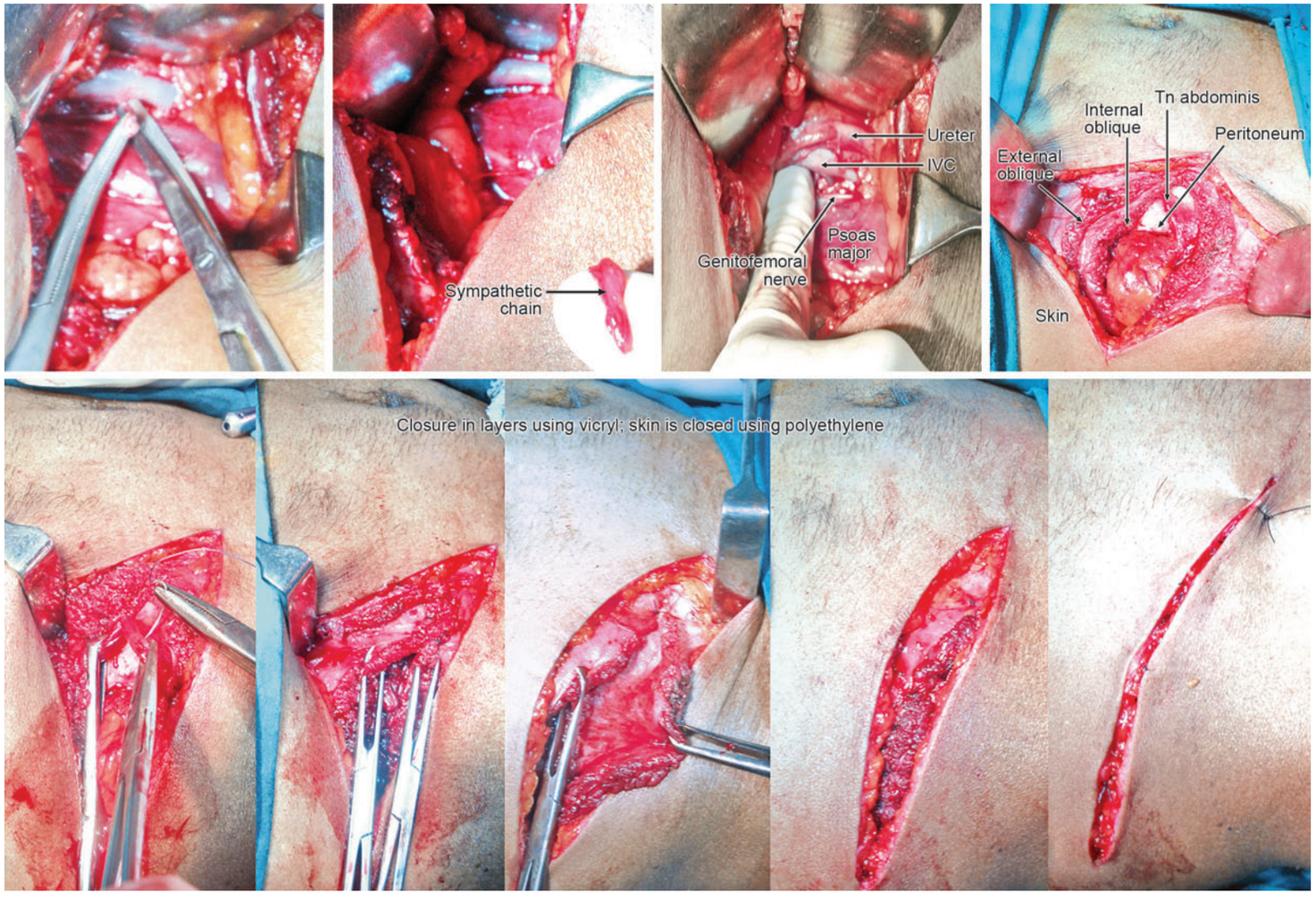
Effects of lumbar sympathectomy are *temporary (3-4 weeks)*. By improving the cutaneous blood supply it promotes ulcer healing. But it may reduce the blood supply of deeper muscles (as it is diverted towards skin), and hence claudication is not benefited by lumbar sympathectomy but may get aggravated.


Position of the patient:
- Sand bag behind lumbosacral region
- Hip and knee flexed
- Pillow between thighs
Incision is at the level of umbilicus obliquely from lateral (anterior axillary line) to medial (up to lateral margin of rectus)
External oblique muscle
Internal oblique muscle
External oblique
Internal oblique
Transverse abdominis
Split the transversus abdominis at posterior aspect
Peritoneum is visible
- Do not open peritoneum
- But reflect it with finger dissection/sweeping
Deaver retractor medially
Psoas major muscle
Retractor below
Deaver retractor above

Figs 13-16(1)


Gonadal vessel (vein)
Ureter
Genitofemoral nerve
Psoas major
IVC
Lumbar sympathetic chain behind the IVC
Finger/gentle peanut dissection behind IVC. Care about lumbar veins
IVC
IVC
Lumbar sympathetic chain
Holding the lumbar sympathetic chain with long artery forceps
Applying two long artery forceps to cut in between

Figs 13-16(2)



Figs 13-16(3)

Fig. 13-16: Operative steps in lumbar sympathectomy.

Laparoscopic Retroperitoneal Lumbar Sympathectomy

Lumbar sympathectomy also can be done using laparoscopic retroperitoneal approach with same position by placing three ports. One port is placed at anterior axillary line (10 mm port for camera); two 5 mm ports are placed medially above and below. Dissection is done in front of the psoas major muscle towards medially reflecting the peritoneum, ureter in front. IVC is identified. Dissection is done behind the IVC. Sympathetic chain is identified and removed.

Chemical Sympathectomy

It is done in lateral position using a long spinal needle. Local anaesthesia is infiltrated first. Position of the chain is confirmed under fluoroscopy by injecting dye. 5 ml of phenol in water or absolute alcohol is injected lateral to the vertebral bodies of 4th and 2nd lumbar vertebrae. Needle should not enter the IVC or aorta. Limb becomes warmer immediately. Initial trial injection of the lignocaine to confirm the benefit may be done. Technique should not be done in bleeding disorders and in patients who are on anticoagulants.

CERVICOTHORACIC SYMPATHECTOMY

It is the removal of 2nd and 3rd thoracic ganglia which contain postganglionic fibers supplying the upper limb. Preganglionic white rami communicantes fibres of 2nd and 3rd sympathetic nerves enter thoracic T1 ganglion supplying the head and neck region through upper part of the stellate ganglion. Pre-ganglionic sympathetic nerve entering the 2nd and 3rd ganglia from below supplies sympathetic fibres of upper limb through lower part of the stellate ganglion.

In cervical sympathectomy for upper limb ischaemia, lower part of the stellate ganglion and Kuntz nerve is divided. For head and neck hyperhidrosis entire stellate ganglion is removed which leads to development of Horner's syndrome.

For hyperhidrosis of axillary region stellate ganglion, upper four thoracic ganglia are removed.

Surgical Anatomy

Preganglionic fibres arise from lateral horns of the T_1 to T_{12} segments of spinal cord. T_1 to T_{12} lateral horns → Preganglionic fibres → Ventral

roots of spinal cord → Beginning of ventral rami → White rami communicantes (14 on each side)

↓	↓	↓	↓
Relay in sympathetic trunk ganglia which gives post ganglionic fibers as grey rami communicantes	Pass through ganglia without any connection to higher or lower ganglia where it communicates.	Synapses in ganglia to supply viscera – heart, lungs, aorta, oesophagus (T1-5).	White rami pass through corresponding ganglia without relay and emerges out as greater (T5-9); lesser (T9-10); lowest/least (T11) splanchnic nerves to supply abdomen through splanchnic ganglia.

Ganglia are connected to respective spinal nerves through white rami (from spinal nerve to ganglia) and grey rami (from ganglia to spinal nerves) communicantes.

In the neck there are 3 cervical sympathetic ganglia – *superior,* at the level of greater cornu of hyoid; *middle,* at the level of cricoid; *inferior,* 3 cm above the sternoclavicular joint. Sympathetic chain here is located behind the carotid sheath in front of the prevertebral fascia. Superior is the largest of the three – 2.5 cm; located below the skull opposite 2nd and 3rd cervical vertebrae behind carotid sheath; which actually is fused upper 4 cervical ganglia. It communicates with 9th, 10th, 12th cranial nerves and external and recurrent laryngeal nerves. It sends branches to plexus around ECA, ICA and other branches in the neck; branches to otic, submandibular, ciliary and pterygopalatine ganglia in neck; to pharynx. Middle cervical ganglion is very small, often it is branched or absent; situated in front of the C6 vertebra above inferior thyroid artery behind the carotid sheath. It is formed by 5th and 6th ganglia; is connected to inferior cervical ganglion through a looped ansa subclavia and also directly. It gives branches to C5 and C6 spinal nerves, thyroid, parathyroid, trachea, oesophagus and middle cervical cardiac branch. Inferior cervical ganglion is formed by 7th and 8th cervical ganglia; often it is fused with 1st thoracic ganglion to form stellate ganglion. It is located between transverse process of C7 vertebra and neck of first rib. It gives branches to C7, C8 ventral nerves, vertebral and subclavian artery plexus, inferior cervical cardiac branch **(Fig. 13-17)**.

Sympathetic outflow to upper limb is from T2 to T9; T1 also may contribute to supply arm in 10% of cases. A direct communication may be present between 2nd and 3rd thoracic ganglia and brachial plexus through *nerve of Kuntz*.

Indications

Hyperhidrosis (very useful), causalgia (very useful), autonomic nerve dystrophies, cervical rib with vascular manifestations (useful), Raynaud's phenomenon (useful), other causes of upper limb ischaemia (useful), acrocyanosis (useful), Sudeck's osteodystrophy (useful). Conditions with vasospasm will get benefited rather than conditions with obliterative digital vessel occlusion.

Approaches

Supraclavicular, transthoracic/axillary approach *(Hedley Atkins),* thoracoscopic approach (better) are the different approaches used.

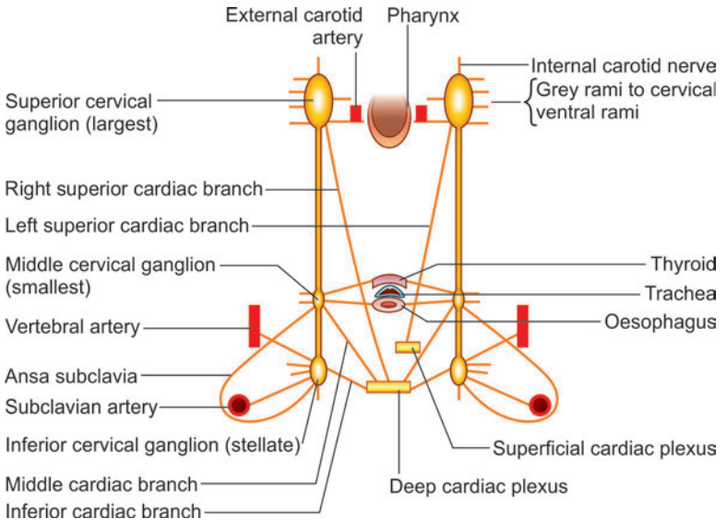


Fig. 13-17: Cervical sympathetic chain – surgical anatomy.

Supraclavicular Approach

It is done under general anaesthesia. Patient is positioned supine with head end of the table elevated by 15°to reduce venous congestion and head is tilted to opposite side; arms are placed on the sides of the patient. Incision is placed a fingerbreadth (1.5 cm) above the clavicle from anterior border of the sternocleidomastoid muscle extending laterally for 7-8 cm. It is usual but not mandatory practice to pull/drag the skin downwards below the clavicle and make incision on the clavicle from medial to lateral; and when pulled skin is released after making incision, incision will be in supraclavicular area. It is said to prevent inadvertent injury to deeper structures. Incision is deepened; Platysma is incised. External jugular vein is divided with ligatures. Supraclavicular nerves are retained. Exposed sternocleidomastoid muscle is identified for its full width. The clavicular head is divided using scissor/cautery/or by piecemeal using fine forceps (used in olden days). IJV behind the muscle should not be injured. Scalene pad of fat is dissected. Inferior belly of omohyoid muscle is divided. IJV is mobilised and retracted medially. Bipolar cautery dissection is done in front of the scalene muscle. Phrenic nerve is identified in front of the scalenus anterior muscle deep to deep fascia running vertically downwards from lateral to medial side. Phrenic nerve is retracted medially (should not be retracted laterally as it may cause traction injury to upper trunk of brachial plexus). Dissected scalenus anterior muscle is cut layer by layer carefully using scissor / by piecemeal method to protect subclavian artery underneath. Medial part of the brachial plexus is dissected carefully. Subclavian artery is dissected on its summit and pushed downwards. Occasionally thyrocervical trunk may have to be ligated. Often subclavian artery is dissected and slinged upwards; but one should be careful while pulling the sling especially in atherosclerotic vessel. Head light may be better used for further dissection. Subclavian artery is retracted downwards. In the triangle between brachial plexus, subclavian artery and IJV, suprapleural membrane (Sibson's fascia) is felt with index finger which is divided using finger dissection by pushing it downwards against vertebra (*Sibson's fascia* also called as vertebropleural fascia is tent like thickening of the prevertebral fascia extending from transverse process of C7 to first rib). Once it is divided, retropleural space is dissected by pushing the pleura downwards using finger and pleura and Sibson's fascia is retracted downwards. Stellate ganglion is identified at the

neck of the first rib. By finger and swab dissection entire ganglion is exposed. Right angle is passed underneath; sympathetic chain below is dissected up to 3rd ganglion. Intercostal veins crossing the chain should be carefully separated or ligated between haemoclips. Entire ganglion is not removed for upper limb diseases as it will cause Horner's syndrome. Lower part of the ganglion, where rami from 1st thoracic nerve enters is divided. Lower end is dissected downwards below the level of thoracic 3rd ganglion and chain is cut again at this level. Chain is sent for histology. Lung is inflated. Wound is closed in layers. Drain is usually not necessary **(Fig. 13-18)**.

Complications

Complications are bleeding; injury to subclavian artery and nerves; pneumothorax and haemothorax; Horner's syndrome presenting as ptosis, miosis, anhydrosis, enophthalmos, loss of ciliospinal reflex. Chest X-ray is taken during postoperative period when suspected to rule out pneumothorax. If pneumothorax is present, intercostal tube should be placed. Left sided sympathectomy may cause thoracic duct injury. Neuropraxia of brachial plexus is known to occur due to traction during procedure.

Advantages

Postoperative recovery is faster with less duration of hospital stay and less disability.

Disadvantage

Difficult narrow space approach is the limitation.

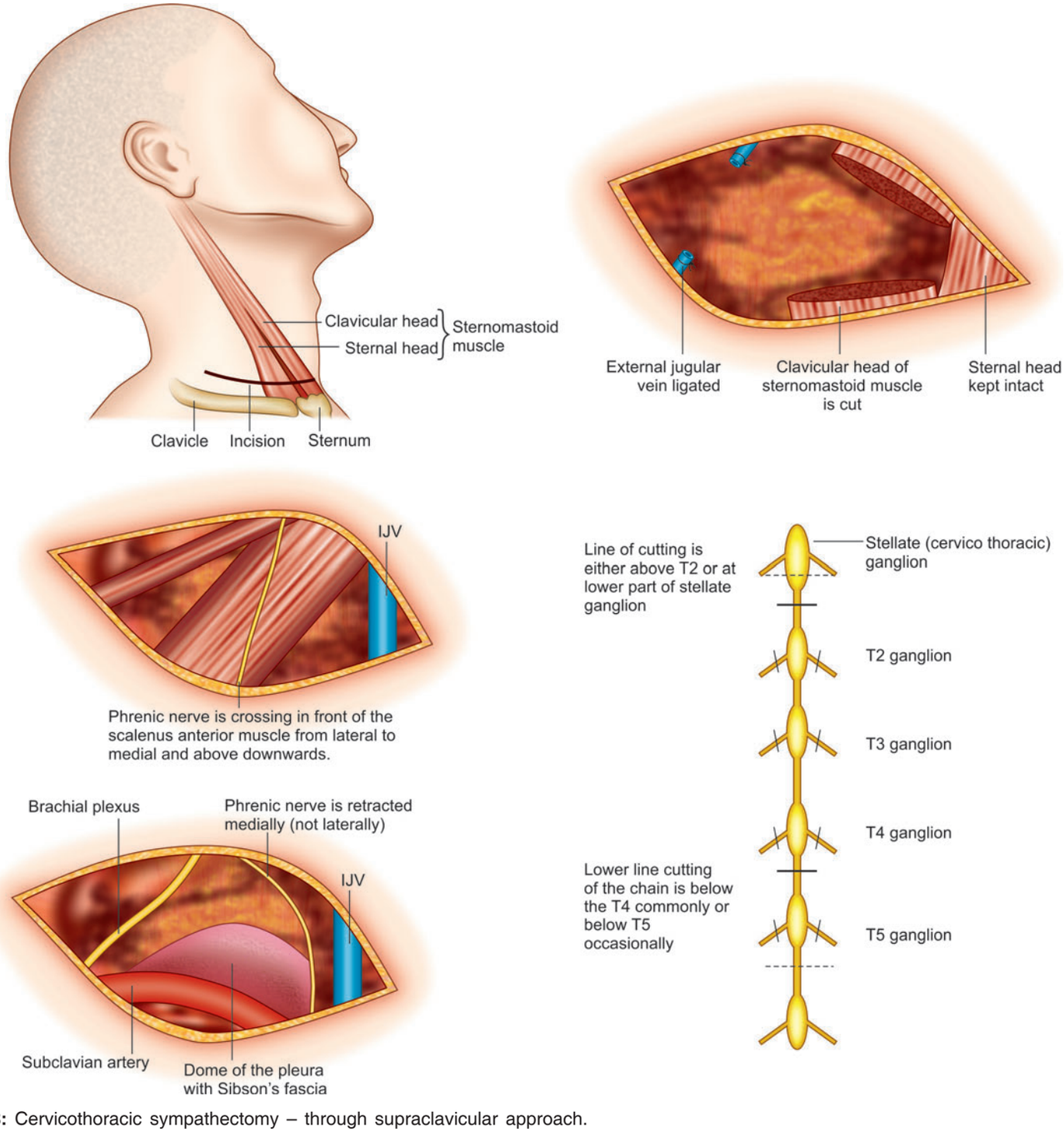

Clavicular head
Sternal head
Sternomastoid muscle
Clavicle
Incision
Sternum
External jugular vein ligated
Clavicular head of sternomastoid muscle is cut
Sternal head kept intact
IJV
Phrenic nerve is crossing in front of the scalenus anterior muscle from lateral to medial and above downwards.
Brachial plexus
Phrenic nerve is retracted medially (not laterally)
IJV
Subclavian artery
Dome of the pleura with Sibson's fascia
Line of cutting is either above T2 or at lower part of stellate ganglion
Stellate (cervico thoracic) ganglion
T2 ganglion
T3 ganglion
T4 ganglion
Lower line cutting of the chain is below the T4 commonly or below T5 occasionally
T5 ganglion

Fig. 13-18: Cervicothoracic sympathectomy – through supraclavicular approach.

Transaxillary Approach

It is better approach but needs prolonged hospitalisation and has slow postoperative recovery. Either extrapleural or transpleural approaches are used.

Transaxillary extrapleural approach is done using standard thoracotomy position. Arm of the same side is fully abducted to expose the entire axilla. Arm, chest, back, shoulder area is cleaned and draped. Incision is placed at lower margin of the axillary hair line from margin of pectoralis major in front to margin of latissimus dorsi behind **(Fig. 13-19)**.

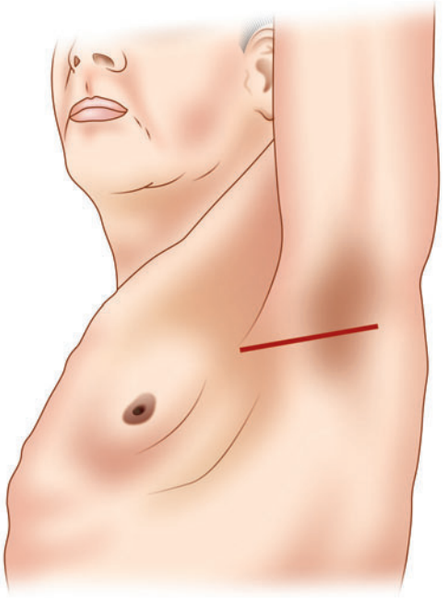


Fig. 13-19: Incision for the transaxillary extrapleural approach – It is in the axilla placed at lower margin of the hairline from pectoralis major to latissimus dorsi muscle along the first rib.

Incision is deepened to reach the first rib. Intercostobrachial nerve is divided. A branch from axillary artery is divided. Anterior scalene muscle is divided to expose the superior surface of the first rib. Intercostal muscles are stripped off from the inferior surface of the first rib using periosteal elevator. First rib is excised using bone cutter and end is smoothened using rongeur. Pleural dome is pushed away from the mediastinum using finger dissection. Subclavian vessels are identified. Sympathetic chain is identified between T1 nerve root and subclavian artery. Sympathectomy is done from lower half of the stellate ganglion to lower margin of T 3 ganglion. One should confirm that there is no pleural tear and pneumothorax, if it so chest tube may be placed and wound is closed in layers. Postoperative chest X-ray is a must.

Transaxillary transpleural approach is done through 3rd intercostal space. Position is same as extrapleural approach. Incision of 15 cm in length is made along the line of 3rd rib from posterior axillary fold to anterior axillary fold downwards and forwards. Incision is deepened to periosteum of the 3rd rib **(Fig. 13-20)**.

Pectori are retracted forward; latissimus dorsi, teres major, subscapularis and long thoracic nerve are retracted backward. Lateral thoracic artery near the posterior portion of the wound is divided. Attachment of serratus anterior is removed from 3rd rib. Using cautery, periosteum of the 3rd rib is incised throughout its full length. Often 3rd rib is resected deep to its periosteum. Pleura is opened through the

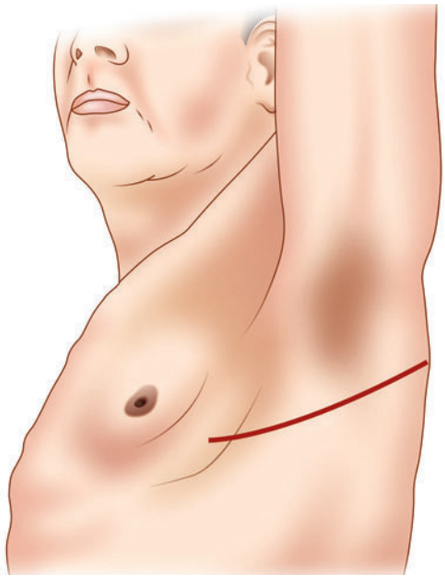


Fig. 13-20: Incision for transaxillary transpleural approach is through 3rd rib.

periosteum of the 3rd rib to avoid injury to intercostal neurovascular bundle. Thorax is opened widely using a rib spreader. Lung is deflated to visualise the mediastinal and dome of the pleura. Thoracic vertebrae (upper five) and corresponding ribs are exposed to visualise the sympathetic chain beneath the pleura on the necks of the ribs. Parietal pleura is opened vertically on the sympathetic chain using long fine scissor. Nerve is held with nerve hook below the 4th thoracic ganglion and cut and rami communicantes are divided. Chain above the 2nd or lower half of the stellate ganglion is cut to remove needed segment of the sympathetic chain. Dissection along the chain should be careful and gentle as intercostal vessel bleeding, if occurs, is often difficult to control. If bleeding occurs, bleeding point is carefully identified by proper suction and haemoclips are applied. Bipolar cautery is used for fulguration if needed. Care should be taken not to injure or cauterise the intercostal nerve which will cause troublesome neuralgia. Chest tube is inserted to pleural cavity and wound is closed in layers. Bilateral sympathectomies, if needed, should be done in different sittings.

Thoracoscopic Sympathectomy

It is preferred method than open method as there is better visualization and identification of the sympathetic chain, faster recovery, and small incisions. Procedure is done under general anaesthesia with open thoracotomy position with operating side of the patient elevated. Double lumen or bronchial blocker is used to facilitate the deflation of the same side of the lung. Zero or 30° telescope is used through 10 mm port at the centre of 4th or 5th intercostal space in anterior or mid-axillary line. Two 5 mm ports are placed side wards above and below the 10 mm port through intercostal spaces which will be in front of the 10 mm camera port to provide adequate triangulation. Lung is deflated by anaesthetist. If not deflated properly then CO_2 insufflation may be used. Sympathetic chain is visualised properly on the necks of the ribs. Overlying pleura is opened using cautery, harmonic scalpel or scissor. Care should be taken not to injure intercostal vessels and nerve. Chain from T4 to T1 is removed. Haemostasis is maintained. Chest tube is placed. Difficulties lie in identifying the chain, lifting the pleura, haemostasis. Advantages are fast recovery, good magnification, and less painful.

Chapter

14

Surgeries of Face, Head and Neck

SURGICAL ANATOMY OF NECK

Neck has got anterior and posterior triangles on each side. Skin over the anterior triangle is supplied by anterior cutaneous nerve of neck (C_2, C_3).

Superficial fascia in anterior triangle contains *platysma*, cervical branch of facial nerve, anterior jugular vein and few superficial lymph nodes. Flaps in the neck are usually elevated in *subplatysmal plane*.

Platysma is a wide thin subcutaneous muscle running upwards and medially from *deltoid and pectoral fascia* to the *base of the mandible*. It is supplied by cervical branch of facial nerve. It prevents the skin pressing into superficial veins. Superficial vessels and nerves lie deep to platysma.

Anterior jugular vein is located in superficial fascia which begins below the chin runs vertically downwards 1 cm from the midline; 2.5 cm above the sternum, it pierces the deep fascia to reach suprasternal space where it communicates with opposite anterior jugular vein through jugular venous arch and travels above the clavicle behind the sternocleidomastoid muscle to join external jugular vein.

Structures above the hyoid bone are – anterior belly of digastric, submandibular salivary gland, mylohyoid nerve and vessels, submental branch of facial artery, hyoglossus, intermediate digastric tendon with pulley, stylohyoid muscle tendon, and hypoglossal nerve. *Subhyoid bursa* is located between posterior surface of the body of hyoid bone and thyrohyoid membrane to reduce the friction between the two during swallowing **(Figs 14-1 and 14-2)**.

Structures below the level of hyoid bone are – infrahyoid muscles [sternohyoid (medial front), omohyoid [lateral in front], sternothyroid (lateral deep, below), thyrohyoid (lateral, deep, above); pretracheal fascia (with thyrohyoid membrane, thyroid cartilage, cricothyroid membrane, cricoid arch, cricothyroid muscle, trachea and carotid sheath).

Anterior triangle of neck is bound by midline, sternocleidomastoid muscle laterally, base of mandible and line joining angle of mandible and mastoid process above. Triangle is divided by digastric muscle and superior belly of omohyoid muscle as muscular, submental, carotid and digastric triangles. Suprahyoid muscles are digastric, mylohyoid, stylohyoid and geniohyoid muscles **(Fig. 14-3)**.

Submental triangle is median in location and is bound by anterior bellies of digastric muscles of both sides with the base on the hyoid bone. Floor is formed by right and left mylohyoid muscles. It contains submental veins and submental lymph nodes (*located in superficial fascia*) which drain from superficial tissues below chin, central part of lower lip, adjacent gum, anterior part of floor of the mouth, and tip of tongue. These lymph nodes drain into submandibular lymph nodes.

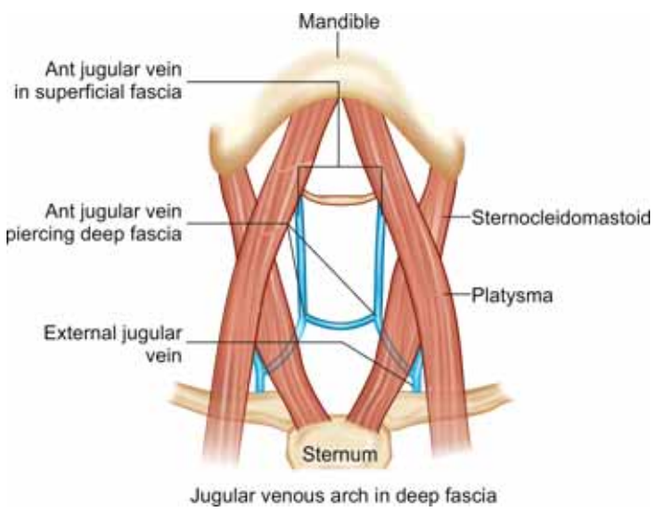


Fig. 14-1: Anatomy of anterior jugular vein and platysma.

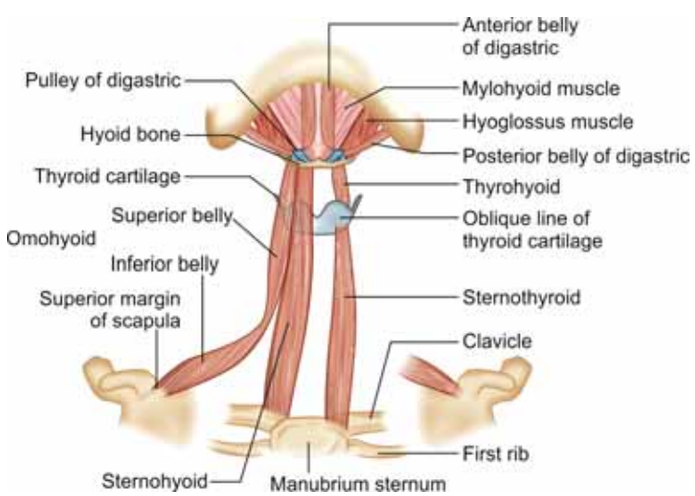


Fig. 14-2: Strap and front muscles of the neck.

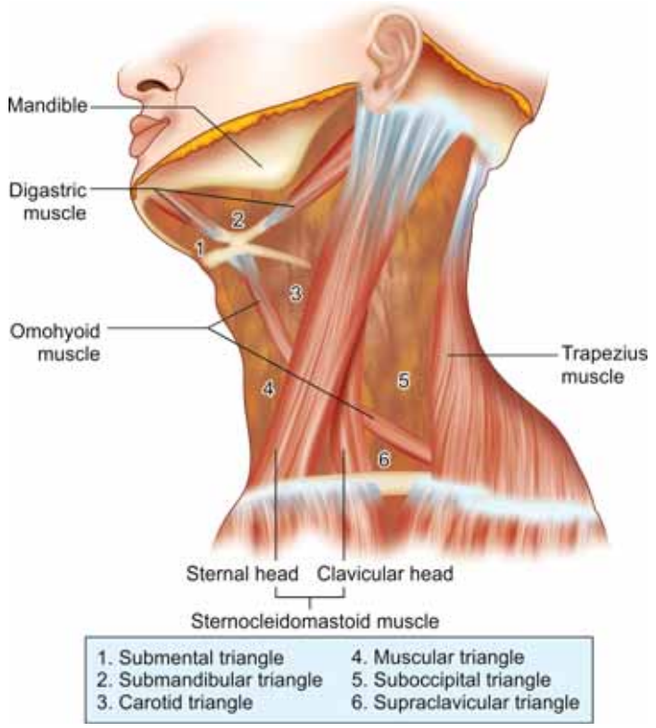


Fig. 14-3: Different triangles in neck.

Digastric triangle is formed by two bellies of digastric muscle, posteriorly also by stylohyoid muscle, base above is by the base of mandible and line joining the angle of mandible and mastoid process. Its roof is formed by skin; superficial fascia with platysma, cervical branch of facial nerve and ascending branch of anterior cutaneous nerve; deep fascia splits to enclose submandibular salivary gland. Its floor is formed by mylohyoid muscle in front, hyoglossus behind and middle constrictor partly. Structures superficial to mylohyoid and hyoglossus are – submandibular salivary gland (superficial part), facial vein, submandibular lymph nodes, submental artery and mylohyoid nerve and vessels, intermediate tendon of the digastric muscle and stylohyoid, hypoglossal nerve. Facial artery is deep to mylohyoid muscle. In the posterior part of digastric triangle lower pole of the parotid and external carotid artery entering the parotid are in superficial location; whereas structures passing between ECA and ICA (styloglossus, stylopharyngeus, glossopharyngeal nerve, pharyngeal branch of vagus, styloid process) are in deeper plane. ICA, IJV and vagus are located still in deeper plane. Submandibular lymph glands are located *deep* to deep fascia on the surface of submandibular salivary gland which drains from forehead, nose, frontal, maxillary and ethmoidal air sinuses, inner canthus of eye, upper lip, anterior cheek with adjacent gums and teeth, outer part of lower lip with adjacent teeth and gums except incisors, anterior 2/3rd of tongue except tip of tongue and floor of the mouth, from submental lymph glands. Efferent vessels drain mainly into jugulo omohyoid lymph nodes.

Carotid triangle is bound above and in front by posterior belly of digastric and stylohyoid muscle; below by superior belly of omohyoid; behind by sternocleidomastoid muscle. Its roof is formed by skin; superficial fascia with platysma, cervical branch of facial nerve and transverse cutaneous nerve; deep fascia. Its floor is formed by thyrohyoid, hyoglossus, and middle and inferior constrictor muscles. It contains – arteries (CCA, ICA, ECA, superior thyroid, facial, ascending pharyngeal, occipital arteries); veins (IJV, common facial vein entering the IJV, pharyngeal vein entering IJV or common facial vein, lingual vein entering the IJV); nerves (Vagus, superior laryngeal nerve and its branches, spinal accessory nerve, hypoglossal nerve, ansa cervicalis, sympathetic chain behind carotid sheath); carotid sheath with its contents; lymph nodes (jugulodigastric is below the posterior belly of digastric and jugulo omohyoid above the inferior belly of digastric).

Investing layer of deep fascia is attached above to external occipital protuberance, superior nuchal line, mastoid process; fascia splits between angle of mandible and mastoid process to enclose parotid. Above the parotid the outer lamina (split part) which is dense and thick gets attached to zygomatic arch. Thin deeper lamina is attached to styloid process, mandible and tympanic plate. Deeper lamina is condensed between angle of mandible and styloid process to form stylomandibular ligament. Below, investing layer is attached to scapular spine, acromion, clavicle, manubrium in front. Behind it is attached to ligamentum nuchae and C_7 spine; in front to symphysis menti and hyoid bone. Investing layer of deep fascia *encloses* trapezius and sternocleidomastoid muscles, parotid and submandibular salivary glands, supraclavicular and suprasternal spaces. Deep fascia forms digastric and omohyoid *pulleys*. Suprasternal *space of Burns* contains tendinous sternal heads of both sternocleidomastoids; jugular venous arch, a lymph node and interclavicular ligament.

Prevertebral fascia is in front of the prevertebral muscles is attached above to the base of skull; below extends into the superior mediastinum to attach to anterior longitudinal ligament and body of T_4 vertebra. In front it is separated from pharynx by retropharyngeal space. Laterally, it merges deep into trapezius. Cervical and brachial plexus of nerves lie behind this fascia. Four cutaneous branches of cervical plexus pierce this fascia. Subclavian artery and brachial plexus runs between scalenus anterior and medius carrying with them prevertebral fascia as *axillary sheath*. Subclavian and axillary veins are away and below this fascia and so are not inside the axillary sheath.

Posterior triangle is the space located between sternocleidomastoid muscle, trapezius and middle 1/3rd of clavicle. Its *roof* is formed by investing layer of deep fascia. Superficial fascia in posterior triangle contains platysma, external jugular and posterior jugular veins.

External jugular vein is located in superficial fascia deep to platysma; begins at lower part of the parotid by union of posterior auricular vein and posterior division of retromandibular vein; descends downwards in front of the sternocleidomastoid muscle; enters the roof of posterior triangle – investing layer of deep fascia at anteroinferior angle of roof to join subclavian vein. Deep fascia is densely adherent to vein at the point of entering the roof and so external jugular vein when cut, opening cannot be closed, as a result of which air is sucked inside causing air embolism. Before ligating the vein deep fascia should be cut to collapse the vein. Tributaries of external jugular vein are—posterior external jugular vein, transverse cervical vein, suprascapular vein and anterior jugular vein. An oblique jugular vein connects between external jugular vein and IJV at anterior margin of sternocleidomastoid at middle third of the muscle. Surface marking of the vein is from below and behind the angle of the mandible to a point lateral to the posterior border of the sternocleidomastoid near clavicle.

Floor of the posterior triangle is formed by prevertebral fascia over splenius capitis, levator scapulae, scalenus medius, and often scalenus posterior **(Fig. 14-4)**.

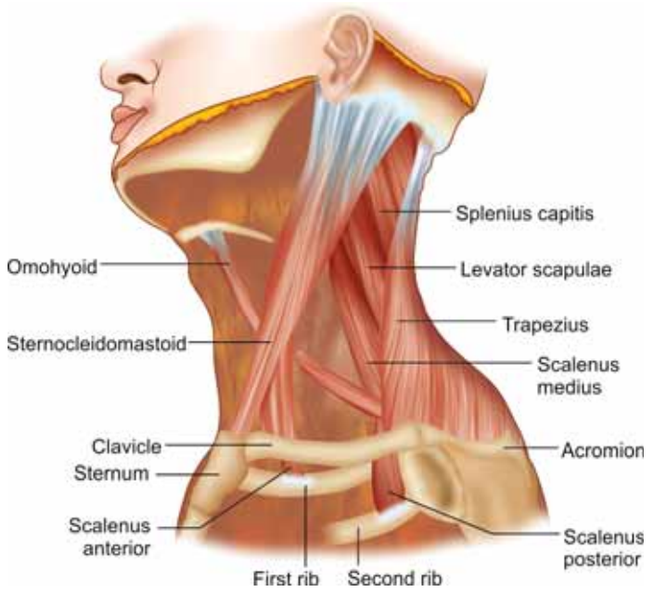


Fig. 14-4: Structures forming the floor of posterior triangle.

Posterior triangle is divided by inferior belly of omohyoid into a *smaller lower supraclavicular* / subclavian triangle and a *larger upper* occipital triangle. *Contents of the posterior triangle* are: The nerves—the spinal accessory nerve; four cutaneous branches of cervical plexus (lesser occipital (C_2), great auricular ($C_{2,3}$), anterior cutaneous nerve of the neck ($C_{2,3}$), supraclavicular nerves ($C_{3,4}$)); muscular branches to levator scapulae and trapezius ($C_{3,4}$); nerve to rhomboideus (C_5); nerve to serratus anterior ($C_{5,6,7}$); nerve to subclavius ($C_{5,6}$); suprascapular nerve ($C_{5,6}$); three trunks of brachial plexus. Arteries, from above downwards are – occipital artery at the apex of the posterior triangle superficial to splenius capitis, transverse cervical artery, suprascapular artery and subclavian artery. Transverse cervical artery arises from thyrocervical trunk, crosses scalenus anterior, phrenic nerve, upper trunks of brachial plexus, nerve to subclavius, suprascapular nerve, and scalenus medius. It is deep to inferior belly of omohyoid muscle. At the anterior margin of levator scapulae it divides into superficial and deep branches. Posterior triangle also contains many deep lymph nodes of the neck (level V) **(Fig. 14-5)**.

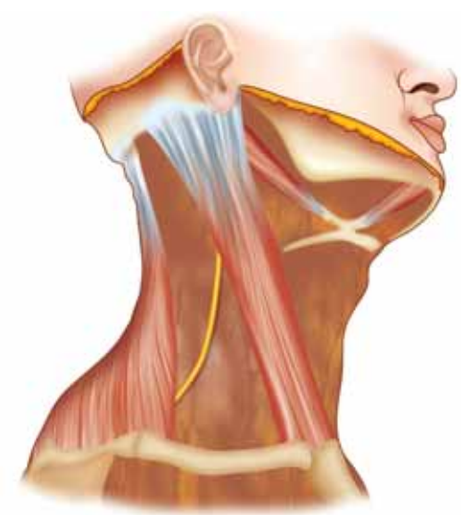


Fig. 14-5: Location of spinal accessory nerve.

BASIC PRINCIPLES IN HEAD AND NECK SURGERY

General anaesthesia with intubation is essential in all head and neck surgeries. Only surgeries like superficial excision (cyst/lipoma excision) can be done under local infiltration anaesthesia. Cervical block is often used by few experts for laryngeal surgeries, carotid endarterectomy, and thyroidectomy. Fitness for prolonged anaesthesia, arranging adequate amount of blood, proper assessment of the lesion by CT scan, usage of different energy sources, need for tracheostomy should all be thought of.

Extension of the head is usually needed in most of the head and neck surgeries which is achieved by placing a sandbag/rolled up towel/round pillow under the shoulder. Arms are pulled down with the shoulder depressed and both hands tugged under the buttock. Neck may require to be turned towards opposite side. Head end of the table is raised 15^0 in order to reduce venous congestion and bleeding.

Cleaning is done over entire neck in front, face, upper chest up to the nipple line, both shoulder area. Head is draped with sterile double towel technique. Two towels are placed under the head; towel in front is folded over the head up to chin in neck surgery, up to eyebrow in face surgery **(Fig. 14-6)**.

Skin incisions in the neck are usually placed along the lines of natural skin crease which are horizontal in front of the neck, horizontally oblique on the side of the neck. So, most of the neck incisions are horizontally placed to achieve better scar. Vertical incision causes scar contraction, hypertrophy and results in poor scar. Vertical incision is used for major vascular access (for carotids), and in trauma. In such occasions, incision is placed along the anterior border of the sternocleidomastoid muscle or along the anterior border of the trapezius.

Surgical dissection in head and neck is done using 15 number scalpel blade or fine scissor or fine monopolar/blended cautery tip. Skin hooks are used while elevating the skin flaps. Dissection should be perfect with meticulous haemostasis. Proper knowledge of surgical anatomy of neck is essential. Usually subplatysmal plane is raised. Finally closure is also equally important to achieve cosmetically acceptable good healthy scar.

Since neck is a compact area, small incision should be avoided. An adequate incision which will expose the surgical area is essential. Proper haemostasis by ligature/cautery harmonic energy is needed. *Haematoma in the neck under the deep fascia* will compress trachea and can cause life threatening respiratory arrest. A *suction drain* is usual practice to prevent this. Drain is removed in 48 hours. *Haematoma superficial to deep fascia* also can occur but is not life threatening. It may cause fibrosis and poor scarring. During closure, deep fascia, platysma are closed in layers using absorbable 3 zero vicryl interrupted sutures.

Skin is closed with interrupted sutures (using monofilament nonabsorbable suture material) in major surgeries. Skin clips also can be used. Subcuticular absorbable 3 zero vicryl or monocryl or PDS sutures can be placed if there is sure about complete haemostasis. These sutures are not removed. Additional advantage of subcuticular suture over interrupted suture is doubtful. Often it causes troublesome induration and discomfort. Interrupted sutures are removed in 5-7 days.

Surgery of larynx and laryngectomy are beyond the scope of this book as it s a specialised subject as such. But basic anatomy of larynx and principles should be remembered by general surgeon **(Fig. 14-7)**. Incision used for laryngectomy, *Gluck Sorenson's incision* is shown in **Figure 14-8**. Different surgeries are done for laryngeal

Fig. 14-6: Position, cleaning and draping of the neck for neck surgery.

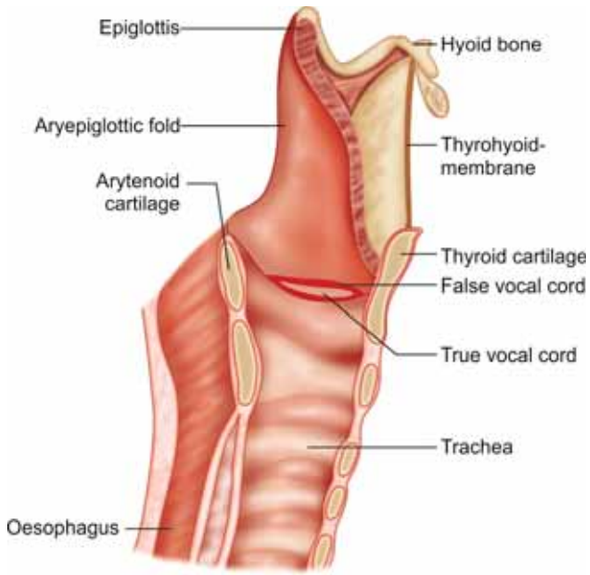


Fig. 14-7: Anatomy of the larynx.

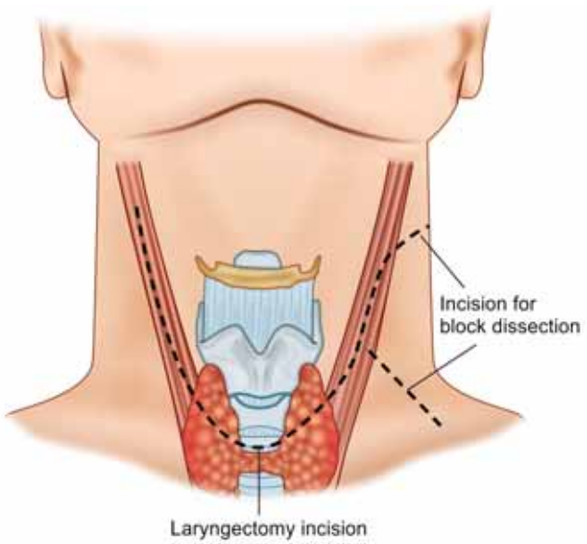


Fig. 14-8: Gluck Sorenson incision for laryngectomy.

cancers – partial or total. Neck node dissection also should be done. Permanent tracheostomy is needed. In case of pharyngeal involvement laryngopharyngectomy with tracheostomy, gastric pull up as pharyngooesophageal substitute. Speech therapy, tracheostomy care, prevention of respiratory infection are essential post operative care needed in these patients.

HEAD AND NECK TRAUMA

It can be open trauma or a closed one. Open trauma is usually penetrating. It can be from knife, sickle, and bullet injuries. Injury can occur to major vessels, trachea, oesophagus, soft tissues, thyroid, nerves, cervical and brachial plexus. External wound/stab may be small but deeper injury may be extensive.

Closed trauma may be to cervical spine, carotid artery leading to an intimal tear which may cause *carotid blowout* at a later period. Slowly expanding haematoma may be possible with blunt injury to neck. Only external bruising may be evident in such occasion. Unstable fracture of cervical spine may be present; spine should be protected mechanically in such suspected cases.

Injury to oral cavity, pharynx can cause bleeding into the airway causing life threatening airway block. Maintenance of the airway is a crucial need here.

Major vessel injury can cause torrential bleeding. Digital compression, early exploration and vessel repair is the treatment.

Management of Head and Neck Trauma

General condition should be assessed. Immediate resuscitation by inserting a central venous line, and an airway is done. Adequate

blood should be arranged for transfusion. Other injuries in the body should be looked for – abdomen/thorax/head/limb fractures. Duplex US scan of neck is a good way of assessing the neck injuries. *Assessment* is done as 3 categories - vascular, tracheal, oesophageal injuries.

Airway is maintained by endotracheal intubation or tracheostomy or cricothyroidotomy as an emergency procedure.

Bleeding is controlled by pressure, packing, early exploration, ligation of external jugular vein, IJV, ligation of small vessels. Torrential bleeding in face, and proximal neck can be controlled by ligating the external carotid artery distal to origin of superior thyroid artery. ECA has got branches whereas ICA does not have branches in the neck. Wounds in lower neck zone (zone 1) may be associated with injury to mediastinal major vessels and so exploration of mediastinum with *median sternotomy* is needed. Angiography should be done for all zone 1 penetrating injury. CT chest and neck is also often desirable if patient is stable. Penetrating injuries in zone 3 may include injury to ICA extending onto the intracranial cavity. Neurosurgical approach may be needed in such injury. Lateral injury in zone 2 causes carotid injuries which require wound exploration. Wound should be explored with an adequate lengthy incision. All haematomas are gently evacuated. Suction should be used to identify the bleeding point. Vascular clamps should be used if carotid injury is present. Intraluminal stent is better to maintain the brain circulation until repair is over. Small tear in the carotid is sutured using continuous polypropylene 3 or 4 zero suture material. Occasionally venous patch or graft is required. Intimal injury of carotid is observed for formation of pseudoaneurysm, haematoma, late rupture, thrombosis and blockage. Follow up duplex US scan is essential at repeated sittings. If such significant findings are found, exploration and vascular reconstruction is done **(Fig. 14-9)**.

Laryngeal injury is identified by CT neck. Hyoid fracture is treated conservatively. Injury to thyroid cartilage may require repair using wires or plates with a covering tracheostomy. *Tracheal injury* in proximal part is repaired using interrupted polypropylene or vicryl sutures. Tracheostomy is often needed. Tracheal injury in lower neck needs median sternotomy ,mediastinal exploration and tracheal suturing.

Small *oesophageal injury* is managed by placing nasogastric tube for 2-3 weeks. Large injury needs proper exploration of posterior neck, suturing of the oesophagus. A feeding gastrostomy with or without diversion oesophagostomy in neck which can be corrected at later period once patient's condition stabilizes is the other option.

Nerve injuries are corrected electively at a later period by nerve suturing using microscope by skilled meticulous method.

Complications of Neck Injury

Airway block, bleeding, haematoma, infection, retro or parapharyngeal haemato ma or abscess formation.

RETROPHARYNGEAL ABSCESS

Surgical Anatomy

The wall of the pharynx has got 5 layers. Mucosa, submucosa, pharyngobasilar fascia, muscular layer (contains 3 constrictors and stylo, salpingo, palatopharyngeus muscles) and buccopharyngeal fascia covers outer part of constrictors and extends over buccinator. Buccopharyngeal fascia is adherent to prevertebral fascia posteriorly in the midline. Retropharyngeal lymph nodes are located between buccopharyngeal fascia and prevertebral fascia in paramedian (eccentric) position (not midline). Retropharyngeal space is situated between pharynx and posterior layer of deep fascia, extending from base of the skull to the level of tracheal bifurcation in the posterior mediastinum. Abscess in this plane can be acute or chronic **(Fig. 14-10)**.

Acute is seen in children; abscess lies on either side of the midline. It is due to bacterial infection like staphylococci or streptococci. It is drained under general anaesthesia (with intubation) through oral cavity.

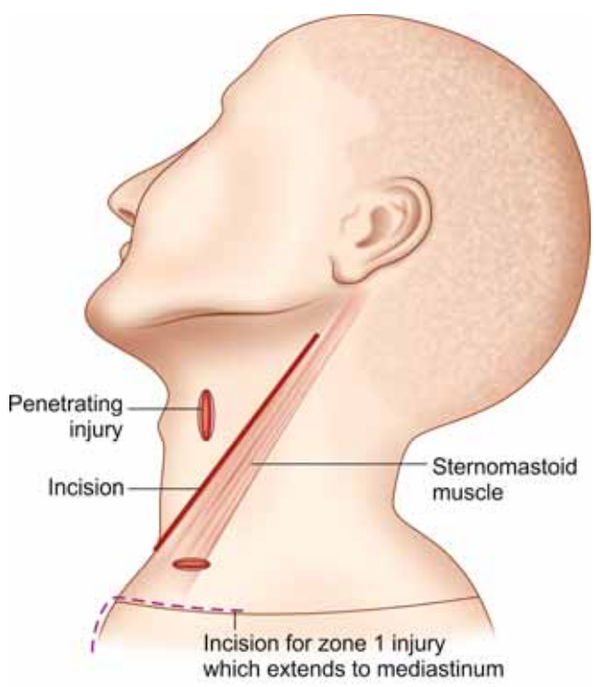


Fig. 14-9: Incisions used in head and neck trauma.

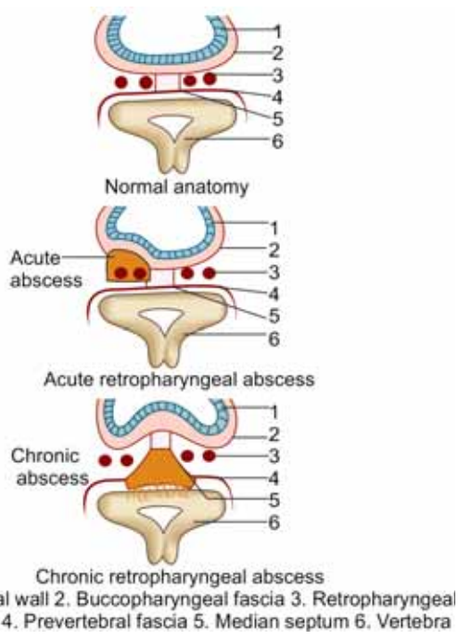


Fig. 14-10: Note acute and chronic retropharyngeal abscess. Normal anatomy is also shown. Acute is eccentric and is due to suppuration of retropharyngeal lymph nodes. Chronic is central, midline and is due to tuberculosis of the cervical vertebra.

Chronic retropharyngeal abscess is usually due to tuberculosis of the cervical spine which is in the midline; confirmed by CT scan; it is drained through neck incision under general anaesthesia. Horizontal incision is made 2 cm below the angle of the jaw. Sternomastoid muscle is separated from tail of the parotid and is retracted behind. Carotid sheath is identified and retracted behind. Superior constrictor is identified; finger is passed behind the muscle to reach retropharyngeal space; pus is drained and collected for culture and AFB staining. Antituberculous drugs are started.

PARAPHARYNGEAL ABSCESS

Parapharyngeal space is cone-shaped space with its base at base of skull and apex at greater cornu of hyoid bone. Medial wall is formed by superior constrictor; lateral wall by lateral pterygoid, angle of mandible and parotid gland; posteriorly by carotid sheath, below by submandibular salivary gland. Abscess in this region usually is spread from tonsils, infected lower 3rd molar tooth. Thrombosis of internal jugular vein, erosion of ICA and bleeding, and septicemia are the possible complications **(Fig. 14-11)**.

It is drained under general anaesthesia with neck extended and turned to opposite side. Horizontal incision is made over the anterior margin of the sternomastoid muscle 2 cm below the jaw. After retracting the muscle behind, deep fascia is opened to reach the abscess cavity. All loculi are broken using finger. After thorough warm saline irrigation drain is placed and dressing is done. Wound is not closed usually but allowed to heal spontaneously. Often secondary suturing may be required. Causative pathology should be addressed.

TREATMENT OF LUDWIG'S ANGINA

It is an inflammatory oedema of submandibular region and floor of the mouth causing diffuse swelling and brawny oedema of the submandibular region usually due to dental or oral infection. It presents with toxicity, trismus, brawny swelling in upper neck, dysphagia and dyspnoea, putrid halitosis and fever.

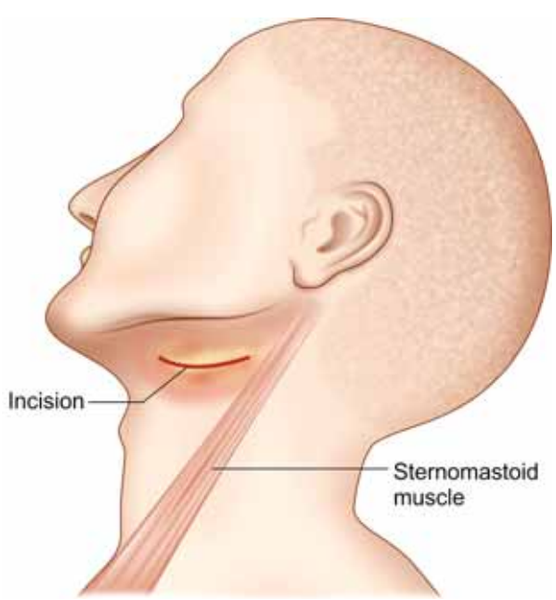


Fig. 14-11: Drainage of parapharyngeal abscess through neck incision.

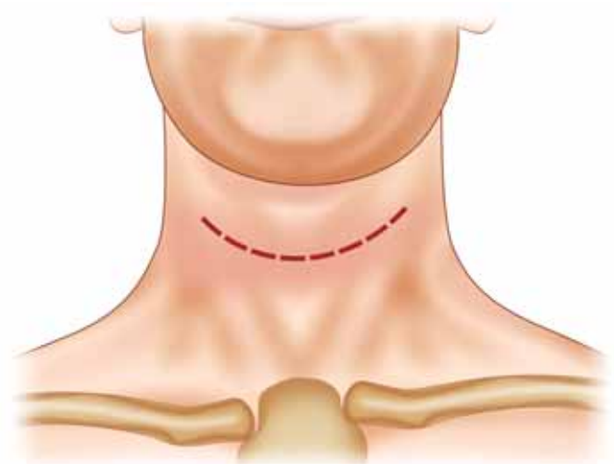


Fig. 14-12: Incision for Ludwig's angina drainage.

It should be drained by making a *transverse skin incision* in submental region; incision is deepened through deep fascia and mylohyoid muscle is cut *vertically*. Wound is left open and delayed suturing is done. Often it is difficult to intubate the patient for anaesthesia due to trismus, and tracheostomy may be needed **(Fig. 14-12)**.

TREATMENT OF TUBERCULOUS LYMPHADENITIS AND COLD ABSCESS IN THE NECK

In cold abscess, initial *aspiration* is done through a wide bore needle in a nondependent site using 'Z'/zigzag track (to prevent sinus formation). If aspiration is not effective then *drainage* is done through a nondependent incision; all caseating material is removed; wound is closed without a drain. *Surgical removal of tuberculous lymphadenitis* is indicated whenever patient is not responding to drugs and in persistence of sinus. It is done by elevating skin flaps and removing all diseased lymph nodes. Due to chronic inflammation adhesions are common. Injury to IJV, nerves can occur. In a *chronic long standing tuberculous sinus*, treatment is surgical excision of the entire track through an elliptical incision. It is done under general anaesthesia **(Figs 14-13 and 14-14)**.

Fig. 14-13: Tuberculous cold abscess and its aspiration.

Fig. 14-14: Excision of tuberculous sinus in the neck.

EXCISION OF THE BRANCHIAL CYST AND FISTULA

Branchial Cyst

It is due to remnants of second branchial cleft. Cholesterol crystals are typical. Branchial cyst is situated in the anterior border of the upper third of the sternomastoid muscle. It is seen in adolescent period **(Figs 14-15 and 14-16)**.

Excision of cyst is done under general anaesthesia. Neck is slightly extended and head turned towards opposite side. After cleaning and draping, horizontal incision is made 2 cm below the mandible; deepened across skin and platysma without elevating the flap to avoid injury to marginal mandibular nerve. Adjacent to anterior margin of the sternomastoid muscle deep fascia is incised carefully to reach the cyst. Cyst is dissected gently and carefully. Often extension of the track between ICA and ECA towards tonsillar fossa will be found which should be dissected carefully using fine scissor and bipolar cautery. Such extended track should be entirely removed. Incomplete removal will lead into fistula formation **(Fig. 14-17)**.

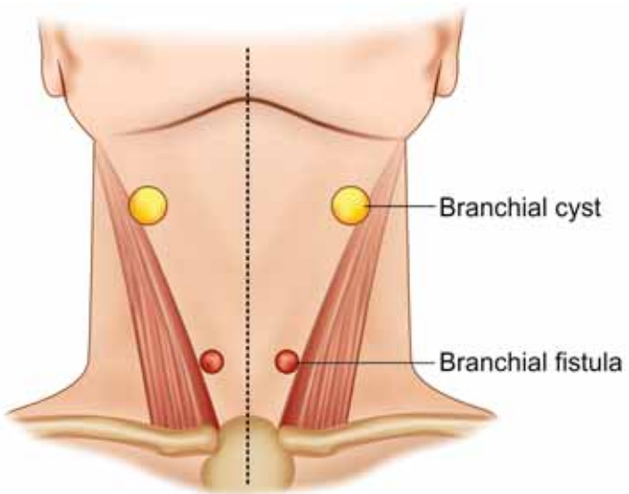


Fig. 14-15: Anatomical location of branchial cyst and fistula.

Fig. 14-16: Branchial cyst.

Branchial Fistula

It is usually congenital; its external opening is adjacent to lower third of anterior border of the sternocleidomastoid muscle. Its internal orifice is near posterior pillar of the tonsil. Fistulogram / CT fistulogram and discharge study are the needed investigations. Often it is bilateral **(Fig. 14-18)**.

Stepladder excision - It is excised under general anaesthesia. Position is similar to branchial cyst. An elliptical horizontal incision is placed in the lower neck which includes the external orifice of the fistula. Often methylene blue dye is injected through the external orifice to identify the track during dissection. Track is dissected carefully upwards. Another horizontal incision is made 2 cm below the lower margin of the mandible. Further dissection of the track is done through upper incision. Entire track is dissected up to internal opening at posterior pillar of the tonsil. During dissection, carotids, IJV, hypoglossal, accessory and glossopharyngeal nerves should be taken care of. After excision of the track skin incisions are sutured. Often suction drain may be used. Bilateral fistula can be operated in the same sitting.

Complications are bleeding, incomplete excision of the track injury to nerves **(Figs 14-19 and 14-20)**.

PHARYNGEAL POUCH

Progressive symptoms, respiratory distress and dysphagia are definitive indications for surgery **(Fig. 14-21)**.

Procedure

Under general anaesthesia endoscope is passed to identify the opening of the pouch. Pouch is packed with acriflavine soaked gauze for identification. Nasogastric tube is passed into the oesophagus under visualisation. Pouch is approached through neck incision for proper removal. As pouch is usually left sided, left sided lower third horizontal incision is made. Gauze filled pouch sac is felt which is dissected with sharp and finger dissection. Opening of the pouch is located usually behind/on posterior aspect of the oesophagus. Entire pouch is dissected to visualise fundus, neck and junction. Neck is partially opened to identify the nasogastric tube. Traction over the pouch sac stretches the cricopharyngeus. Vertical posterior midline 4 cm myotomy is done to this muscle. Both recurrent laryngeal nerves which are on lateral walls are safeguarded. Sac/pouch at the neck are divided and pouch is removed. Defect in the posterior oesophagus is closed using 2 zero vicryl or silk interrupted sutures. Wound is closed with a drain.

In *Dohlman's operation* pharyngeal pouch is excised endoscopically.

Postoperatively nasogastric tube left in place for 7–10 days. Nasogastric feeding can be started early. Drain is removed in 5–7 days.

Problems and Complications

Often there will be dense adhesions between pouch wall and adjacent structures due to recurrent infection and inflammation which makes dissection difficult. Injury to surrounding structures can occur.

Infection, mediastinitis, pneumonia, lung abscess can occur as often fundus of the pouch may be in the mediastinum. Abscess neck itself can occur postoperatively. Pharyngeal fistula may develop whenever there is sepsis and dense adhesions. Stenosis of oesophagus leading into recurrence is known to occur.

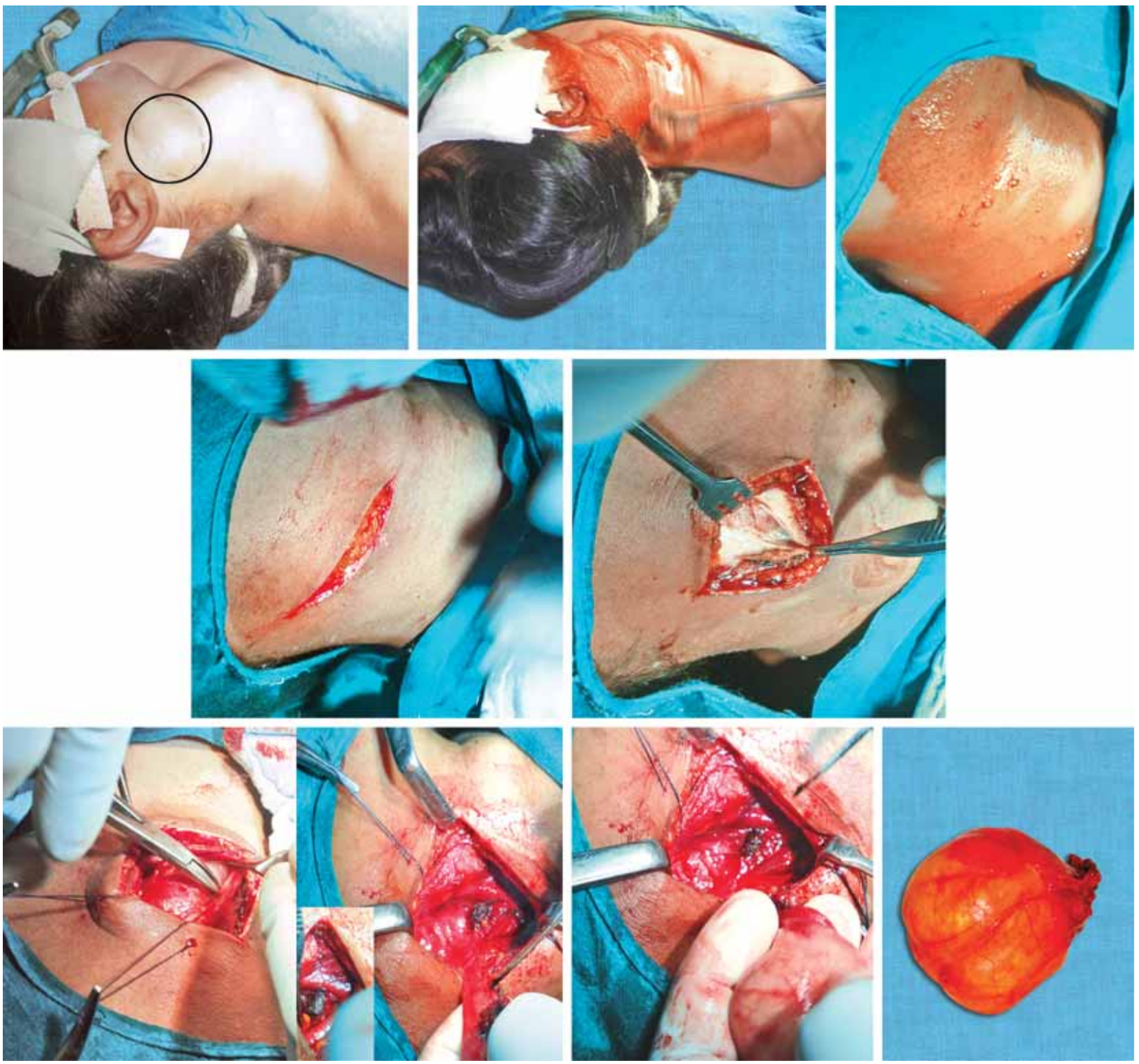


Fig. 14-17: Excision of branchial cyst.

SURGICAL TREATMENT OF CYSTIC HYGROMA

Excision is done under general anaesthesia with extended neck, head turned towards opposite side. Transverse skin incision in the supraclavicular region of adequate length is made. Subplatysmal plane is reached. Circumferential meticulous dissection with slow gradual mobilisation of cyst is done. Cyst does not occupy the natural planes; but encroaches vital neurovascular structures. Often it extends into mediastinum also. After complete excision, drain is placed, antibiotics are given. Higher lesion may extend to parotid region often causing risk of facial nerve injury. In spite of proper dissection there is high recurrence rate (20–30%) due to incomplete excision, inability to identify the entire lesion during excision. Aspiration of the cyst and injecting sclerosant OK – 432 (*picibanil*) will cause pronounced inflammation and fibrosis which facilitates complete excision at a later period.

Staged surgery / repeated surgery / adding superficial parotidectomy are additional things needed to achieve complete cure.

Fig. 14-18: Branchial fistula – photo and diagram.

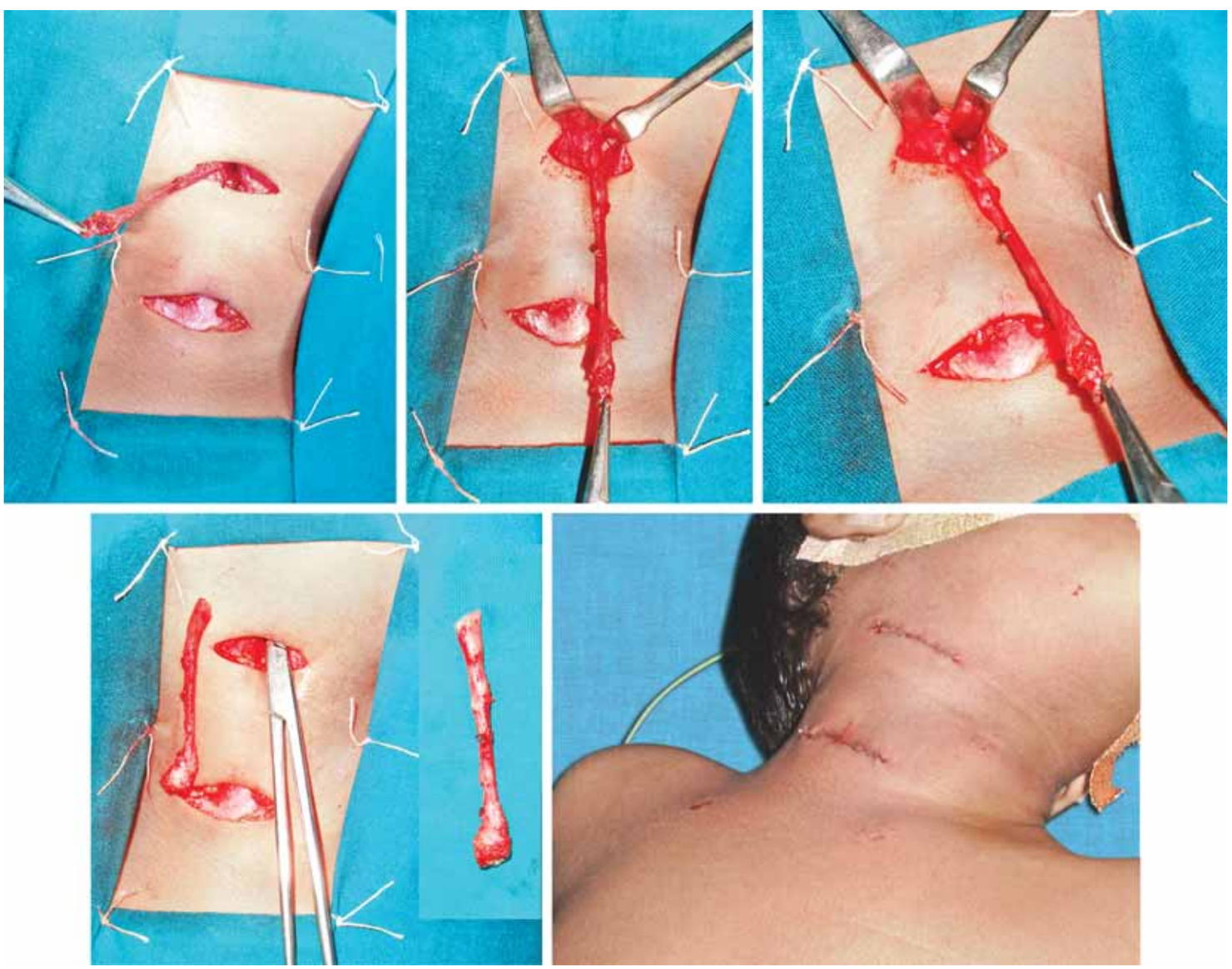
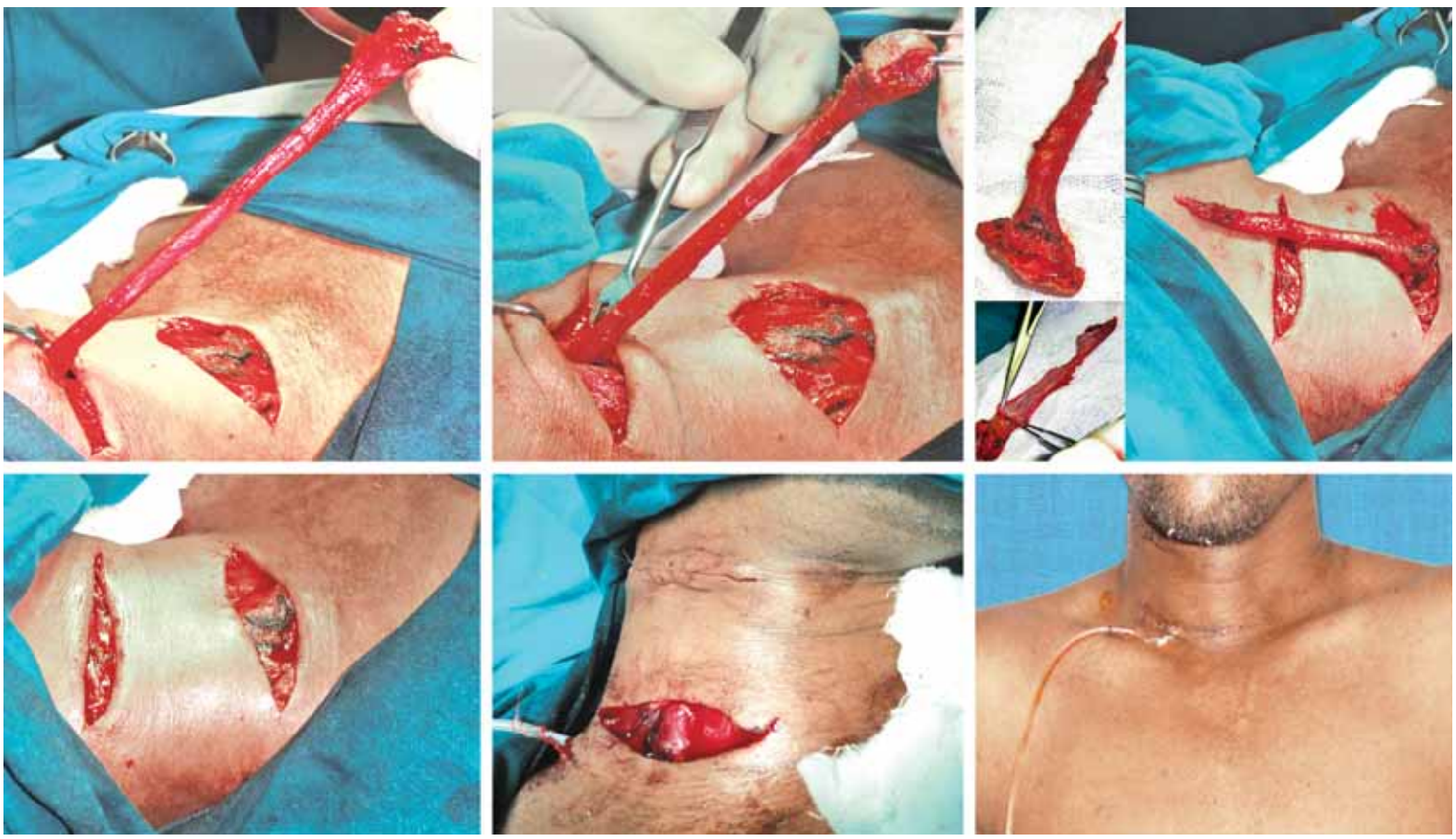


Fig. 14-19: Branchial fistula surgery in a child/boy.

Figs 14-20(1)



Figs 14-20(2)

Figs 14-20(1 and 2): Branchial fistula surgery in an adult.

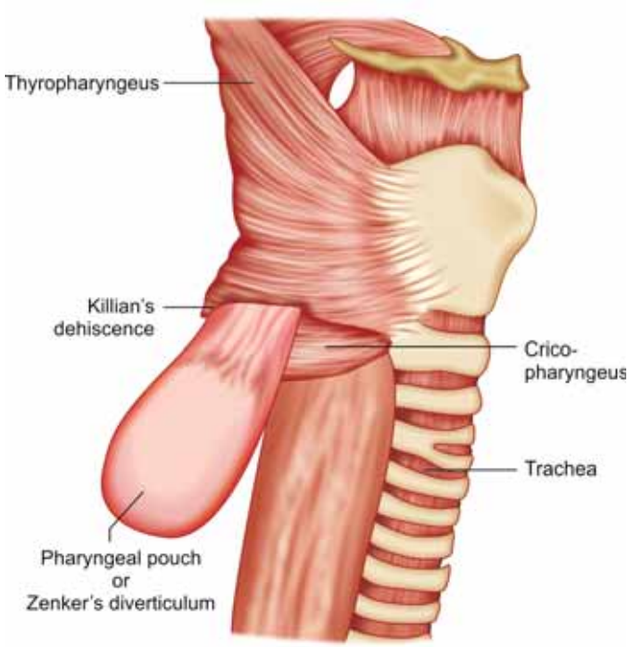


Fig. 14-21: Anatomy of pharyngeal pouch.

TONGUE TIE

It is short, thick fibrous frenum linguae. Tip and lateral margins of the tongue during protrusion will be everted with dorsal mid part heaping. It causes difficulty in speech and cleaning the inner part of the lower teeth. It is treated surgically either under local or general (in child) anaesthesia. Stay suture is placed at the tip of tongue to lift it upwards. Fibrous frenum is divided using fine scissor. Linear wound is either left alone or closed longitudinally using fine 4 zero catgut continuous sutures from the tip of the wound towards the margin of the floor of the mouth **(Fig. 14-22)**.

SURGICAL MANAGEMENT OF CERVICAL RIB (THORACIC OUTLET SYNDROME/TOS)

It is done in case of thoracic outlet syndrome (TOS) which is due to cervical rib. Rib compresses the neurovascular bundle causing neurological and vascular manifestations. Arterial TOS is mainly caused by cervical rib or rudimentary first rib. Venous TOS is due to costoclavicular ligament and subclavius muscle compressing subclavian vein. Neurogenic TOS is caused by congenital anatomical factors like cervical rib, long C_7 transverse process, anomalous first rib, anomalous insertion of scalene muscles, split scalenus anterior,

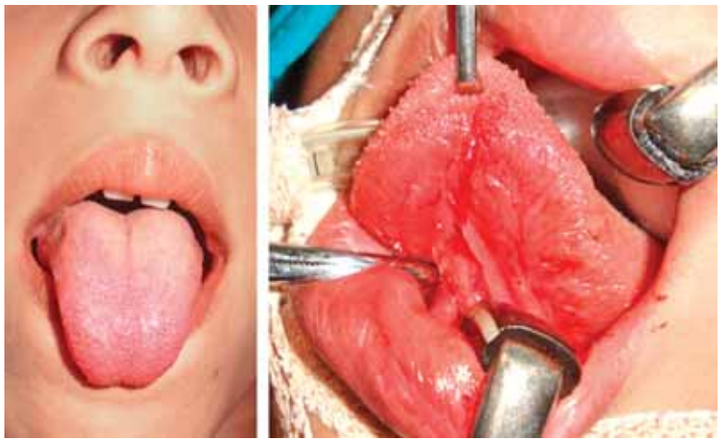


Fig. 14-22: Tongue tie and its release.

scalenus muscle hypertrophy, presence of scalenus intimus muscle (is seen 55% of individuals), abnormal bands and ligaments, brachial plexus anomalies, sagging shoulder; neck trauma (clavicle, callus, first rib, scalene muscles, old scars); soft tissue tumours.

Surgical Anatomy

Scalene triangle is between scalenus anterior, medius and first rib contains brachial plexus and subclavian artery. *Costoclavicular space* contains artery, vein and nerve **(Fig. 14-23)**.

Evaluation

TOS is evaluated by X-ray neck and chest along with X-ray cervical spine; Doppler study, nerve conduction studies, electromyography, CT angiogram, CT neck. Normal nerve conduction velocity is 85 m/second.

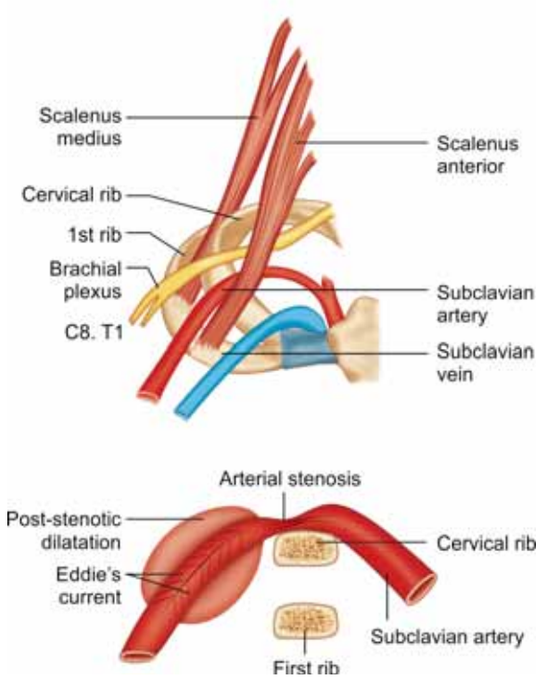


Fig. 14-23: Surgical anatomy of cervical rib.

Conservative Treatment

Initially it is managed conservatively with exercises like—neck stretching, breathing and postural exercises, analgesics, muscle relaxants, antidepressants. Conservative approach is used if nerve conduction velocity is more than 60 m/second.

Surgery

Surgical intervention is required when symptom persists and vascular features are severe with ischaemia of the fingers. Removal of cervical rib and middle portion of first rib with scalenotomy relieves the symptoms. If nerve conduction velocity is less than 60 m/second surgery is indicated.

Approaches

Transaxillary, supraclavicular; combined; supraclavicular and infraclavicular for arterial reconstruction; posterior high thoracoplasty approach for recurrent TOS.

Transaxillary Approach

Roos (1966) popularised this approach. It is mainly used to excise the first rib. Release of lower brachial plexus and vascular compression is done better through this approach. After giving general anaesthesia patient is positioned laterally with arm abducted. Transverse skin incision is made on the 3rd rib level. Axillary tunnel is developed by blunt dissection to reach the first rib and scalenus anterior **(Fig. 14-24)**.

Intercostobrachial nerve is cut. Subclavian vessels and brachial plexus are safeguarded. Vessels are separated by gentle dissection to expose the insertion of the scalenus anterior. Muscle is divided at its attachment. 1–2 cm length of the muscle should be excised to prevent development of fibrosis and recurrence of symptoms. Scalenus medius and intercostal muscles are pushed off the first rib. Subclavius muscle tendon can also be released. C_8 and T_1 nerve roots are identified before dividing posterior part of the first rib behind these nerves. Neurolysis of C_7, C_8 and T_1 is done with fine specialised instruments. Often resection of the costoclavicular ligament is needed.

Supraclavicular Approach

It is used for excision of cervical rib or upper brachial plexus decompression wherein extensive scalenotomy is needed or if there

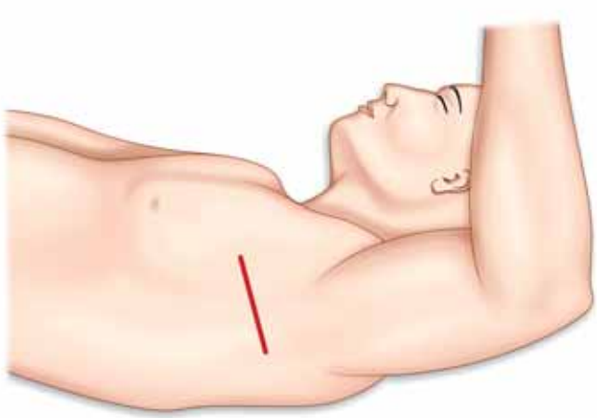


Fig. 14-24: Incision for cervical rib excision through transaxillary approach.

is a need of arterial (subclavian) reconstruction. It is done under general anaesthesia. Patient is positioned supine with head end of the table elevated by 15º to reduce venous congestion and head is tilted to opposite side; arms are placed on the sides of the patient. Incision is placed a fingerbreadth (1.5 cm) above the clavicle from anterior border of the sternocleidomastoid muscle extending laterally for 7-8 cm. It is usual but not mandatory practice to pull/drag the skin downwards below the clavicle and make incision on the clavicle from medial to lateral; and when pulled skin is released after making incision, incision will be in supraclavicular area. It is said to prevent inadvertent injury to deeper structures. Incision is deepened; Platysma is incised **(Fig. 14-25)**.

External jugular vein is divided with ligatures. Supraclavicular nerves are retained. Exposed sternocleidomastoid muscle is identified for its full width. The clavicular head is divided using scissor/cautery/ or by piecemeal using fine forceps (used in olden days). IJV behind the muscle should not be injured. Scalene pad of fat is dissected. Inferior belly of omohyoid muscle is divided. IJV is mobilised and retracted medially. Bipolar cautery dissection is done in front of the scalene muscle. Phrenic nerve is identified in front of the scalenus anterior muscle deep to deep fascia running vertically downwards from lateral to medial side. Phrenic nerve is retracted medially (should not be retracted laterally as it may cause traction injury to upper trunk of brachial plexus). Dissected scalenus anterior muscle is cut layer by layer carefully using scissor/by piecemeal method to protect subclavian artery underneath. Medial part of the brachial plexus is dissected carefully. Subclavian artery is dissected on its summit and pushed downwards. Scalenus medius is also excised. Cervical (accessory) rib is cleared of scalenus medius with its tendinous attachments to it and first rib. T_1 nerve root is identified carefully to avoid injury. Cervical rib is divided posteriorly in level with its transverse process. Central portion of the 1st rib is also excised. Wound is closed with a suction drain **(Fig. 14-26)**.

Posterior High Thoracoplasty

Vertical high paraspinal incision is made at the level of C_7 to T_4 between medial margin of the scapula and spinous process. Through muscle splitting approach, accessory (cervical) rib and first ribs are identified and resected. Neurolysis of C_7, C_8 and T_1 is done. If needed posterior dorsal sympathectomy is also added **(Fig. 14-27)**.

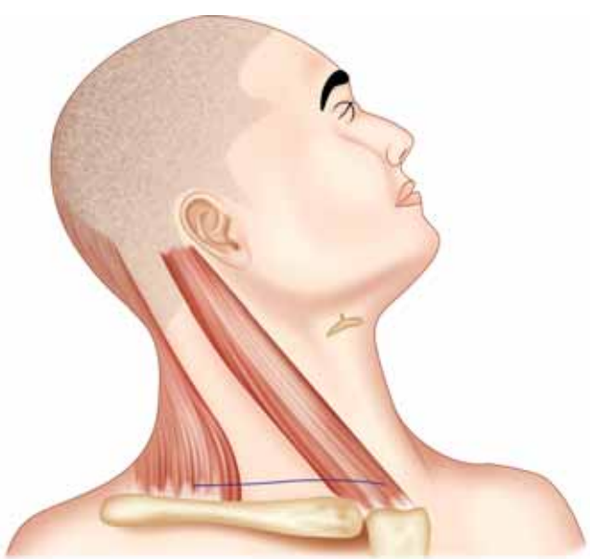


Fig. 14-25: Incision for cervical rib excision through supraclavicular approach.

Complications

- Haemorrhage—due to venous or arterial injury.
- Pain in the wound mainly in transaxillary approach.
- Pleural injury if occurs, ICT should be placed.
- Injury to nerve roots brachial plexus.
- Fibrosis can cause recurrence of symptoms.

CAROTID BODY TUMOUR

It was first described by *Von Haller* in 1743. *Riegner* in 1880 described the first surgical removal of carotid body tumor. Carotid body is *3–5 mm* in diameter size, reddish brown or tan coloured body found in the adventitia of the common carotid artery at its posteromedial wall at bifurcation with a feeding vessel through *Meyer's ligament*. Its size may be larger in individuals in high altitude. It gets its afferent nerve supply from glossopharyngeal nerve. Cells – *Type I – chief cells* store and release catecholamines; *Type II – sustentacular cells*. Carotid body has got autonomic control over cardiovascular and respiratory systems. Hypoxia, hypercapnia, low pH stimulates chief cells to begin autonomic reflex. It gets stimulated also by raise in body temperature, cyanide and nicotine.

Carotid body tumour is usually 4-6 cm in size, behind the bifurcation of the CCA splaying it and extending along the ICA as it enlarges towards skull base. Its incidence is < 0.5% of all neoplasms. It is common in females and in high altitudes. *Presentations* are—neck mass (75%) which shows *transmitted pulsation* and headache, neck pain, dizziness, tinnitus, hoarseness, dysphagia, syncope. It moves sideward but not longitudinally. Thrill and bruit (25%) may be present. Aneurysmal dilatation of the carotids is *not common*. 90% of them are benign; 10% malignant type, spreads to regional nodes, lungs, liver, kidneys, pancreas, thyroid, heart. *Shamblin classification*—Type I – Localised, resectable easily (25%); Type II – Adherent, resectable with difficulty (45%); Type III – Adherent and surrounds the carotids, difficult resection and needs bypass during procedure and carotid to ICA interposition vein graft. It is diagnosed by angiogram which shows widening of the carotid bifurcation with tumour blush—*Lyre sign*. CT/ MR angiogram is useful. FNAC/biopsy are contraindicated **(Fig. 14-28)**.

Surgical Treatment

Excision is done under general anaesthesia. *Nasotracheal intubation* is ideal to facilitate better retraction beneath the mandible. Often CCA with bifurcation and carotid body tumour area is divided into 3 zones – lower, at the level of CCA bifurcation as zone I; upper front, towards ECA as zone II; upper behind towards ICA as zone III. Vagus, hypoglossal nerve, sympathetic chain will be very close during dissection and should be taken care of.

Whenever high exposure of the carotid is needed, ipsilateral mandible should be subluxated. Thigh and leg should be prepared for harvesting long saphenous vein if interposition vein graft is needed. Carotid shunts should be kept ready if temporary bypass is needed. ECA is usually ligated above the origin of the superior thyroid artery.

In small tumour less than 4 cm, incision is along the anterior margin of the sternocleidomastoid muscle; in large tumour 'T' incision is preferred to have adequate exposure **(Figs 14-29 and 14-30)**.

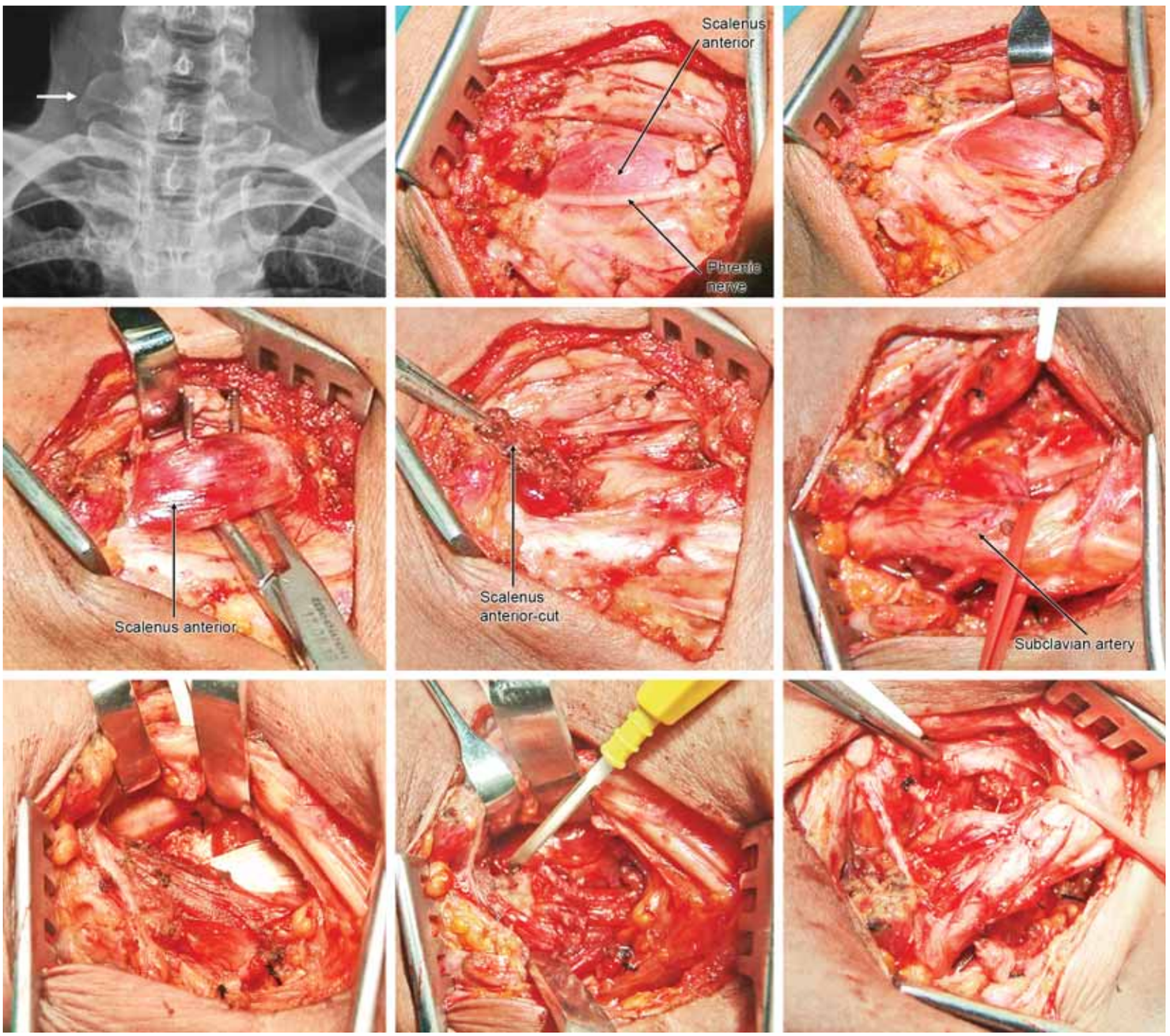


Fig. 14-26: Cervical rib excision through supraclavicular approach.

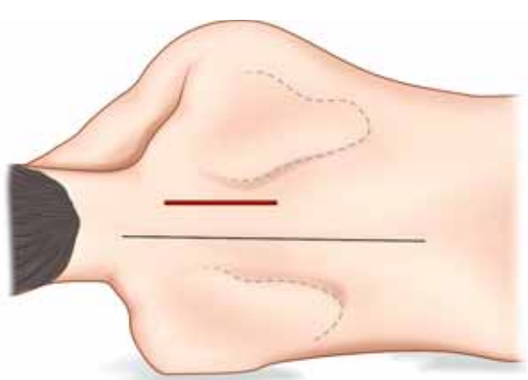


Fig. 14-27: Incision for cervical rib excision through posterior high thoracoplasty approach.

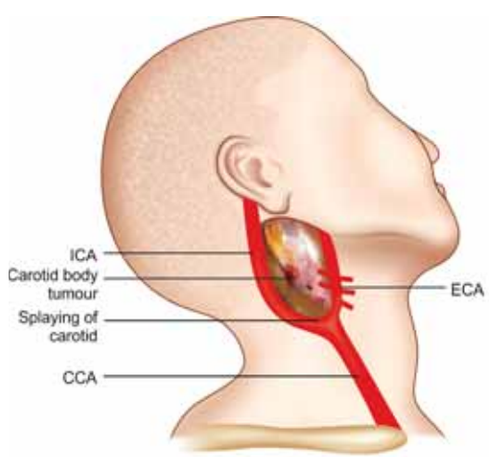


Fig. 14-28: Location of the carotid body tumour.

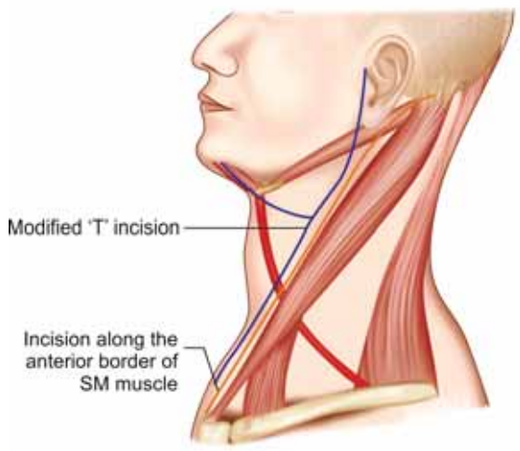


Fig. 14-29: Incision for excision of carotid body tumour.

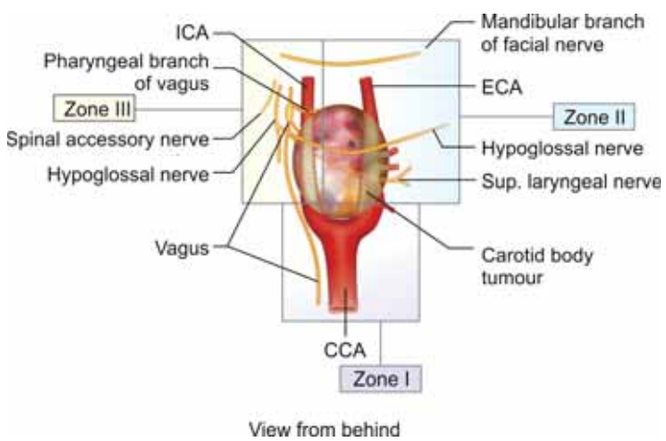


Fig. 14-30: Relations of carotid body tumour.

CCA, ECA, ICA with tumour is dissected and isolated carefully and meticulously with proper haemostasis. Bipolar cautery should be used. Loops/slings are passed around CCA proximally and ECA and ICA distally. Hypoglossal nerve is identified and separated and held using a fine sling gently. *Subadventitial plane* is created to dissect the tumour carefully from the carotid bifurcation from below upwards. All vessels entering the tumour should be individually secured and ligated. Vagus is identified at this stage which is dissected and isolated and held with a sling. ICA should be preserved with care. If injured, it should be repaired. In case of tumour encasement, temporary shunt from CCA below to ICA above is achieved to maintain the cerebral perfusion. Segment of the bifurcation with ICA and ECA with tumour is removed en mass. ECA is doubly ligated using silk above. Great saphenous vein is harvested from the thigh and is interposed as vein graft between CCA below and ICA above.

Complications

- Injury to vagus and hypoglossal nerves – 40%.
- Vascular injuries.
- Stroke due to compromised cerebral perfusion (3%).

BIOPSY IN HEAD AND NECK DISEASES

Biopsy in head and neck diseases needs a comprehensive approach as many lesions are easily amenable but many are in deeper places and often not visible.

Lesions which are easily accessible are biopsied with open incision biopsy. Usually more than two biopsies from the edge are taken. Often biopsy site may require suturing using 3 zero vicryl to control bleeding. Cautery is avoided or used only when essential as much as possible (especially in suspected melanoma lesions) to prevent tissue getting desiccated. Suction should always be used during biopsy. Posterior lesions should be biopsied under general anaesthesia with endotracheal intubation.

Nasopharyngoscopy, laryngoscopy, oesophagoscopy are needed to take biopsy from these sites.

CT guided biopsy is done in base skull tumours or deep seated primaries.

Blind biopsy of different suspected areas in the fossa of Rosenmuller, pyriform fossa, lateral wall of pharynx is done in a clinically unknown primary but confirmed secondaries in neck by FNAC.

Maxillary tumour biopsy is done using Caldwell–Luc operation.

Secondaries in neck node are usually confirmed *not by* open biopsy but *by FNAC*. Fungating secondaries can be biopsied by open method **(Fig. 14-31)**.

CERVICAL LYMPH NODE BIOPSY

Indications

Cervical lymph node biopsy is done mainly in patients with suspected lymphoma. Lymph node biopsy is done in patients where FNAC is inconclusive like in tuberculosis, rare lymph node diseases, and chronic inflammation. Staging, grading and histochemistry are needed in lymphoma and so biopsy is mandatory.

Lymph node secondaries are usually not an indication for open biopsy especially in squamous cell carcinoma. Diagnosis is usually done by FNAC. Open biopsy may aggravate the spread to further lymph nodes altering the prognosis and survival. Malignant supraclavicular

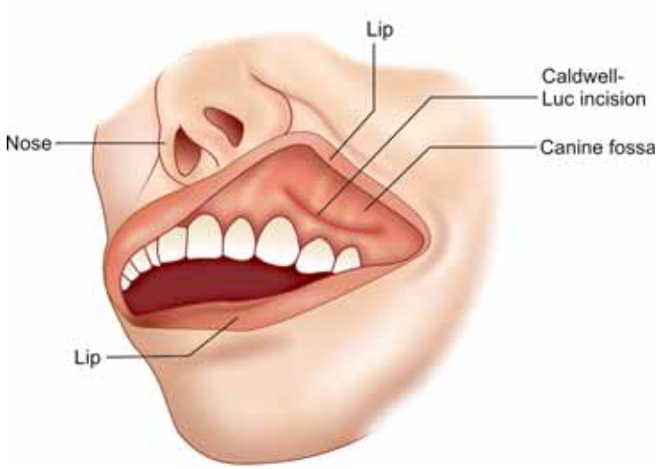


Fig. 14-31: Incision for Caldwell-Luc operation which is used for taking biopsy from maxillary tumour. Incision is not used for definitive therapy for carcinoma maxilla. Incision also used in benign conditions to approach maxillary sinus. Gingivobuccal mucosa is incised and mucoperiosteum is raised. Bone of canine fossa is cut to reach the maxillary antrum.

lymph nodes are considered as advanced with primary in breast/chest/abdomen. So excision biopsies of these lymph nodes are acceptable as it will not alter the prognosis.

Principles

All nodes in deep cervical and supraclavicular region should be biopsied under general anaesthesia. Biopsy of occipital and posterior triangle nodes can be done under local anaesthesia as these nodes are superficial and not much vital structures are present in this region. However accessory nerve is under risk in this location and should be taken care of while doing excision. Skin incision should be marked prior to injecting local anaesthesia, otherwise node may get masked making it difficult to identify it during surgery. Xylocaine 1% with adrenaline can be used **(Fig. 14-32)**.

Procedure

Position is supine with head turned towards opposite side. After cleaning and draping, an adequate transverse incision is made. Skin and platysma are incised. Sternomastoid is retracted. Deep fascia is incised. Lymph node is held gently using nontoothed forceps. Lymph node is dissected all around. Bipolar cautery may be used to control small bleeders. Earlier surgeons used to cut the node into half to take imprint cytology. Nowadays it is not done. Large adequate '*wedge excision*' of the lymph node is done if lymph node is large, if there are adhesions, if nodes are matted, if node is in close proximity to a vital structure. After removal haemostasis is maintained. Wound is closed in layers. Skin is closed using interrupted nonabsorbable or subcuticular absorbable sutures **(Fig. 14-33)**.

Complications

Haemorrhage and haematoma formation can occur which often needs reexploration and controlling of the bleeder. Injury to adjacent nerves can occur. Infection and sinus formation are other complications.

RADICAL NECK DISSECTION (RND)

It is removal of all neck nodes with fat, fascia, internal jugular vein, sternomastoid muscle, spinal accessory nerve, submandibular salivary gland and lower pole of parotid gland with dissection in front of the prevertebral fascia leaving behind structures deep to prevertebral fascia (brachial plexus, cervical nerves, prevertebral muscles); pretracheal fascia; carotid artery; vagus nerve and strap muscles. It is an important oncological clearance surgery in the neck. For operable mobile metastatic neck nodes neck dissection is ideal method. Radiotherapy is not a prime approach whatever the type of primary.

Principles

Primary should be treated independently by wide local surgical excision or curative radiotherapy depending on the site of the primary.

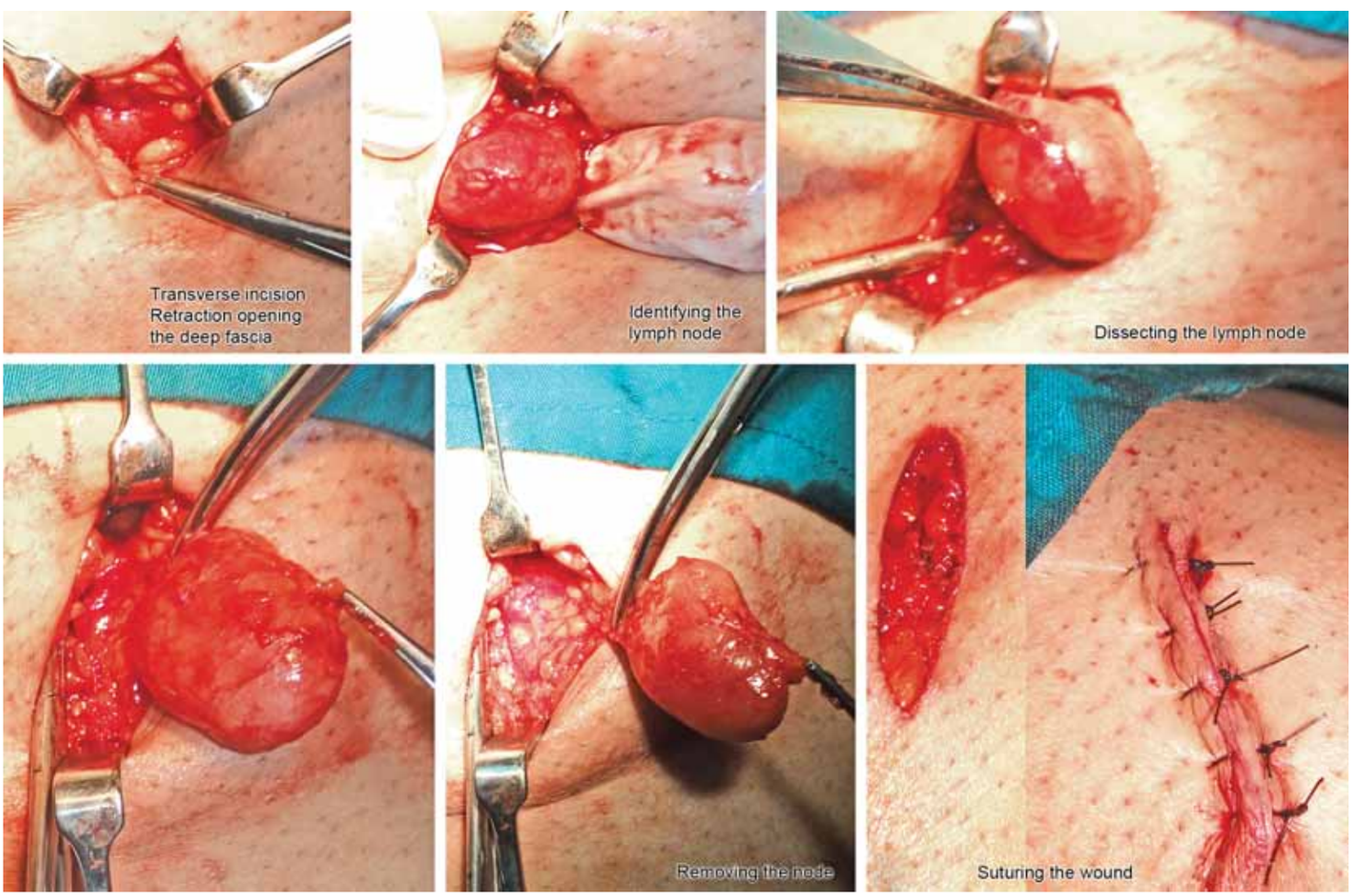


Fig. 14-32: Technique of lymph node biopsy.

Fig. 14-33: Neck lymph node biopsy. Spinal accessory nerve should be kept intact during nodal biopsy. Biopsy is done under general anaesthesia.

RND or MRND is the choice for all confirmed positive nodes in all oral malignancies.

Supraomohyoid neck dissection (SOHND) is done for oral squamous cell carcinoma with clinically negative nodes. On table frozen section biopsy is needed. If nodes become positive, then MRND I is carried out immediately.

Extended supraomohyoid neck dissection is done when primary is in lateral border of the tongue which also includes level IV, as lateral margin of tongue cancer can cause skip metastasis in the level IV lymph node.

Anterolateral neck dissection is done for laryngeal and pharyngeal cancers (in clinically node negative disease) with level II, III, IV dissection; if primary is in midline, it is done bilaterally.

Posterolateral neck dissection is done for primary cutaneous malignancies of the scalp (posterior aspect) like melanoma or SCC.

In thyroid malignancy, total thyroidectomy (MRND type III/ selective neck dissection) with bilateral and central node clearance is done.

Table 14-1: Nodal staging in secondaries in neck

Nodal stage in secondaries in neck nodes	*Involvement of nodes in different stages*
N_x	Assessment of regional nodes not possible
N_0	Regional nodes not involved by spread
N_1	Spread to single same side < 3 cm sized node
N_{2a}	Spread to single same side 3-6 cm sized node
N_{2b}	Spread to multiple same side nodes each < 6 cm in size
N_{2c}	Spread to bilateral/opposite side nodes each < 6 cm in size
N_3	Spread to any node with size > 6 cm

Indications

Secondaries in the neck which are mobile (not fixed); common site of primary in head and neck malignancies, thyroid malignancy, malignancy of skin in head and neck region, malignant parotid tumours, etc. Secondaries in the neck with occult primary is initially treated with radical neck dissection; regular follow up is done later, until primary gets revealed; and once primary reveals it is managed accordingly depending on location. Here one cannot wait for primary to reveal as by then metastatic nodes become advanced and inoperable resulting in poor prognosis.

Contraindications for Radical Neck Dissection

Fixity of metastatic nodes, distant spread and advanced uncontrollable primary disease are the contraindications **(Fig. 14-34)**.

Levels in Neck Nodes

(Memorial Sloan –Kettering Cancer Center leveling of neck nodes) **(Figs 14-35 to 14-37)**.

Structures removed in classical RND –
- All neck nodes
- Fat, fascia
- Internal jugular vein
- Sternomastoid muscle
- Spinal accessory nerve
- Submandibular salivary gland
- Lower pole of parotid gland.

Plane of dissection
- Anteriorly deep to platysma
- Posteriorly with dissection from the prevertebral fascia leaving behind prevertebral fascia and structures deep to it (brachial plexus, cervical nerves, prevertebral muscles), pretracheal fascia, carotid artery, vagus nerve, and strap muscles.

Table 14-2: Types of neck dissection

Type of neck dissection	*Nodes removed*	*Structures preserved*
Comprehensive –		
Radical neck dissection (RND)	Level I-V	None
MRND type I	Level I-V	Spinal accessory nerve
MRND type II	Level I-V	Spinal accessory nerve; sternomastoid muscle
MRND type III	Level I-V	Spinal accessory nerve; sternomastoid muscle; IJV
Bilateral RND	Level I-V (both sides)	
Selective node dissection –		
Supraomohyoid neck dissection (N_0)	Level I-III	Spinal accessory nerve; sternomastoid muscle; IJV
Extended supraomohyoid dissection (N_0)	Level I-IV	Spinal accessory nerve; sternomastoid muscle; IJV
Anterolateral neck dissection ($N_{0)}$	Level II-IV	Spinal accessory nerve; sternomastoid muscle; IJV
Posterolateral neck dissection (N_0)	Level II-V with suboccipital, retroauricular nodes	Spinal accessory nerve; sternomastoid muscle; IJV
Anterior/central dissection	Level VI	Spinal accessory nerve; sternomastoid muscle; IJV

Level I – Submandibular lymph nodes and submental lymph nodes – from lower border of mandible to hyoid bone and posterior belly of digastric muscle.

Level II - Lymph nodes in upper deep cervical region. (It extends from base of skull to hyoid bone and from lateral margin of sternohyoid muscle to posterior margin of sternomastoid muscle).

Level III - Lymph nodes in middle cervical region (from hyoid bone to cricothyroid membrane).

Level IV - Lymph nodes in lower cervical region (from cricothyroid membrane to clavicle).

Level V - Lymph nodes in posterior triangle including supraclavicular region.

Level VI - Lymph nodes in the midline neck—pretracheal and prelaryngeal – from hyoid bone above to suprasternal notch below; laterally medial border of carotid sheath on both sides.

Level VII - Lymph nodes in the mediastinum; from suprasternal notch to inferior mammary artery.

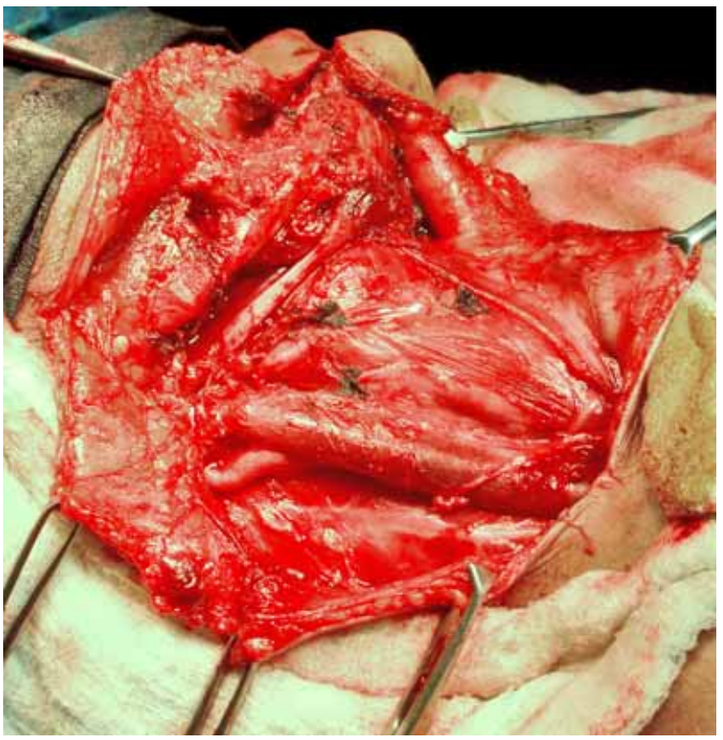


Fig. 14-34: Surgical field after completion of neck node dissection with preservation of the IJV. Carotid artery, digastric muscle, lower margin of the mandible is visualised.

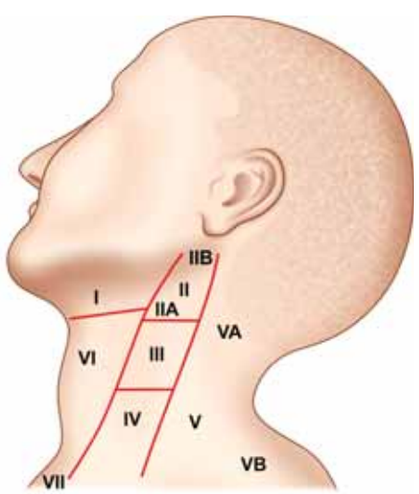


Fig. 14-35: Surgical (oncological) levels of neck lymph nodes.

Note: Level II and V are now subdivided into Level IIa / Level IIb and Level Va / Level Vb; depending whether these nodes are above the level (Level IIb / Level Va) of the spinal accessory nerve or below (Level IIa / Level Vb).

Preparation

General assessment like anemia and nutritional status is done. Cardiac and respiratory assessment; improvement of intraoral hygiene by mouth wash using povidone iodine or hydrogen peroxide is done. When primary is in larynx/pharynx, tracheostomy may be needed. It is done usually on table just prior to surgery. Shaving of the chest,

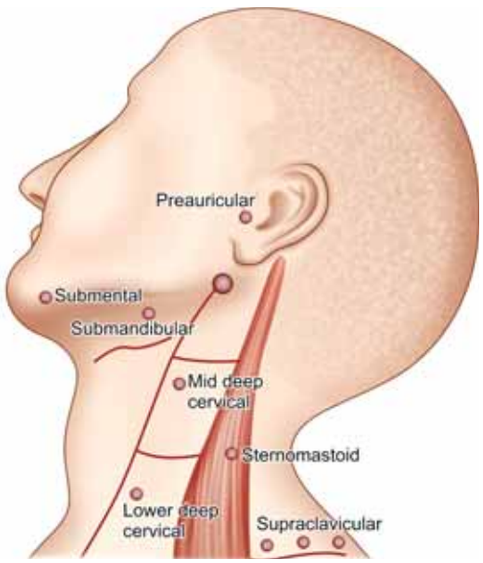


Fig. 14-36: Different lymph nodes in the neck.

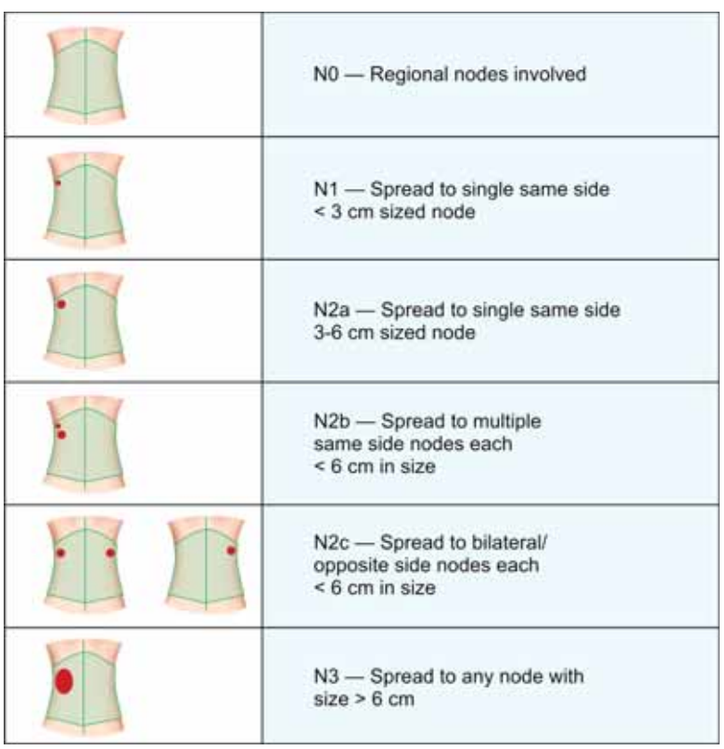


Fig. 14-37: Staging of neck lymph nodes in secondaries.

neck and face is done on the day of surgery. If there is need for reconstruction of the wide area of excision of the primary area like cheek, it also should be planned and area should be prepared.

Anaesthesia

General anaesthesia is used with endotracheal intubation. Tracheostomy may be needed depending on the site of primary which is being operated. Some prefer hypotensive anaesthesia. But even though surgical field is clean, postoperative bleeding and haematoma due to eventual bleeding from small vessels, which was not cauterised at the time of surgery, is known to occur.

Position of the Patient

Patient is placed in supine position with hyperextended neck turned to opposite side with sandbags under the shoulder. Head end is elevated to 15° to reduce venous bleeding during surgery. Hands are tucked under the buttock. There should be adequate space near head end to allow assistants and scrub nurse to work on. Anaesthetist and Boyle's apparatus should be on opposite side of the dissecting area.

Incision

Many incisions are used. Modified triradiate incision is commonly used. Mac Fee incision is also used. Selection of incision is of individual surgeon's choice. Centre of the lateral aspect of the neck is the least vascular area for skin flap. One should avoid making incision in this part of the skin **(Figs 14-38 and 14-39)**.

Technique

Flaps are elevated (*subplatysmal*). Posterior flap, anterior, upper and lower flaps are elevated in subplatysmal plane. Flaps are raised

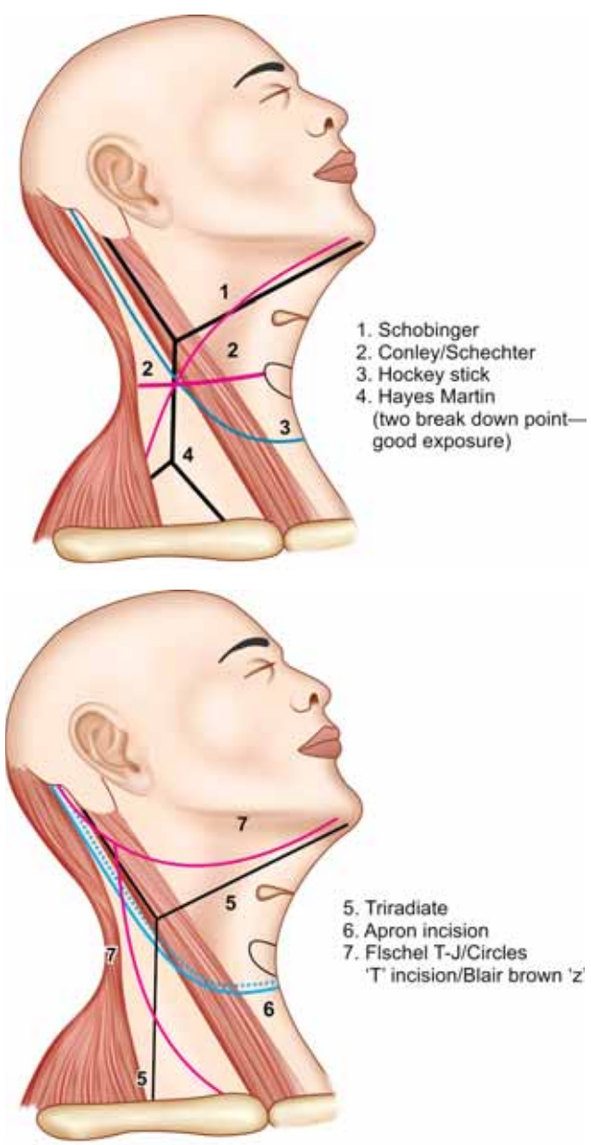


Fig. 14-38: Different incisions used in radical neck dissection.

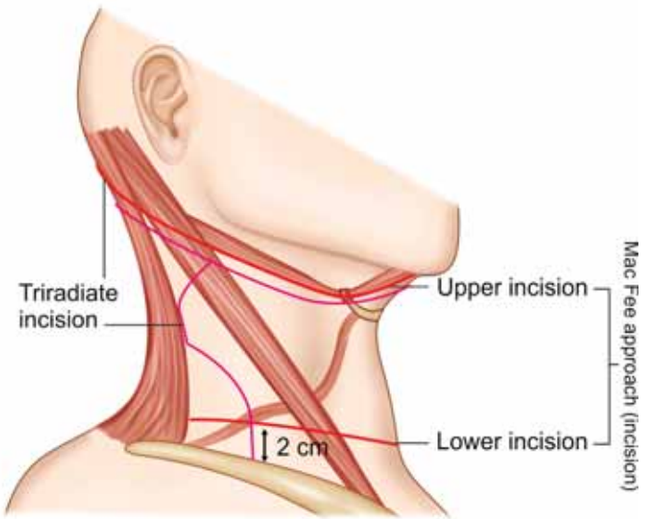


Fig. 14-39: Mac Fee and trifurcate incisions used for radical neck dissection.

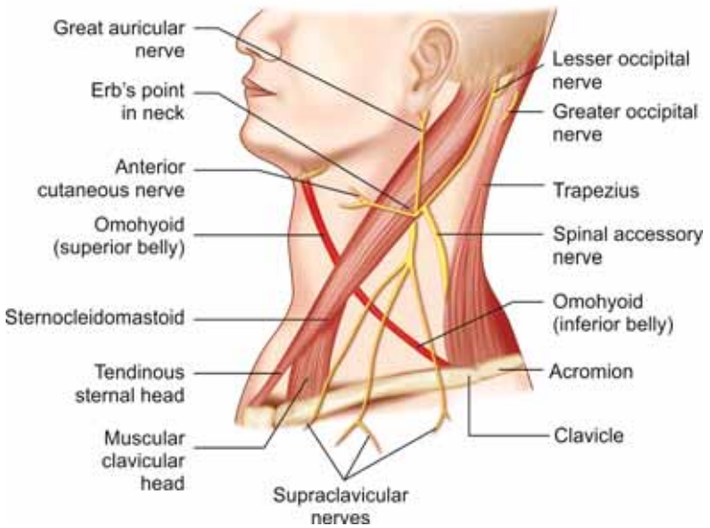


Fig. 14-41: Nerves in relation to posterior triangle which come across during neck dissection.

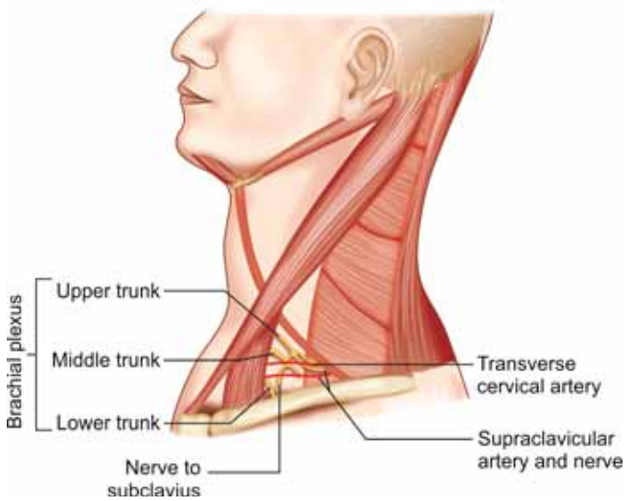


Fig. 14-40: Structures in supraclavicular triangle.

by holding skin hooks. Fine scissor/cautery are used. Trapezius is exposed fully on posteriorl aspect. While elevating superior flap care should be taken not to injure the marginal mandibular nerve which lies parallel to lower border of the mandible. This nerve crosses the anterior facial vein and vein is ligated. Inferior flap is elevated up to the clavicle. All elevated flaps are retracted or sutured to the drape margin temporarily **(Fig. 14-40)**.

Sternocleidomastoid muscle is cut at its attachments to clavicle (muscular) and sternum (tendinous). Care should be taken not to injure the IJV in the deeper plane. Layer by layer cutting of the muscle is usually practiced. External jugular vein and supraclavicular nerves are divided. Anterior border of the trapezius muscle is dissected to identify the spinal accessory nerve at its lower end. Nerve is traced by careful dissection above towards posterior border of the sternomastoid muscle which is 1 cm above the *Erb's point* or 5 cm below the inferior lobule of the ear. *Erb's point* is located 6 cm below the ear lobule where cutaneous branches (lesser occipital, great auricular, anterior cutaneous and supraclavicular little below) of cervical plexus comes out from posterior border of the sternomastoid muscle. Nerve is dissected upwards through the sternomastoid muscle by cutting the muscle fibres, along the lateral margin of the IJV, behind the posterior belly of the digastric muscle up to a point where it comes out of the skull to skull base through jugular foramen **(Fig. 14-41)**.

Upper attachment of the sternomastoid from mastoid process is detached. It is cut at a line extending from tip of mastoid to angle of jaw. Facial nerve may be existing at higher level in deeper plane. Fibrofatty tissue is dissected off from lateral to medial from splenius capitis, levator scapulae which is passed under the spinal accessory nerve; then dissected off from posterior scalene muscle. Inferior belly of omohyoid muscle is cut from its attachment to upper border of the scapula. Transverse cervical vessels are ligated and divided. Tissues are reflected off from middle and anterior scalene muscles to expose brachial plexus between these two muscles. Phrenic nerve is seen running lateral to medial from above downwards on the anterior surface of the scalenus anterior muscle. Cutaneous cervical nerves are cut adjacent to sternomastoid muscle.

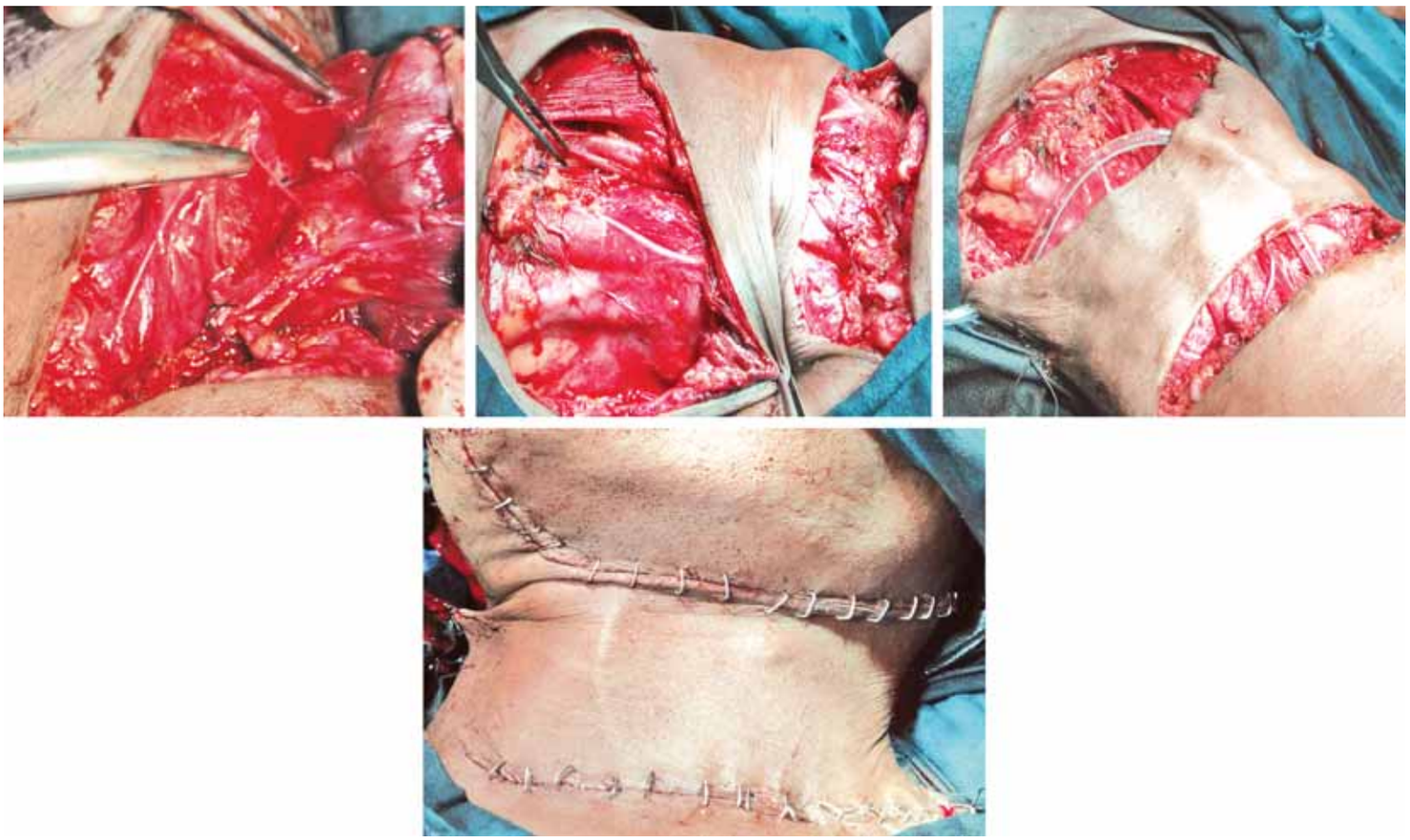
Sternomastoid muscle is dissected off in upward direction to reach carotid sheath. Lateral border of strap muscles are retracted medially to expose carotid sheath from medial side. Carotid sheath is opened to expose CCA, IJV and vagus nerve. IJV is clamped and divided. Ends are doubly ligated with transfixation using 2 zero silk or vicryl. Lymphatics lateral to IJV are ligated using silk and divided. Transverse cervical vessels at its proximal part are also ligated. On left side thoracic duct if encountered is ligated safely to prevent chyle leak.

Fat, fascia, lymphatics with nodes, sternomastoid muscle, ligated IJV are dissected upwards from the carotid and vagus. Middle thyroid vein is identified, ligated and divided. Superior belly of omohyoid is identified, detached from hyoid bone. Superior thyroid vessels are dissected; only superior thyroid vein is ligated retaining the artery **(Fig. 14-42)**.

Upper flap is further elevated deeper to submandibular fascia (fascia in front of submandibular salivary gland) and posterior facial vein. Vein is ligated and retracted along with flap above. Flap is elevated along the lower border of the mandible. Fascia along the margin and angle is cleared. Facial lymph nodes are dissected. Facial artery and facial vein are ligated (at posterosuperior part of submandibular salivary gland). Anterior bellies of same and

Position of neck
Subplatysmal plane
IJV is ligated below
Sternomastoid muscle is cut

Figs 14.42(1)



Figs 14.42(2)

Figs 14-42(1 and 2): Steps in radical neck node dissection using Mac Fee incision approach.

opposite side digastric muscles are identified and exposed. Nodes in submental triangle are removed. Nodes with tissues dissected off the submental triangle towards the side to reach and identify mylohyoid neurovascular bundle which is ligated and divided. Gentle traction to submandibular salivary gland is applied using Allis tissue forceps to expose the lingual nerve, secretomotor fibres to submandibular ganglion, submandibular salivary duct. Secretomotor fibres are cut. Duct is cut and often ligated. Fascia over the hyoglossus muscle is kept intact to safeguard the hypoglossal nerve. Submandibular gland is further retracted laterally from posterior belly of the digastric muscle. Proximal part of the facial artery is identified at posteromedial part of the posterior belly of digastric muscle at deeper plane which is doubly ligated using silk and divided. Further retraction of the dissected tissue behind allows ligation of small pharyngeal veins and complete retraction of the posterior belly of digastric muscle. Occipital vessels (artery and vein) are ligated to visualise the upper end of the IJV. Transverse process of atlas can be felt at this level. IJV is dissected around and double ligation is done using 2 zero silk and divided. If upper attachment of sternomastoid muscle is not divided earlier, it is detached now to complete the surgery. Specimen is removed. After proper haemostasis and saline irrigation of the area suction drains are placed; one in front of trapezius and another along the strap muscle in front of carotid artery. Wound is closed using interrupted 3 zero polypropylene sutures.

Drains are kept for 4-7 days. Sutures are removed in 7-10 days **(Fig. 14-43)**.

Complications

Haemorrhage can occur due to small bleeders, carotid blow out in 7-14 days. Shock, haematoma formation, dyspnoea and compression are the features. Arranging adequate blood and immediate exploration is essential to save the life of the patient. Bleeders are ligated, carotid blow out is treated by ligating carotid artery. Since it is due to infective necrosis of carotid wall, graft reconstruction of the carotid is difficult.

Flap necrosis can occur; if a wide area of flap necrosis develops then some flap reconstruction is done using PMMC flap/deltopectoral cutaneous flap **(Fig. 14-44)**.

Infection, lymph ooze, carotid blow out, seroma formation, frozen shoulder are other complications. Drooping of shoulder can occur due to trapezius muscle paralysis. Pneumothorax and chylous fistula are rare complications.

Note:

To control haemorrhage in head and neck cancers and during head and neck surgeries (like radical parotidectomy, commandos and operation, maxillectomy) ligation of external carotid artery is often required. ***Ligation should be done distal to the origin of the superior thyroid artery***. It should never be ligated below the origin of the superior thyroid artery as this will lead to *eddy current* and thrombus formation at the carotid bifurcation resulting in intracranial embolism through ICA. Ligation of ECA to control bleeding is usually done in continuity **(Fig. 14-45)**.

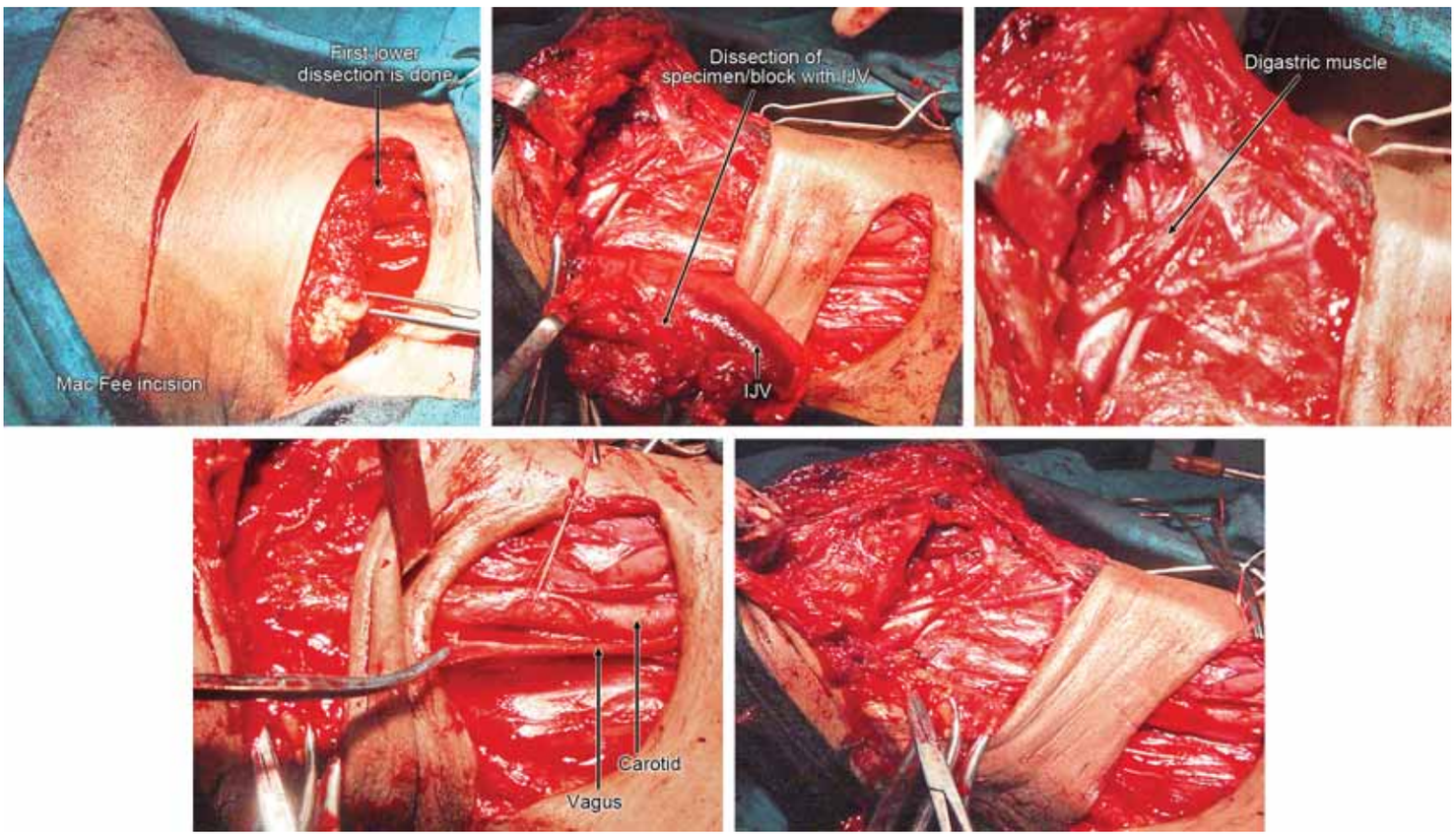


Fig. 14-43: Structures observed in neck node dissection.

Fig. 14-44: Postoperative look after radical neck dissection.

Carotid Blow Out

Carotid blow out is most dangerous complication. It is due to sepsis, wound breakdown, arterial adventitious stripping and necrosis and drying of the artery. Ligation of the carotid is done to save the life of the patient but procedure itself has got 20% mortality and 50% morbidity (hemiplegia).

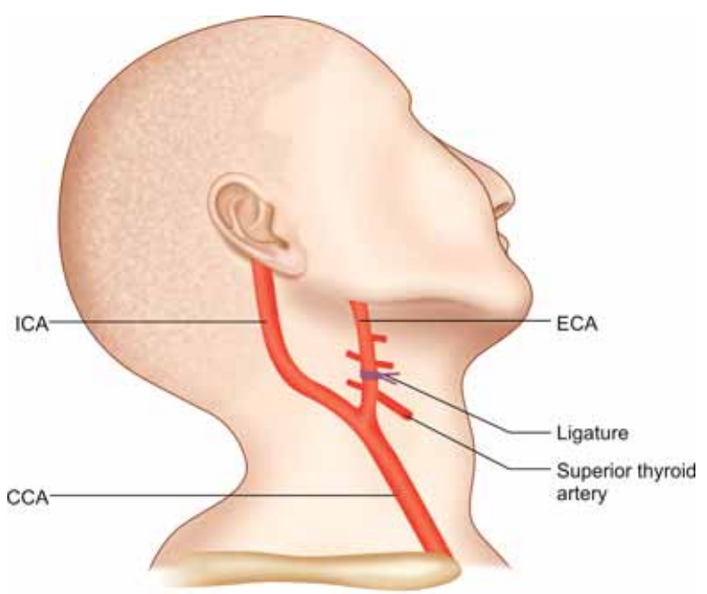


Fig. 14-45: Ligation of external carotid artery should be done when needed distal to the origin of the superior thyroid artery.

Bilateral Neck Dissection

It is done in carcinoma tongue or pharynx where lesion is in midline. In such case of bilateral neck dissection, internal jugular vein has to be preserved on one side. *Always the side where the vein is preserved is operated first.* Ligation of both the jugular veins will cause cerebral congestion leading to cerebral oedema which is dangerous.

During surgery if both IJV are ligated due to injury as an inevitable consequence, the patient has to be kept in propped position; antibiotics, diuretics and steroids are given; repeated CSF taps are done to control the cerebral oedema.

SURGERY OF HEAD, FACE AND JAW

This is a wide surgical topic which is basically practiced by ENT surgeons/faciomaxillary surgeons/plastic surgeons/ophthalmologists. Extensive descriptions are beyond the scope of this book however basic principles needed for general surgeons or a surgery postgraduate are given in this topic.

Principles in Face Injuries

Initial complete assessment is done like in any polytrauma. Resuscitation should be done accordingly.

Facial wounds retract widely giving false impression of wide area defect. It is due to elastic nature of facial skin and retraction by facial muscles.

All wounds by trauma in face should be cleaned thoroughly using adequate amount of warm saline; wound debridement is done; tissues are apposed layer by layer to create proper acceptable scar. Wound debridement is done using number 15 blade or fine scissor. All foreign bodies in the wound should be removed meticulously. One should avoid unnecessary excision of tissues. It is better to clean and scrub under general anaesthesia to achieve proper thorough cleaning.

If injury involves entire thickness of the face involving skin, muscle and mucous membrane, suturing is done layer by layer from mucous membrane, muscle and skin in order.

Injury to facial nerve, parotid ducts should be identified. If terminal branches of facial nerve are severed, it is not necessary to approximate it. But main branches or trunk should be sutured using fine (6 zero) polypropylene sutures using microscope. Specialised reconstructive surgeons are better to be called to handle such cases. Parotid duct is also sutured with interrupted polypropylene sutures (6 zero) using microscope.

Skin is sutured with interrupted sutures using 5 zero polypropylene sutures. It is placed close to skin edge with deeper fat plane to prevent dead space. Sutures are placed every 5-8 mm gap. Knots should only be adequate to approximate the skin. One should not strangulate the skin.

In the lip, vermillion border should be sutured first to get accurate apposition.

Sutures are removed in 5 days in face. Later wound support may be given using steri strip **(Fig. 14-46)**.

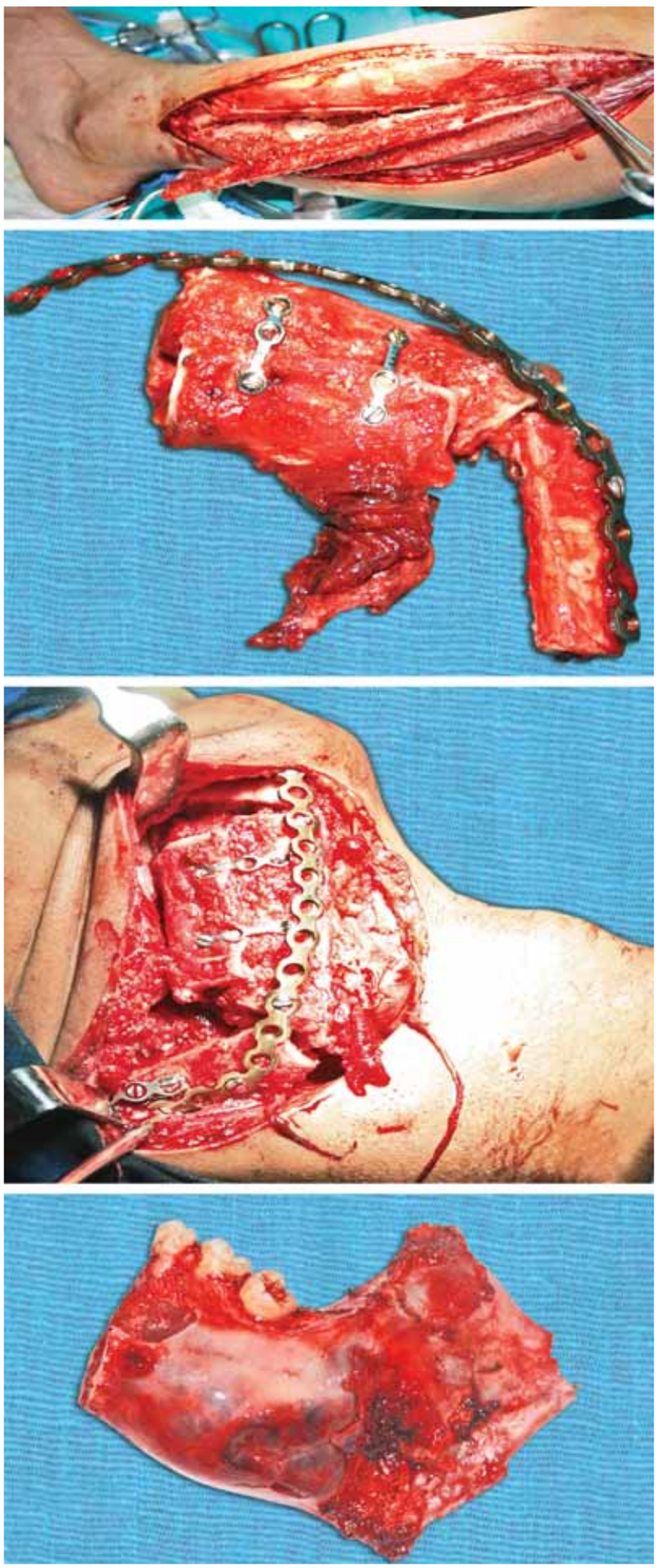


Fig. 14-46: Reconstruction of the mandible after segmental resection of the mandible for ameloblastoma using fibular microvascular flap.

SURGERY OF THE EYELIDS/ORBIT/ EYEBALL

Eyelid is sutured accurately using fine interrupted sutures. Grey line of tarsal conjunctiva should be approximated accurately. If it is not accurate 'a step deformity' in the eyelid margin will develop. Tarsal plate should be approximated using fine 5 zero vicryl or PDS sutures (absorbable). If lacrimal canaliculus is injured, a lacrimal probe is passed to assess the injury; then a fine silicone tube is passed across punctum in the lid. Suturing is done over it using magnifying lens. Silicone tube is kept in place for 6 months.

Eyebrows *should never be shaved* in trauma or in any surgeries. If shaved original eyebrow will not come back.

Tarsorrhaphy is a common procedure done as temporary basis. It is done in facial nerve palsy as there is improper closure of eyelids during blinking, trauma, hyperthyroidism with proptosis, burn injury. Lateral 1/3rd of upper and lower eyelid margins are incised between eyelashes and Meibomian glands. Created raw margins are sewed together.

Ectropion is everting of the eyelid due to scarring. It may be due to excision of an infraorbital swelling which causes scarring and ectropion. Scar tissue is released and full thickness (Wolfe) graft is placed.

Entropion is inverting of the eyelid due to conjunctival scarring (trauma, trachoma). Eyelashes get inverted and irritate the cornea. Scarred conjunctiva is excised and full thickness mucosal graft taken from oral cavity is placed on the defect. Deformed tarsal plate should be divided and everted. Radical excision of inverted eyelashes can also be done as a simple procedure. Temporary relief can be achieved by placing everting sutures through skin, tarsal plate and conjunctiva.

Eyelid tumour is excised as a full thickness. If length of excised area is less than 1/4th of the length of the eyelid, then primary suturing of the eyelid can be done. If excised defect is more than 1/4th then proper reconstruction of the defect is needed.

Excision of the external angular dermoid is done under general anaesthesia. Prior X-ray of skull or CT head in suspected intracranial extension is a must. Incision is just below and parallel to the eyebrow. Eyebrow should not be shaved. Incision within the eyebrow should not be done as scarring of hair follicle will cause eyebrow deformity with poor cosmetic outcome. Cautery usage is better during surgery. Two layer closure of the wound is done **(Fig. 14-47)**.

Periorbital lesion / swelling in the lower eyelid are excised circularly and a full thickness Wolfe graft is placed. Primary closure of the defect can cause ectropion of the lower eyelid with exposure of the lower punctum of the eyelid exteriorly; with its inability to come in contact with eyeball can cause continuous watering of the eye **(Fig. 14-48)**.

Evisceration of eye is done to prevent sympathetic ophthalmia (on opposite normal eye). Here cornea is incised and all contents are curetted. All uveal tissues should be removed completely otherwise sympathetic ophthalmia can occur. Evisceration is better to have cosmetic result.

Enucleation is done by removing the entire eyeball. Conjunctiva is incised at the corneal junction. Plane is created around the eyeball. All intrinsic muscles are detached from orbit by hooking forward. At the end optic nerve is cut. Conjunctiva is sutured.

SURGERY OF THE EAR

It is basically done by an ENT surgeon.

Haematoma of the ear is aspirated under aseptic precaution using a syringe and large bore needle. Clot gets slowly organised. Due to

Fig. 14-47: Incision to excise external angular dermoid. Eyebrows should not be shaved.

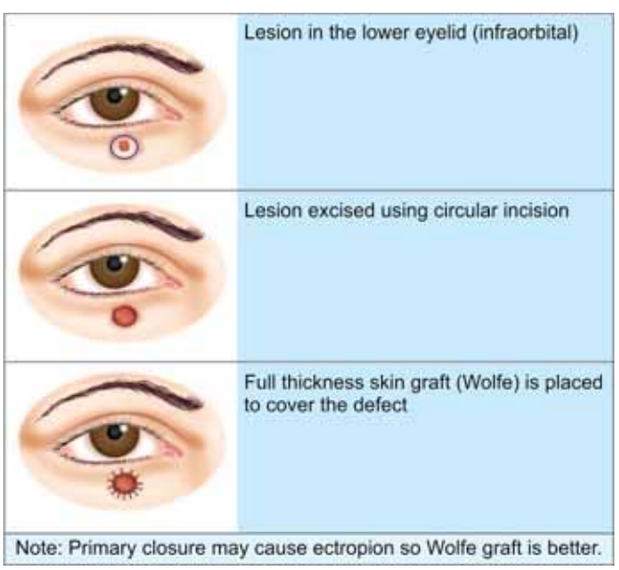

Lesion in the lower eyelid (infraorbital)
Lesion excised using circular incision
Full thickness skin graft (Wolfe) is placed to cover the defect
Note: Primary closure may cause ectropion so Wolfe graft is better.

Fig. 14-48: Full thickness Wolfe graft is needed after excision of the periorbital lesion to prevent ectropion.

Swelling in the ear lobe is excised along with cartilage adjacent
Skin incision
Incision on cartilage
Cartilage is removed wider than the skin to allow tension free suturing
Skin on either side is sutured separately without suturing the cartilage

Fig. 14-49: Excision of benign lesion in the ear lobe.

pressure ischaemia of underlying cartilage and necrosis can occur. Multiple small incisions should be made. Repeated aspirations and pressure dressings are needed. Two sterile shirt buttons are placed on either sides of the ear and sutured to achieve adequate compression. *Perichondritis and cartilage necrosis* are dreaded complications. *Cauliflower ear* may develop if not treated properly.

Injury to ear is sutured on both surfaces separately using fine polypropylene sutures (interrupted). Cartilage is not usually sutured. Proper antibiotics (anaerobic infection of cartilage is common) should be given to the patient.

Swellings/tumours in the ear is excised with V shaped incision. Underlying cartilage is excised more widely than skin to facilitate the tension free suturing of the skin on either side. Cartilage is not sutured **(Fig. 14-49)**.

Accessory auricle is excised with its deeper core cartilage and skin is sutured. It is done for cosmetic purpose. *Keloid in the ear* should not be excised.

Ear lobe repair is discussed in chapter 7 (Please refer).

CLEFT LIP AND CLEFT PALATE

Problems in Cleft Lip and Cleft Palate

There is difficulty in sucking and swallowing. This is commonly observed in cleft palate than in cleft lip. Speech is defective especially in cleft palate, mainly to phonate B, D, K, P, T and G. Problems in cleft disease are—altered dentition or supernumerary teeth, recurrent upper respiratory tract infection, respiratory obstruction (*Pierre Robin syndrome*), chronic otitis media, middle ear problems, cosmetic problems, hypoplasia of the maxilla, problems due to other associated disorders **(Fig. 14-50)**.

Treatment for Cleft Lip

Millard criteria are used to undertake surgery for cleft lip.

Millard criteria (Rule of `10')
- 10 pound in weight
- 10 weeks old
- 10 gm % hemoglobin

a. *Millard cleft lip repair* by rotating the local nasolabial flaps.
b. Management of associated primary or secondary cleft palate deformity.
c. Proper postoperative management like control of infection, training for sucking, swallowing and speech.

Fig. 14-50: Cleft lip and palate.

d. Tenninson's 'Z' plasty (Tenninson-Randall triangular flap) **(Fig. 14-51)**.

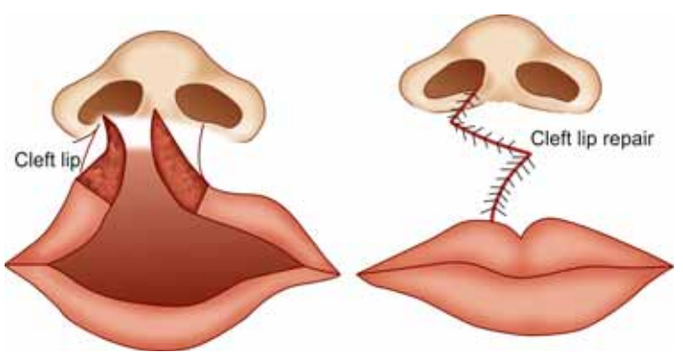


Fig. 14-51: Steps of cleft lip repair.

Principles of cleft lip repair
- 'Rule of 10' should be fulfilled
- It should be operated before 6 months
- Infection should not be present
- Millard advancement flap is commonly used for unilateral cleft lip repair
- Bilateral cleft lip repair can be done either in single or two stages (with 6 months gap between each stage)
- One stage bilateral cleft lip repair is done using Veau III method / Millard's single stage/Black method
- Proper markings are made prior to surgery and incision should be over full thickness lip
- Often 1:2,00,000 adrenaline injection is used to achieve haemostasis
- Three layer lip repair should be done (mucosa, muscle and skin)
- Cupid's bow should be horizontal
- Continuity of white line should be maintained
- Vermilion notching should not be there

Note:

Delaire timing of the cleft surgery – Unilateral / bilateral cleft lip alone, in one stage operation done in 4-6 months. Cleft palate alone involving only soft palate, is one stage surgery done in 6 months. Cleft palate

alone but involving both soft and hard palates – soft palate in 6 months; hard palate in 18 months. In combined cleft lip and palate, unilateral or bilateral, done in two stages – cleft lip and soft palate in 6 months; hard palate in 18 months.

Treatment for Cleft Palate

Criteria for surgery

- 10 Kg weight
- 10 months of age (10–18 months)
- 10 gm % hemoglobin

Cleft palate is usually repaired in 12–18 months. Early repair causes retarded maxillary growth (probably due to trauma to growth centre and periosteum of the maxilla during surgery if done early). Late repair causes speech defect. Both soft and hard palates are repaired. Abnormal insertion of tensor palati is released. *Mucoperiosteal flaps* are raised in the palate which is sewed together. If maxillary hypoplasia is present then *osteotomy of the maxilla* is done. With *orthodontic help teeth extraction and alignment* of dentition is done. Regular examination of ear, nose and throat during follow up period is needed. Postoperative speech therapy is essential. Whenever complicated problems are present, staged surgical procedure is done.

Wardill-Kilner push back operation—here mucoperiosteum flaps based on greater palatine vessels is raised, a better method **(Figs 14-52 and 14-53)**.

Secondary management – Hearing support using hearing aid is given if defect is present. Control of otitis media when present. Speech problems occur due to velopharyngeal incompetence; articulation problems also can occur – speech therapy is given. It is corrected by pharyngoplasty, veloplasty or speech devices. Dental problems like uneruption, nonalignment are common. They should be corrected in a proper way by a dentist, along with reconstructive surgery. Orthodontic management with alveolar bone graft, maxillary osteotomy – done in 8-11 years of age. Veloplasty, dental implants, rhinoplasty, orthognathic surgeries, etc. are done based on requirement.

Principles of palatoplasty

- Timing is between 10–18 months
- Mucoperiosteum flap is raised
- Palatal defect is closed using 3 layers—nasal, muscle and oral layers
- Hook of pterygoid hamulus is fractured to relax tensor palati muscle to relieve tension on suture line

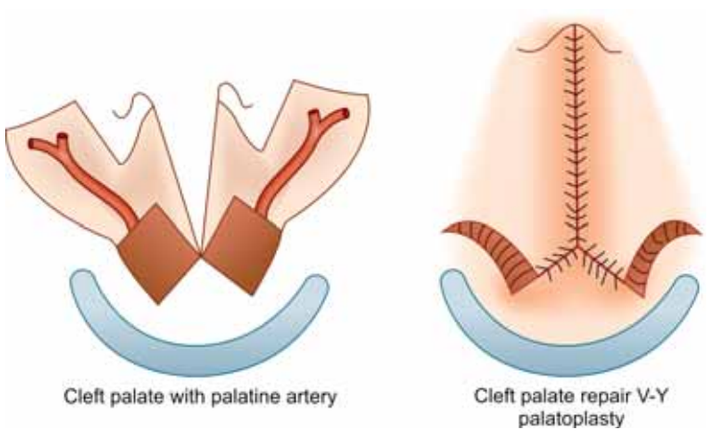


Fig. 14-52: V-Y palatoplasty

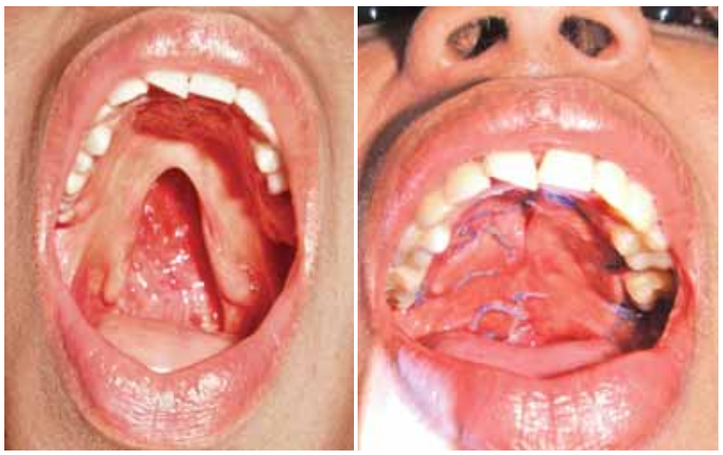


Fig. 14-53: Cleft palate and its repair.

SURGERIES OF THE ORAL CAVITY

Oral surgeries have become a specialty approach. So in detail discussion of each surgery is beyond the scope of this book. However common procedures and approaches are discussed here. Interested students have to refer specialised books for reference. Laser is often used in oral surgery other than cautery **(Fig. 14-54)**.

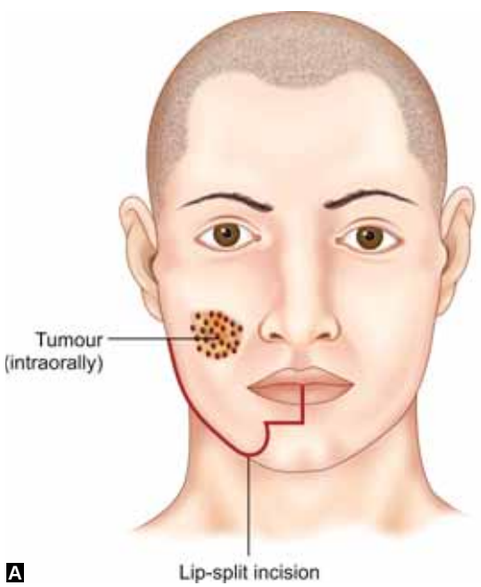
Fig. 14-54: Excision of lesion in the lip using laser.

Surgical approaches to carcinoma cheek (buccal mucosa)/oral cancers –

- Transoral/intraoral approach.
- Lip-split incision.
- *Patterson* approach.
- *Visor* flap approach for anterior mandible, floor of the mouth and tongue. Here skin over the anterior curved margin of the mandible is incised to approach the floor of the mouth for needed procedure. (*Visor* is derived from French word which means mobile lower part of the helmet which covers the chin).
- Mandibulotomy approach (*Kocher's*) for lesion over the floor of the mouth and large tongue which gives very good access **(Figs 14-55 and 14-56)**.

Different mandibular resections

- Rim resection of mandible
- Marginal mandibulectomy
- Segmental resection
- Partial mandibulectomy
- Hemimandibulectomy
- Resection of the anterior mandible through visor approach



Figs 14-55A and B

Figs 14-55A to C: Lip-split incision is used for wide excision of the carcinoma cheek, hemimandibulectomy, approach to lateral part of the floor of mouth and alveolus.

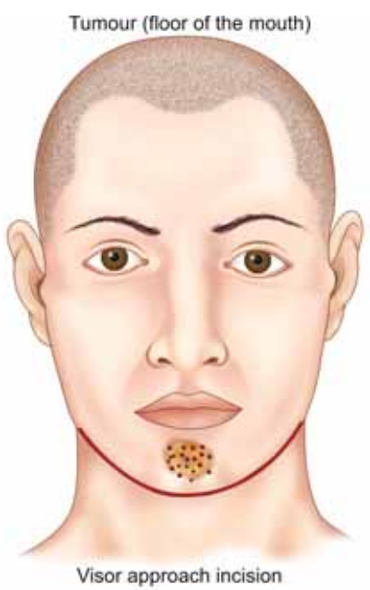


Fig. 14-56: *Visor flap approach* is used for lesions in the floor of the mouth and posterior tongue. Flap necrosis, fistula formation are less, functional results are better in relation to tongue mobility, articulation, swallowing, mastication.

Principles

Surgical approach to primary tumour whether external or transoral; adequacy of clearance in margin and depth; involvement of mandible or requirement of mandibular resection and if so extent of mandibular resection; lymphatic involvement present or not and the plan to address the neck nodes with decision for type of neck node dissection – are to be thought of while approaching the patient with oral cancers. External approaches may be Patterson / lip split / mandibulotomy.

All oral cancers are treated by *multidisciplinary approach*. For surgical treatment it is considered as early and advanced. Involvement

of mandible and nodes are also considered in approaching surgically. Staging of the disease is also essential.

Early superficial oral cancers are treated by wide local excision with 1-2 cm clearance. Frozen section biopsy is essential. Small defect can be closed primarily using 3 zero vicryl continuous sutures. Larger defect can be left alone safely to granulate and heal by secondary intention. Split skin graft (on to underlying buccinators muscle) to a wider area in cheek is useful way of covering the defect. It can be fixed to cheek by passing sutures from outside in and from inside out with knot placing outside which will be removed in 5-7 days **(Fig. 14-57)**.

T1 and T2 lesions are approached with wide local excision with supraomohyoid neck node dissection if N0 OR if nodal status is N1 / N2 radical or modified radical neck dissection I (MRND I - preservation of spinal accessory nerve) is done with or without mandibular resection depending on whether mandible is involved or not or close proximity of primary tumour to mandible. Type of mandible resection is decided by the extent of the mandible involvement.

T3 or T4 lesions are treated probably after initial chemoradiation by surgical wide excision with hemimandibulectomy with neck node dissection (RND). As mucosa, submucosa, buccinators, subcutaneous fat and skin are possibly involved after wide excision a through and through defect will be created. Extension into masseteric space by tumour is common and this area should be cleared meticulously. Reconstruction is essential using free radial forearm flap, rectus abdominis flap, fibular flap, plating, rib flap (opposite 11th rib), etc. Forehead flap may be used for mucosal side with pectoralis major myocutaneous flap for outer coverage. Large PMMF can be split on the skin part after harvesting to fold to cover mucosal as well as cutaneous parts of the defect **(Figs 14-58 to 14-60)**.

Transoral Approach

It is best approach for small lesions in the cheek or lesion in the tongue. As there is no incision outside it is cosmetically acceptable. Lesions less than 2 cm can be approached per orally. Larger lesion also can be approached through oral cavity but dissection and reconstruction is difficult. Nasotracheal anaesthesia is ideal. Often endotracheal tube can be placed on the opposite side of the lesion. Neck is turned towards opposite side. Mastoid retractor is used to retract cheek. C retractor is also helpful. Proper suctioning, adequate good light, cautery is essential. Lesion is excised with 1-2 cm clearance. Depth of the clearance also should be adequate. After excision, small defect can be left like that. Larger defect is covered with a quilted split skin graft from inside.

Transfacial - Patterson Operation (Fig. 14-61)

It is used in carcinoma cheek of early stage when only mucosa is involved. Incision is placed over the (lower border) base of mandible or just above the base parallel to it, often extending vertically over the margin of the ramus. Skin flap is elevated adequately upwards. Tumour with 1-2 cm clearance is excised widely. Skin flap is sutured back. Mucosal defect can be closed primarily. Often may require a skin graft inside. Skin is fixed by quilting sutures from outside in and inside out which are removed after 5 days. Skin graft gives the range of movements and prevents mucosal fibrosis and post operative trismus development which is distressing. Skin is taken from thigh (Split skin graft). Procedure is technically easier with less complications and faster recovery.

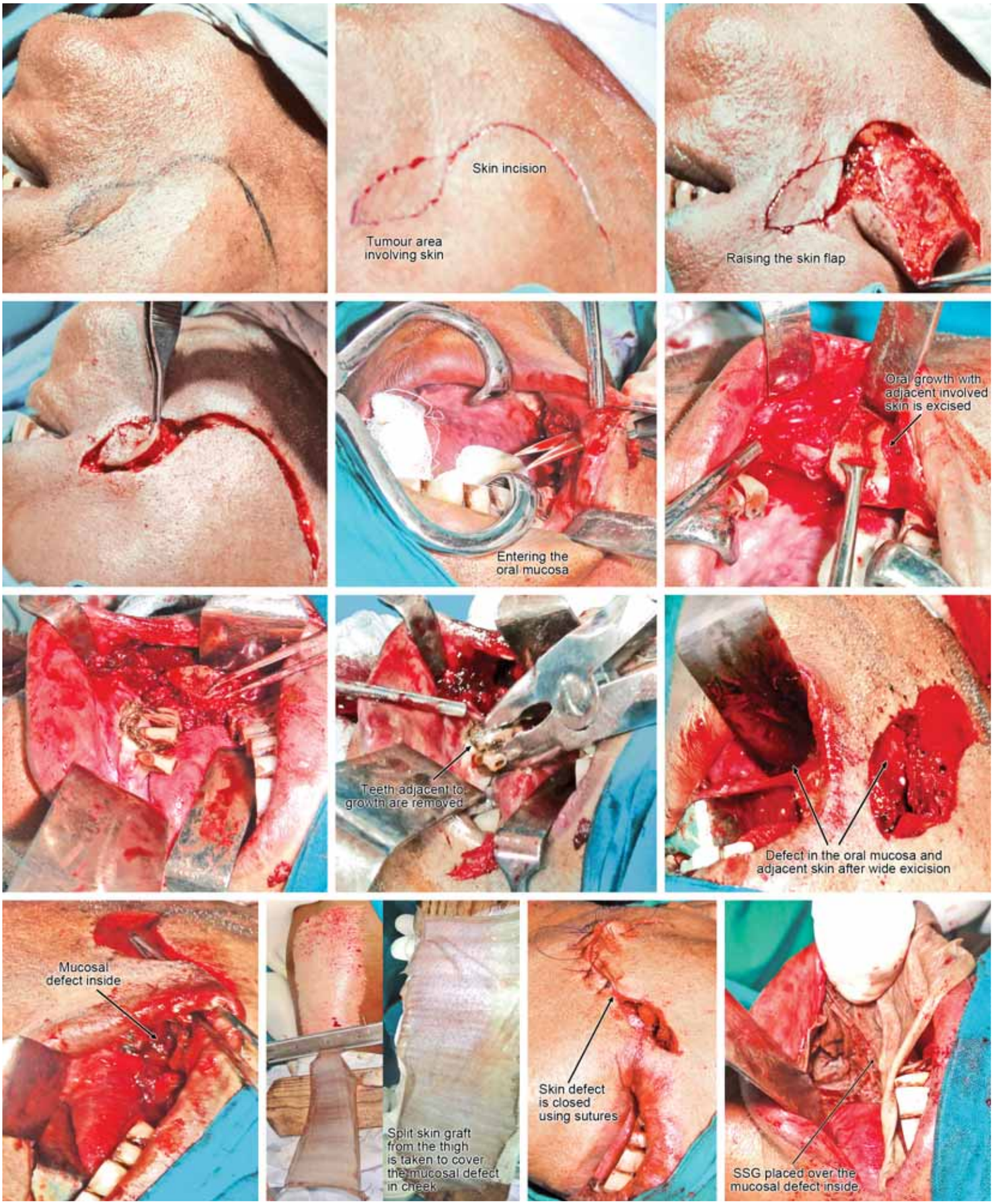
Transfacial Lip Split Incision Approach (Fig. 14-62)

In a wider lesion, transfacial lip split incision is needed to have a wider exposure of the cheek and tumour which facilitates adequate clearance. Inside defect can be reconstructed with forehead flap or SSG; outside, if there is defect, PMMF flap or deltopectoral flap can be used. Hemimandibulectomy or other mandibular resections can be carried out through this incision **(Fig. 14-63)**.

Hemimandibulectomy

Surgical Anatomy of Mandible (Fig. 14-64)

It is the largest and strongest bone of face. It has got horse shaped body with two rami from its posterior ends projecting upwards. Outer surface of body contains symphysis menti, mental protuberance, mental foramen, oblique line and incisive fossa. Inner surface contains mylohyoid line, submandibular fossa (below), sublingual fossa (above) and genial tubercles. Upper alveolar border bears sockets for teeth. Quadrilateral ramus has got medial and lateral surfaces, anterior, posterior, upper and lower borders and coronoid and condyloid processes. Medial surface of ramus contains mandibular foramen above the centre of the ramus at occlusal surface of teeth (transmits inferior alveolar nerve and vessels across mandibular canal to mental foramen on the outer surface); lingula (bony projection of mandibular foramen gives attachment to sphenomandibular ligament); mylohyoid groove (medial pterygoid is inserted below and medial to this groove). Lateral surface of ramus is flat (attachment of the masseter muscle). Upper border of ramus forms curved mandibular notch; lower border containing angle of mandible is the continuation of the base of mandible. Posterior border of ramus is thick; anterior is thin. Anterior projection is called as *coronoid process* (temporalis is inserted on its apex and medial surface); posterior projection is called as *condyloid process*. Condyloid process is strong with expanded upward head which articulates with temporal bone to form temporomandibular joint. Anterior part of neck of condyloid process has got pterygoid fovea for the insertion of lateral pterygoid muscle. Oblique line on the outer surface of the body gives origin to buccinator; mylohyoid line on the inner surface of body gives origin to mylohyoid and superior constrictor muscles; upper genial tubercle gives origin to genioglossus and lower to geniohyoid; digastric fossa gives origin to anterior belly of digastric muscle. Investing layer of deep fascia and platysma is attached to lower border (base) of the mandible. Masseteric vessels and nerve passes through mandibular notch; mental foramen transmits mental vessels and nerve; inferior alveolar vessels and nerve passes through the mandibular canal; mylohyoid vessels and nerve are related to mylohyoid groove; lingual nerve is related on the medial surface; auriculotemporal nerve is related to medial side of the neck of the mandible. Mandible is the second bone to ossify in the body after clavicle. Ossification centre (*only one centre*) appears in 6th week of intrauterine life, one on each side near mental foramen. Entire *body* ossifies from *membrane* except only near incisor teeth; ramus *above the mandibular foramen* ossifies from *cartilage*. Site at canine socket is weak and is the *commonest site of fracture* which may involve inferior alveolar nerve causing neuralgic pain and loss of sensation over the distribution of mental nerve.


Skin incision
Tumour area involving skin
Raising the skin flap
Entering the oral mucosa
Oral growth with adjacent involved skin is excised
Teeth adjacent to growth are removed
Defect in the oral mucosa and adjacent skin after wide excision
Mucosal defect inside
Split skin graft from the thigh is taken to cover the mucosal defect in cheek
Skin defect is closed using sutures
SSG placed over the mucosal defect inside

Figs 14.57(1)

SSG edge is sutured to mucosal edge using vicryl
Folded sofra gauze is placed on the surface of SSG in the cheek oral cavity
Sofra inside is fixed to skin of the cheek using a deep suture

Figs 14.57(2)

Fig. 14-57: Wide excision of the carcinoma cheek with placement of split skin graft on the mucosal aspect.

Fig. 14-58: Carcinoma cheek extending into the skin and soft tissues cleared widely. It needs PMMF to cover the defect from outside; split skin grafting or forehead flap to cover from inside.

Fig. 14-59: Forehead flap is also often used to cover the defect from outside.

Fig. 14-60: Pectoralis major myocutaneous flap is used commonly to cover the cheek defect.

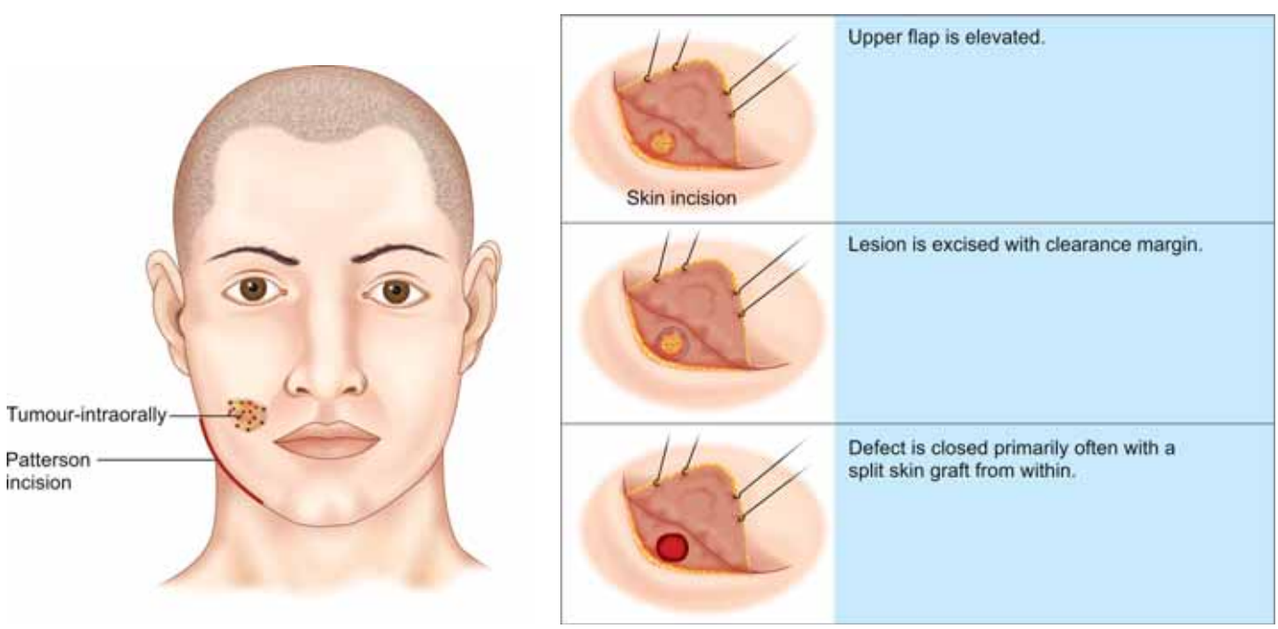

Tumour-intraorally
Patterson incision
Skin incision
Upper flap is elevated.
Lesion is excised with clearance margin.
Defect is closed primarily often with a split skin graft from within.

Fig. 14-61: Transfacial—Patterson operation.

Muscles of mastication (derive from mesoderm of 1st branchial arch, supplied by 1st arch nerve – mandibular) are –

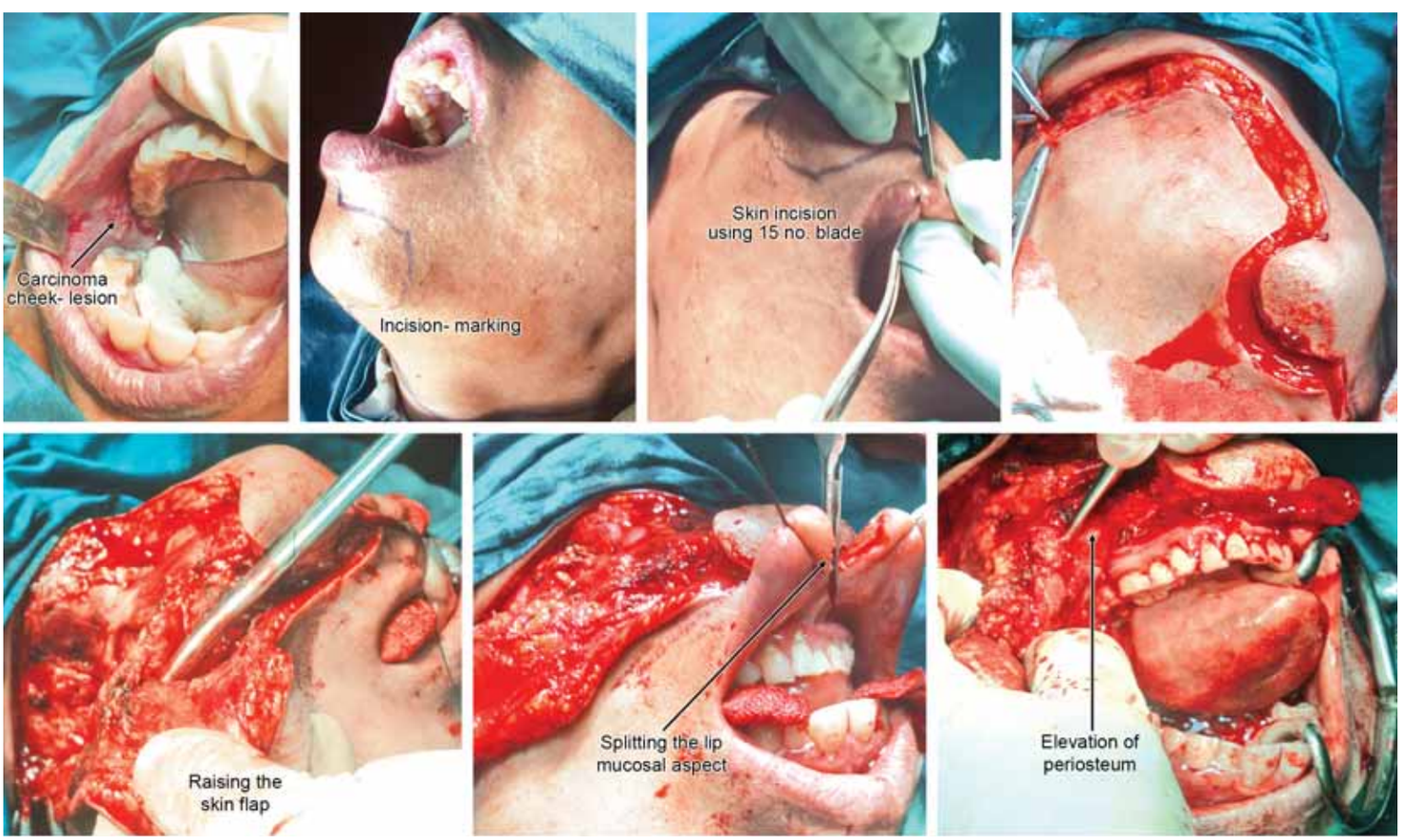
1. *Masseter*—A quadrilateral muscle covering outer surface of mandible has got 3 layers – superficial layer arises from anterior 2/3rd of lower margin of zygomatic arch; middle from anterior 2/3rd of deep surface and posterior 1/3rd of lower margin of zygomatic arch; deep layer from deep surface of zygomatic arch. it is inserted into lower, middle and upper part of the ramus of the mandible and coronoid process of mandible. It is supplied by masseteric branch of the anterior division of mandibular nerve. It elevates the mandible **(Fig. 14-65)**.

2. *Medial pterygoid muscle* – It is quadrilateral muscle with superficial and deep heads. Superficial is arising from tuberosity of maxilla; deep head arises from lateral pterygoid plate and adjoining palatine bone. Fibre runs downwards and backwards to reach medial surface and angle of the mandible below and behind the mandibular foramen and mylohyoid groove. It is supplied by nerve to medial pterygoid, a branch from main trunk of mandibular nerve. It elevates and protrudes

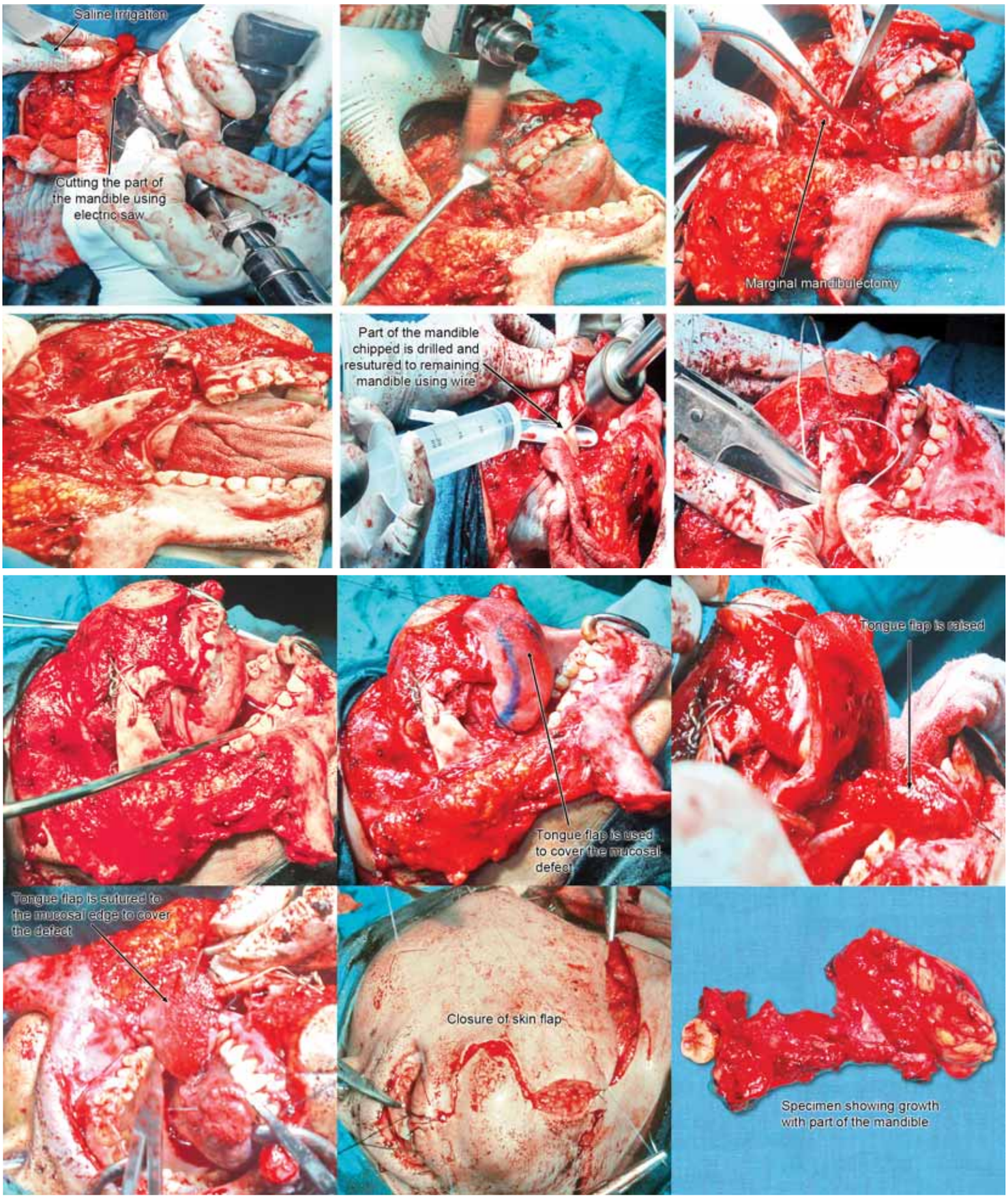
Fig. 14-62: Raising the flap after lip split incision for carcinoma cheek.

mandible. Lateral pterygoid plate, lingual and inferior alveolar nerves and lower head of lateral pterygoid lie superficial to the upper part of the muscle; ramus of the mandible, mandibular nerves, maxillary artery and sphenomandibular ligament lie superficial to the lower part of the muscle. Tensor veli palatini, superior constrictor of the pharynx, styloglossus and stylopharyngeus attached to the styloid process are deep to the muscle.

3. *Lateral pterygoid muscle* – It is a short conical muscle with upper and lower heads; upper arises from infratemporal surface and greater wing of sphenoid bone; lower from lateral surface of lateral pterygoid plate. It runs backwards and laterally to insert into pterygoid fovea on the anterior surface of neck of the mandible and anterior margin of articular disc and capsule of temporomandibular joint. It is superficially related to ramus of the mandible, temporalis muscle tendon and maxillary artery. Its deeper relations are mandibular nerve, middle meningeal artery, sphenomandibular ligament and deep head of pterygoid muscle. Deep temporal nerves and masseteric nerve emerges at its upper margin. Maxillary artery passes upwards and buccal nerve passes downwards between the two heads. Two deep temporal arteries run on the outer surface of upper head. Masseteric artery and nerve passes on the surface of lateral pterygoid towards mandibular notch to enter the masseter muscle from its deeper plane. Masseteric artery arises from maxillary artery and nerve from mandibular nerve. Lingual and inferior alveolar nerve descends from deeper plane of lateral pterygoid at its lower border. Middle meningeal artery runs upwards from its lower border at deeper plane **(Figs 14-66 and 14-67)**.



Figs 14.63(1)


Saline irrigation
Cutting the part of the mandible using electric saw
Marginal mandibulectomy
Part of the mandible chipped is drilled and resutured to remaining mandible using wire
Tongue flap is raised
Tongue flap is used to cover the mucosal defect
Tongue flap is sutured to the mucosal edge to cover the defect
Closure of skin flap
Specimen showing growth with part of the mandible

Figs 14.63(2)

Figs 14-63(1 and 2): Wide excision with marginal resection of the mandible with bone fixing using steel wires. Mucosal defect is covered using tongue flap based posteriorly.

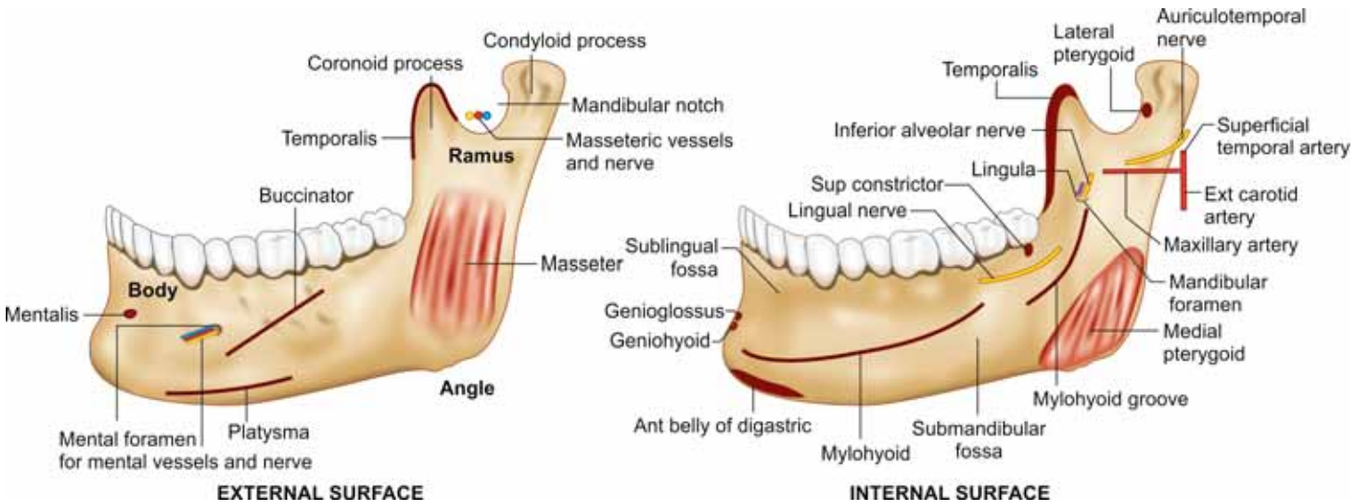


Fig. 14-64: Surgical anatomy of the mandible.

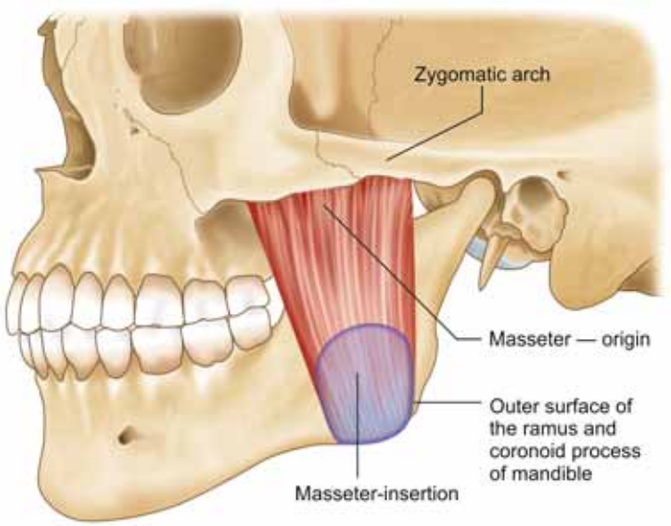


Fig. 14-65: Anatomy of masseter muscle.

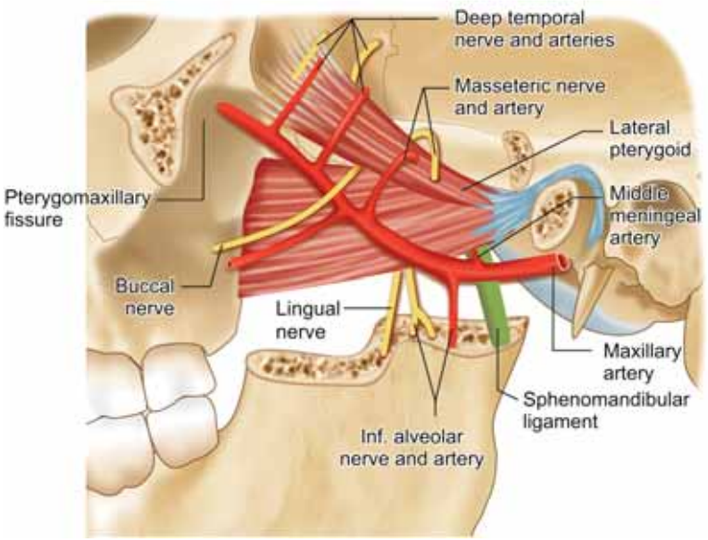


Fig. 14-67: Outer/superficial relations of the lateral pterygoid muscle.

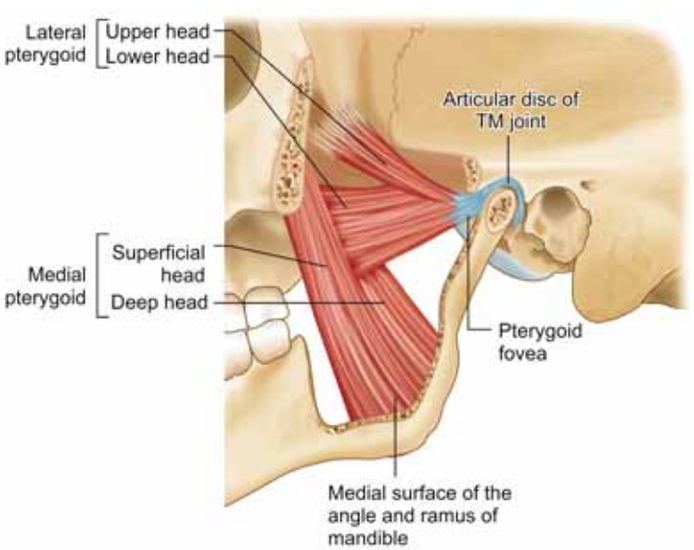


Fig. 14-66: Origin and insertions of the medial and lateral pterygoid muscles.

4. *Temporalis muscle* – It is fan-shaped muscle arising from temporal fossa of temporal bone and temporal fascia passing deep to zygomatic arch towards its insertion at deep surface of coronoid process and anterior ramus of mandible. It is supplied by two deep temporal branches from anterior division of mandibular nerve. It elevates the mandible, retracts the protruded mandible; and facilitates side-to-side mandible movement **(Fig. 14-68)**.

Temporomandibular joint (TM joint): It is synovial condylar joint. Upper part of the articular surface is formed by the temporal bone, articular eminence and anterior part of the mandibular fossa; lower articular surface is formed by the head of the mandible. Joint cavity is divided into upper and lower part by articular disc. *Ligaments of the joint are* – temporomandibular, sphenomandibular and stylomandibular. TM joint is related laterally to skin, fascia, parotid, temporal branches of facial nerve; medially tympanic plate (separates from ICA), spine of sphenoid, upper part of sphenomandibular ligament, auriculotemporal and chorda tympani nerves, middle meningeal artery; posteriorly parotid, external auditory meatus, superficial temporal vessels and auriculotemporal nerve from deep to superfi-

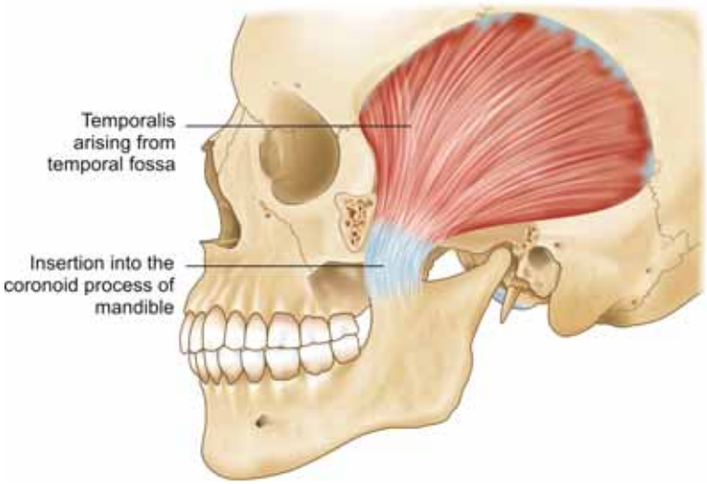


Fig. 14-68: Origin and insertion of the temporalis muscle.

cial; superiorly middle cranial fossa and middle meningeal vessels; inferiorly maxillary vessels. Joint movements are divided between two compartments created by the articular disc – upper meniscotemporal, lower meniscomandibular. Both right and left joints usually move simultaneously. *Movements are* – protraction, retraction, elevation, side-to-side movements **(Fig. 14-69)**.

Procedure

In mandibulectomy, growth with the mandible is removed. It is done in carcinoma cheek (oral carcinomas) which is extending into the mandible. Extent of mandible resection depends on the extent of mandibular involvement by growth and grading of the tumour. It may be rim resection of the mandible, marginal mandibulectomy, segmental resection, partial mandibulectomy, hemimandibulectomy (refer figures). Primary closure is cosmetically poor even though it gives good range of mouth opening. Reconstruction is done by various methods – like plating, bone graft, microvascular fibular graft. If there is defect in the skin and soft tissues, then pectoralis major myocutaneous flap (PMMF) or deltopectoral cutaneous flap is used. Mucosal defect if present is covered by simple split skin graft or forehead cutaneous flap. Reconstruction is done with the help of plastic surgeon.

Incision for hemimandibulectomy is 2 cm below the base of the mandible, parallel and extending towards the ear lobule along the ramus of the mandible. Often lip spilt incision is used. Flap is elevated both upper and lower. Bipolar and monopolar cautery is needed to elevate the flaps. Mandible is transected just adjacent to the mentum towards the side of the lesion using Gigli saw or ideally electric rotary saw. Resected mandible is elevated upwards to facilitate visibility of the soft tissue attachment to the base. Carcinoma lesion can be seen on the mucosal surface of the cheek which is dissected with adequate clearance. Lower flap is elevated to expose the submandibular salivary gland. The submandibular salivary gland in often removed along with the mandible during hemimandibulectomy. Once soft tissue is freed from below, medial pterygoid is cut near its attachment on the inner surface of the mandible. Temporalis is detached from the coronoid process. Small branches of the maxillary artery on the deeper surface of the masseter muscle will be ligated. Masseter muscle is cut from the upper part of its attachment to the mandible. Temporomandibular joint is dissected and lateral pterygoid is detached from its attachment to pterygoid fovea on the anterior surface of the condyloid process of the mandible. Specimen is removed. All bleeders are ligated or fulgurated. Primary closure or ideally reconstruction is planned. Nasogastric tube should be passed which is used for feeding during postoperative period. Tracheostomy is usually not required but when indicated one should not hesitate to do it especially in case if radical neck dissection is combined with hemimandibulectomy **(Fig. 14-70)**.

Flap is sutured. One or two bottles of blood may be required which should be kept ready in theatre. Mandible is reconstructed using cortical bone graft, fibular microvascular flap, synthetic material like, titanium, stainless steel plate **(Figs 14-71 to 14-73)**.

If radical neck dissection is added, a vertical incision in the neck to the existing incision is sufficient to clear the nodes. Technique of neck dissection is same as described above.

Less aggressive surgeries like segmental resection, marginal mandibulectomy, and partial mandibulectomy can be done depending on the extent of bone involvement **(Figs 14-74 to 14-78)**.

Complications of Surgeries

Bleeding, infection, flap necrosis, complications of reconstruction, stiffness, contracture, cosmetic problems, swallowing problems and speech problems are the complications observed. Respiratory

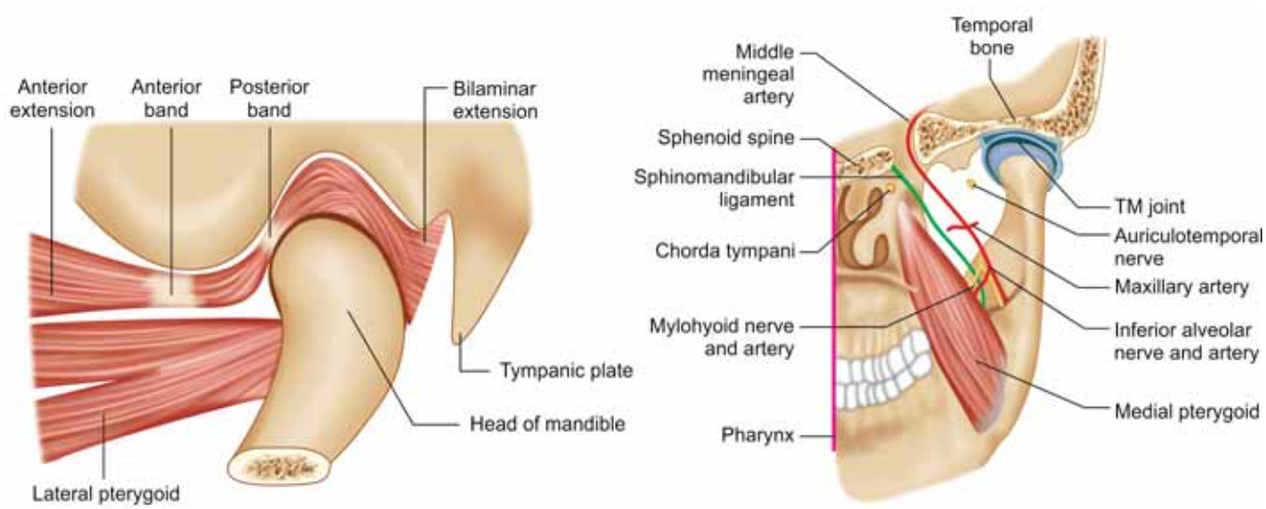
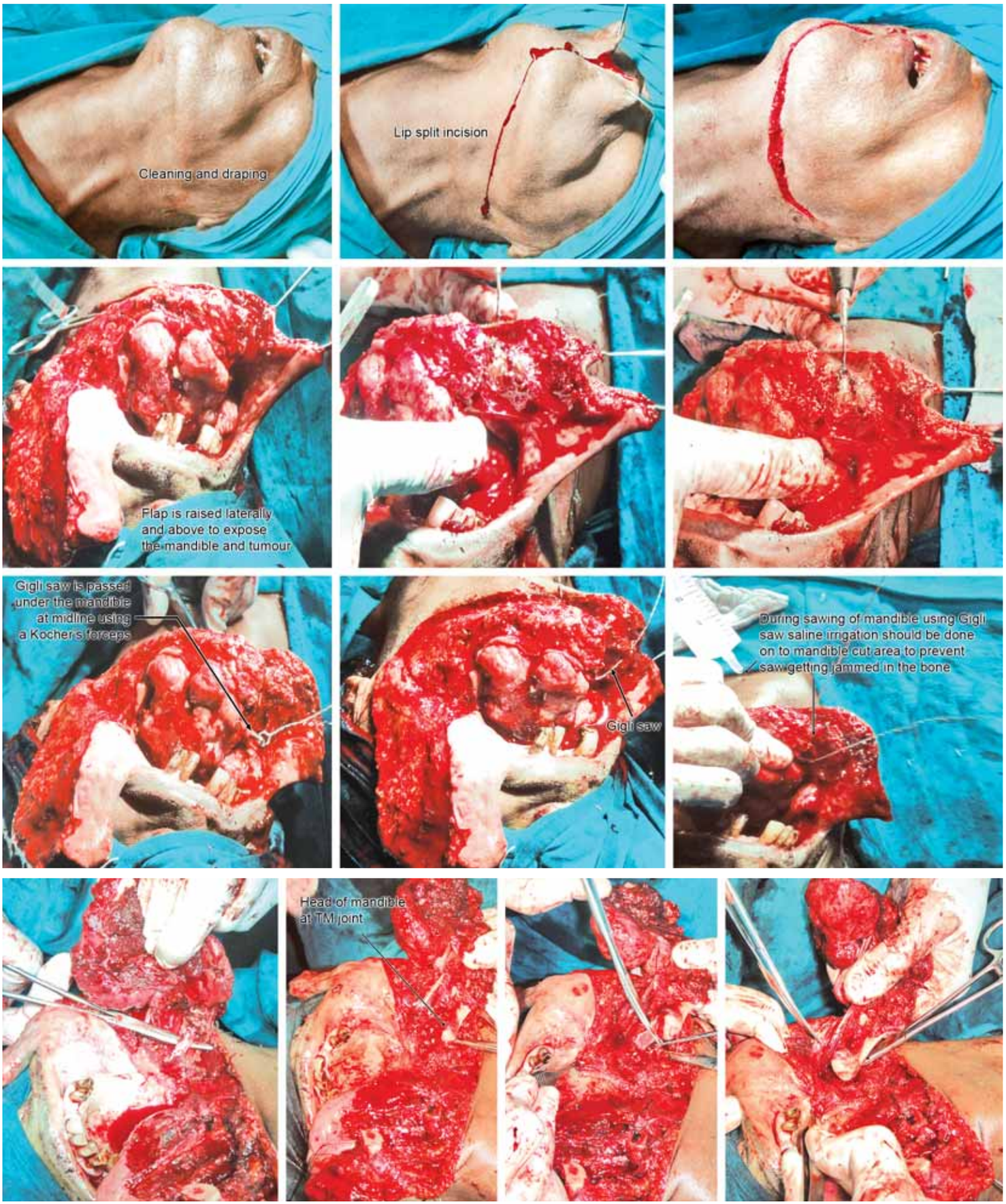
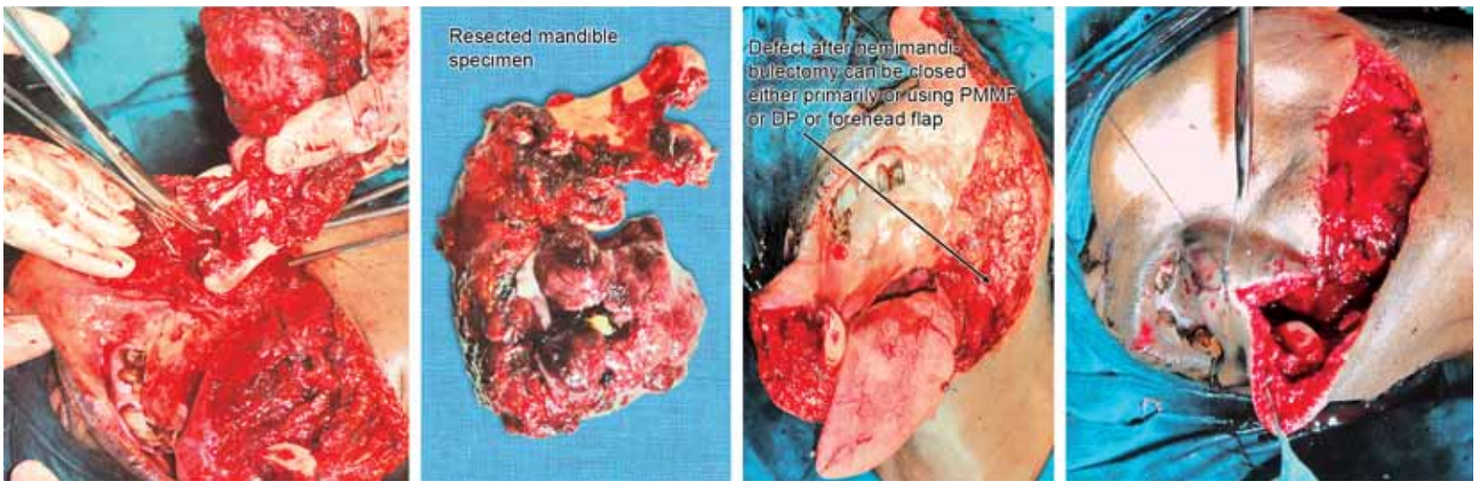


Fig. 14-69: Anatomy and relations of temporomandibular joint.


Cleaning and draping
Lip split incision
Flap is raised laterally and above to expose the mandible and tumour
Gigli saw is passed under the mandible at midline using a Kocher's forceps
Gigli saw
During sawing of mandible using Gigli saw saline irrigation should be done on to mandible cut area to prevent saw getting jammed in the bone
Head of mandible at TM joint

Figs 14.70(1)


Resected mandible specimen
Defect after hemimandibulectomy can be closed either primarily or using PMMF or DP or forehead flap

Figs 14.70(2)

Figs 14-70(1 and 2): Hemimandibulectomy technique using lip split incision with wide excision of primary tumour in the cheek.

Fig. 14-71: Hemimandibulectomy is done in this patient. Reconstruction is not done in this patient leading into poor cosmetic outcome. But mouth opening and jaw movements will be adequate.

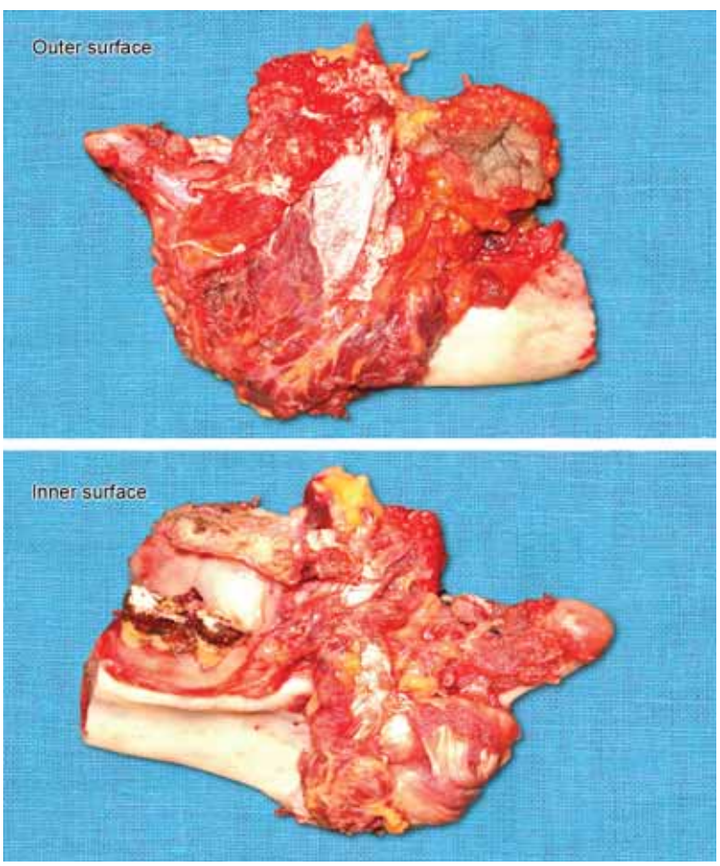


Fig. 14-72: Hemimandibulectomy specimen as viewed both from outer and inner surface.

complications like aspiration and bronchopneumonia are often life threatening. Anaesthetic complications and deep venous thrombosis are other complications.

Approach to Floor of the Mouth

Anatomy - It is U shaped area bounded by lower gum and oral tongue. It ends posteriorly at the insertion of anterior tonsillar pillar into the tongue. Sublingual papilla is present on each side of the frenulum; on summit of which is the opening of the duct (*Wharton's*) of submandibular salivary gland. Laterally and behind this papilla, sublingual fold is present which overlies the sublingual gland. Genioglossus and geniohyoid muscles are deeper to it. On either side mylohyoid muscles form the muscular part of the floor of the mouth. It arises from mylohyoid ridge of the mandible extending up to the 3rd molar tooth. Submandibular salivary gland rests on the external surface of mylohyoid muscle; only small deeper part extends into the internal surface. Submandibular salivary duct runs about 5 cm between sublingual gland and genioglossus to end in papilla. Lingual and hypoglossal nerves are closely related to gland and duct. Alveolingual sulcus is valley shaped space between tongue and mandibular alveolar bone.

In carcinoma floor of the mouth adjacent to ventral part of the tongue, alveolus, submandibular ducts and opposite nodes are involved early. CT scan is a must to assess the stage and plan the therapy.

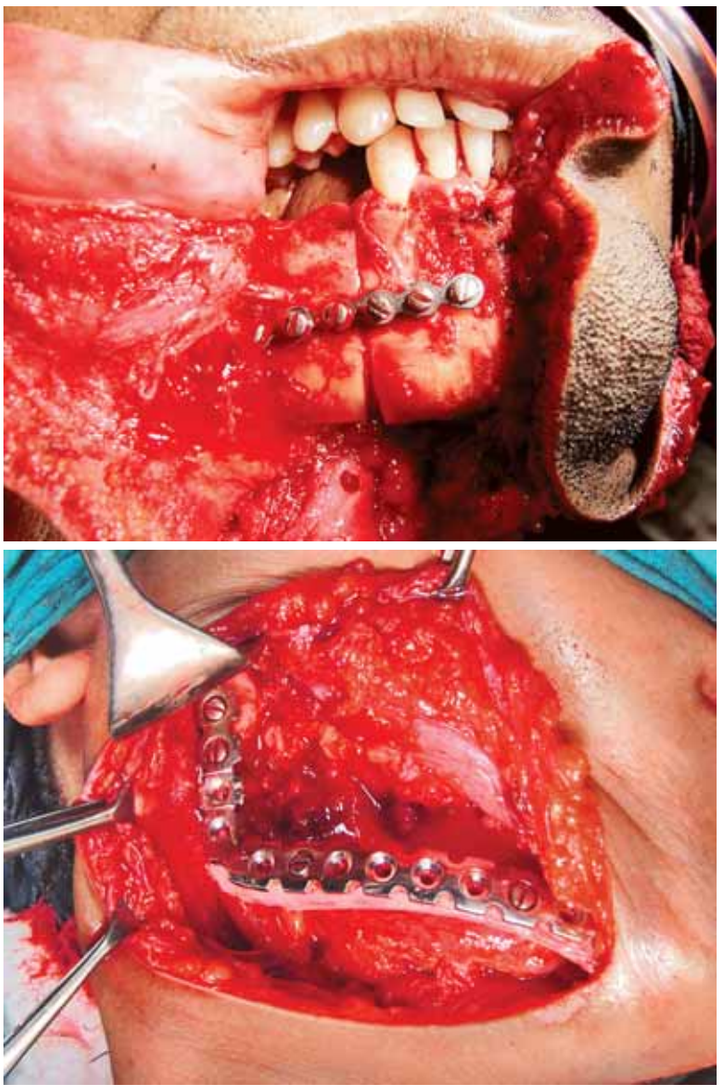


Fig. 14-73: Reconstruction of the mandible is done using plates, screws and bone graft.

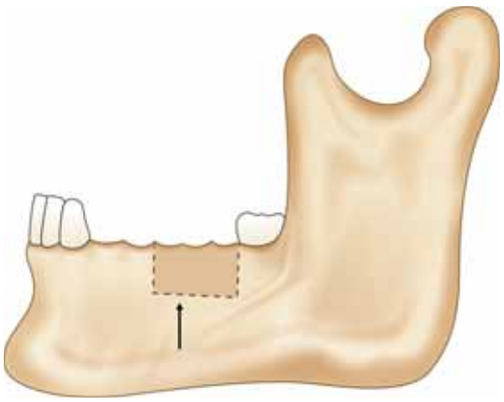


Fig. 14-75: Extent of resection in marginal mandibulectomy.

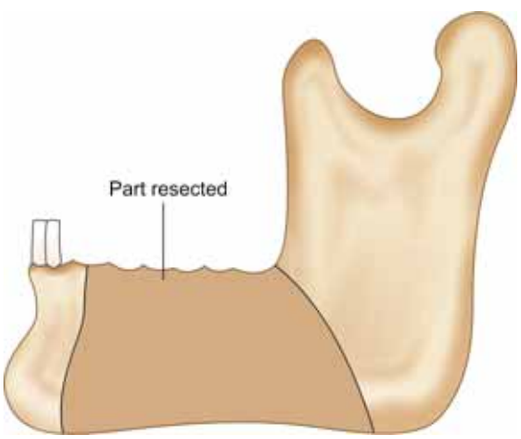


Fig. 14-76: Extent of bone removal in segmental resection of the mandible.

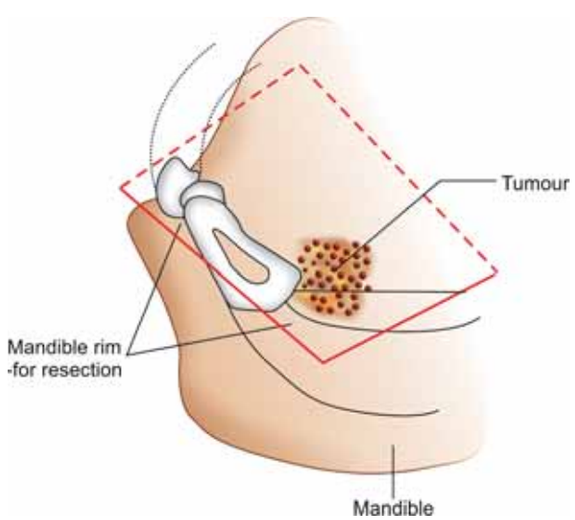


Fig. 14-74: Extent of removal in mandible rim resection.

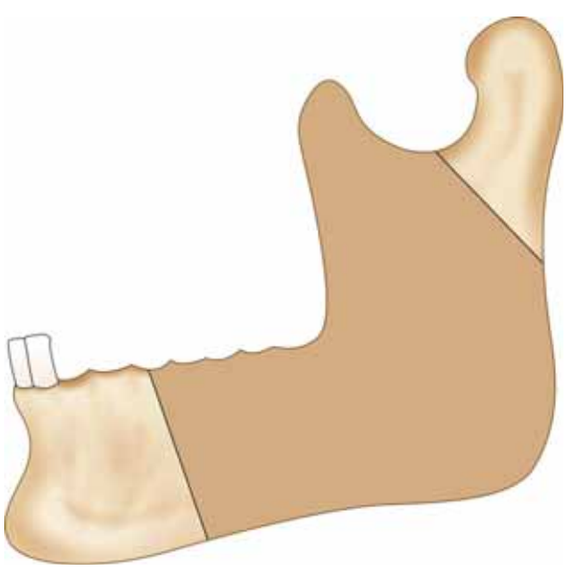


Fig. 14-77: Extent of removal in partial mandibulectomy.

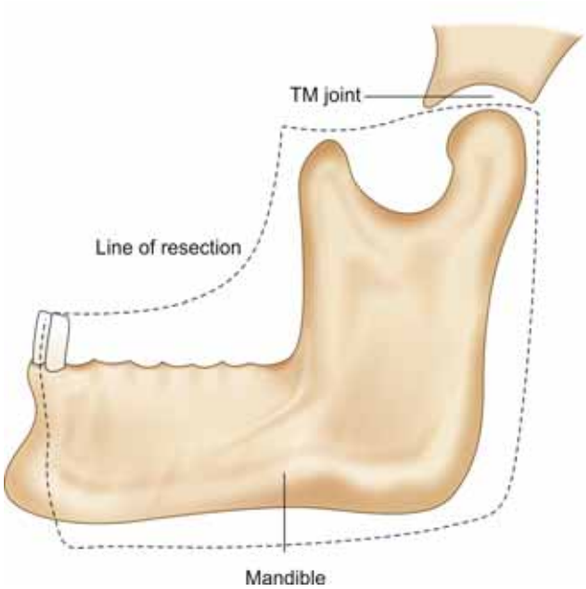


Fig. 14-78: Extent of resection in hemimandibulectomy.

T1 and T2 lesions are treated with wide excision with 2 cm clearance with frozen section biopsy confirmation. Lesion deeper than 4 mm needs elective neck node dissection - N_0. Transoral/lip split/ mandibulotomy/visor approaches are used. Reconstruction is done using radial forearm flap.

T 3 or T 4 lesions when treated surgically needs a well planned approach. *Primary tumour* is approached with lip split and anterior stair step mandibulotomy. Wide excision with 2 cm clearance is done. If bone margin is involved marginal mandibulectomy is done. Cut mandible is distracted to expose the area widely. Hypoglossal nerve visualised in the deeper plane entering the tongue is preserved. Lingual artery is visualised and doubly ligated. Frozen section biopsy should be done for clearance confirmation. *Supraomohyoid neck dissection* one side or both in N_0 nodes is done and frozen section biopsy should be done for nodes. If positive, RND should be done. *Tracheostomy is essential* in all patients. *Nasogastric tube insertion* is also essential for later feeding purpose. Often *percutaneous gastrostomy,* if needed, should be done.

Approach to Tongue Cancers

Surgical Anatomy

Tongue is a muscular, glandular, vascular flat organ. Anterior 2/3rd is termed as body; posterior 1/3rd is base/root. Superior surface *is dorsum of the tongue*. It is an essential organ of taste. Tongue is important in speech, mastication and swallowing. Oral and pharyngeal parts are separated by V-shaped sulcus terminalis. Oral part is anterior 2/3rd and pharyngeal part is posterior third which is lymphoid tissue. Posterior tongue is connected to epiglottis by median and right and left lateral glossoepiglottic folds. Root of the tongue is attached to mandible and hyoid bone below. *Filiform papillae* are located in anterior 2/3rd of the dorsum of tongue and are numerous, fine and hair like. *Fungiform papillae* are mushroom shaped, deep red, larger, sparsely located near the tip of the tongue. Large, red, leaf-like *foliate papillae* are located in posterior third of tongue on lateral aspect which contains taste buds. *Circumvallate papillae* are 8-12 in number, mushroom shaped, arranged in large V-shaped row near posterior third of the dorsum tongue and contains plenty of taste buds. Small circular opening just posterior to this V row in the midline is called as *foramen caecum* which is the remnant of thyroglossal duct. Shallow groove just behind the circumvallate papilla on either sides of the foramen caecum is called as *terminal sulcus*. Numerous mucin glands and lymph follicles in the posterior third of the dorsum of tongue is called as lingual tonsil. *Posterior third of the tongue is difficult to inspect;* it needs head light, and spatula. It is better felt than seen. *Ventral surface* is smooth, has a median fold, *frenulum linguae* and deep lingual veins on either side. *Lingual frenulum* is attached about 10-15 mm below the mandibular central incisor tooth.

There are four extrinsic and four intrinsic *muscles of the tongue*. Extrinsic muscles are – genioglossus, hyoglossus, styloglossus, palatoglossus; intrinsic muscles are – superior longitudinal, inferior longitudinal, transverse, and vertical. Genioglossus is fan-shaped muscle arising from the genial tubercle of the mandible. It fans out and backwards. Upper fibres are inserted to tip; middle to dorsum of tongue; lower to hyoid bone. Upper fibres retract the tip; middle fibres depress the tongue; lower fibres by pulling the posterior part of the tongue forward helps in protruding the tongue.

Arterial supply is from lingual artery, a branch of ECA. Tonsillar and ascending pharyngeal arteries supply root of the tongue. Two venae commitantes accompany the lingual artery; one accompanies the hypoglossal nerve. Deep lingual vein is seen on the ventral surface of the tongue. All these veins join together at posterior border of the hyoglossus below the hypoglossal nerve to form lingual vein which enters either the common facial vein or IJV.

Lymphatic drainage – tip is to submental nodes; remaining anterior part to submandibular lymph glands; posterior third to jugulo-omohyoid nodes. Lymphatics in the midline of the tongue freely cross and communicate each other.

Nerve supply – all intrinsic and extrinsic muscles are supplied by hypoglossal nerve except palatoglossus which is supplied by cranial root of accessory nerve through pharyngeal plexus. Lingual nerve, a branch of mandibular nerve supplies general sensation and chorda tympani for taste of the anterior 2/3rd of the tongue except vallate papillae; glossopharyngeal nerve supplies general and taste sensation of posterior third of the tongue; internal laryngeal nerve of vagus supplies posterior most part of the tongue. Taste buds are numerous on the sides of vallate papillae, foliate papillae and posterior third of the tongue; are very less/sparse in fungiform papillae, soft palate, epiglottis, pharynx; are absent in mid-dorsal region of the oral part of the tongue.

Anterior 2/3rd of the tongue develops from two lingual swellings and one tuberculum impar, developed from first branchial arch (lingual nerve supply); Posterior 1/3rd from 3rd arch (glossopharyngeal nerve); posterior most from 4th arch (vagus nerve).

Principles and Types of Tongue Cancer Surgery

Anaesthesia - Nasotracheal anaesthesia is preferred. Throat packing should be done. Both monopolar and bipolar cautery and proper suction apparatus, adequate light source are needed. If neck dissection is done together then extension of the neck is needed. Turning of the neck towards opposite side of the RND/MRND is done after wide excision of primary lesion.

Intraoral approach is sufficient for small lesions. Lip split or mandibulotomy may be needed for larger and extensive tumour. Total glossectomy even though possible, it is very morbid and

distressing surgery to the patient and so usually not practiced unless proper reconstruction is planned and implemented including voice restoration, and swallowing. Composite excision, commando operation requires tracheostomy, nasogastric intubation, often gastrostomy for feeding purpose.

Small lesion less than 1 cm in the lateral margin is excised widely with 1 cm clearance. Margin and depth clearance should be confirmed by frozen section. Defect is closed *vertically primarily* using 3 zero vicryl or chromic catgut continuous locking sutures or interrupted sutures. Cautery is used for excision. Laser may be used if available. *Vertical closure* maintains the mobility well. *Horizontal closure* is technically easier and practiced by many surgeons but causes tethering of the dorsal of tongue to the floor of the mouth restricting the mobility. Interrupted sutures are better as continuous sutures may get torn off from the tissue. Supraomohyoid dissection is added (N_0) in all tongue cancers as they are usually aggressive **(Figs 14-79 and 14-80)**.

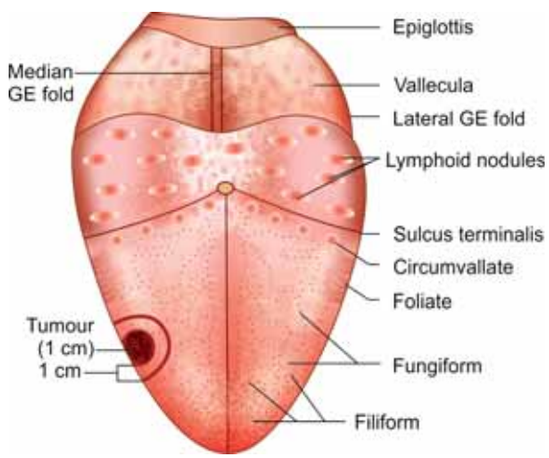


Fig. 14-79: Wide excision of the tongue lesion lesser than 1 cm.

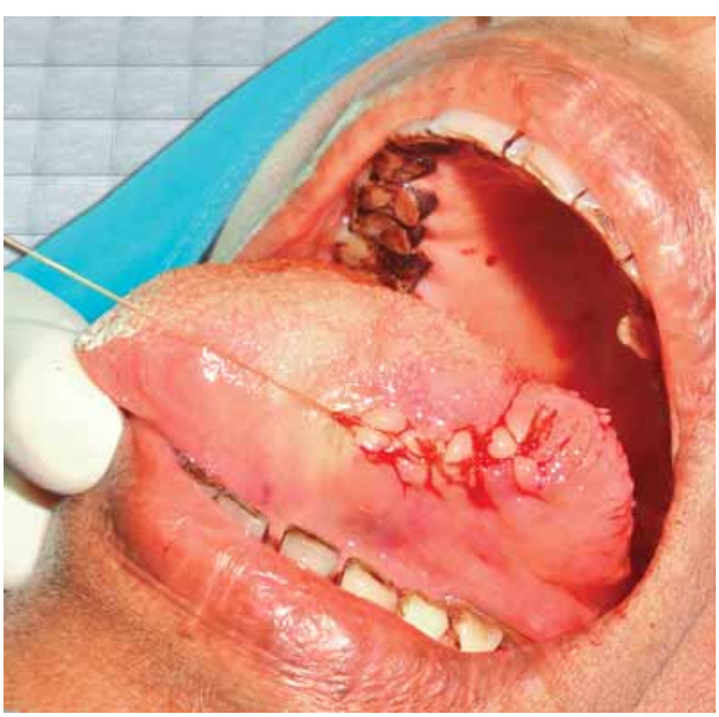


Fig. 14-80: Suturing of the raw area can also be done after excising the lesion.

Lesion in the lateral margin of size 1-2 cm is treated with partial glossectomy with 2 cm clearance. Defect can be sutured primarily or raw area can be left to granulate on its own. Split skin grafting to cover the defect can be done. Supraomohyoid dissection is done for N_0 lesion **(Figs 14-81 and 14-82)**.

Tumour larger than 2 cm in the lateral margin is treated by hemiglossectomy where anterior 2/3rd of the tongue in front of the sulcus terminalis and lateral to midline one side is removed using cautery. Lingual vessels should be doubly ligated using vicryl or monocryl. Reconstruction is done by cheek flap or simply rotating remaining half of the tongue (retained) over the defect. It gives good range of movements of the tongue. Supraomohyoid dissection (N_0) or MRND I/RND are done if nodes are positive **(Fig. 14-83)**.

If mandible is involved hemimandibulectomy and RND is done along with hemiglossectomy which is often called as *commandos operation*.

Composite resection of the tongue cancer (*Commando operation*) with resection of the mandible with RND is done using lip split incision after elevating the skin flaps above.

Dorsal tongue cancer is not common. It is treated by sagittal resection and closed primarily.

Posterior third of the tongue is approached through lip split and anterior mandibulotomy approach.

Pull through visor flap approach to the tongue is another approach for deep rooted tumour. It needs preliminary tracheostomy, nasogastric intubation, gastrostomy for feeding. Bilateral neck dissection is done. One side RND other side MRND II with retaining IJV is done. Side where IJV should be retained is decided prior and should be operated first. A visor flap of skin is elevated up to the inferior margin of the mandible. Mucosa on the uninvolved side floor of the mouth is incised and extended to involved tongue side with 2 cm margin. Mylohyoid muscle is cut and anterior and lateral cuts are communicated. Tongue with tumour is delivered under the mandible through an external neck wound. Lesion is excised with 2 cm clearance taking care of clearance in depth. Reconstruction is essential using radial forearm and PMMF flaps. Postoperative speech therapy and training for swallowing are needed.

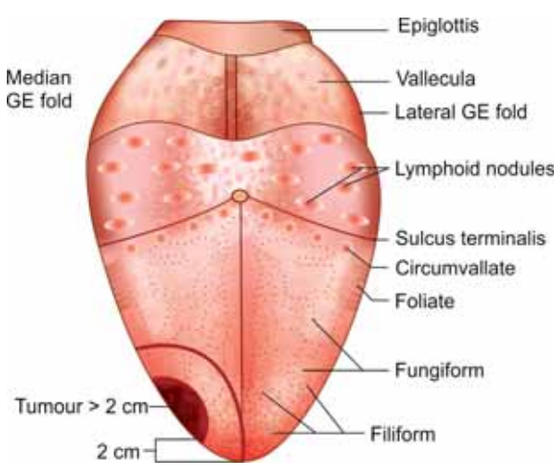
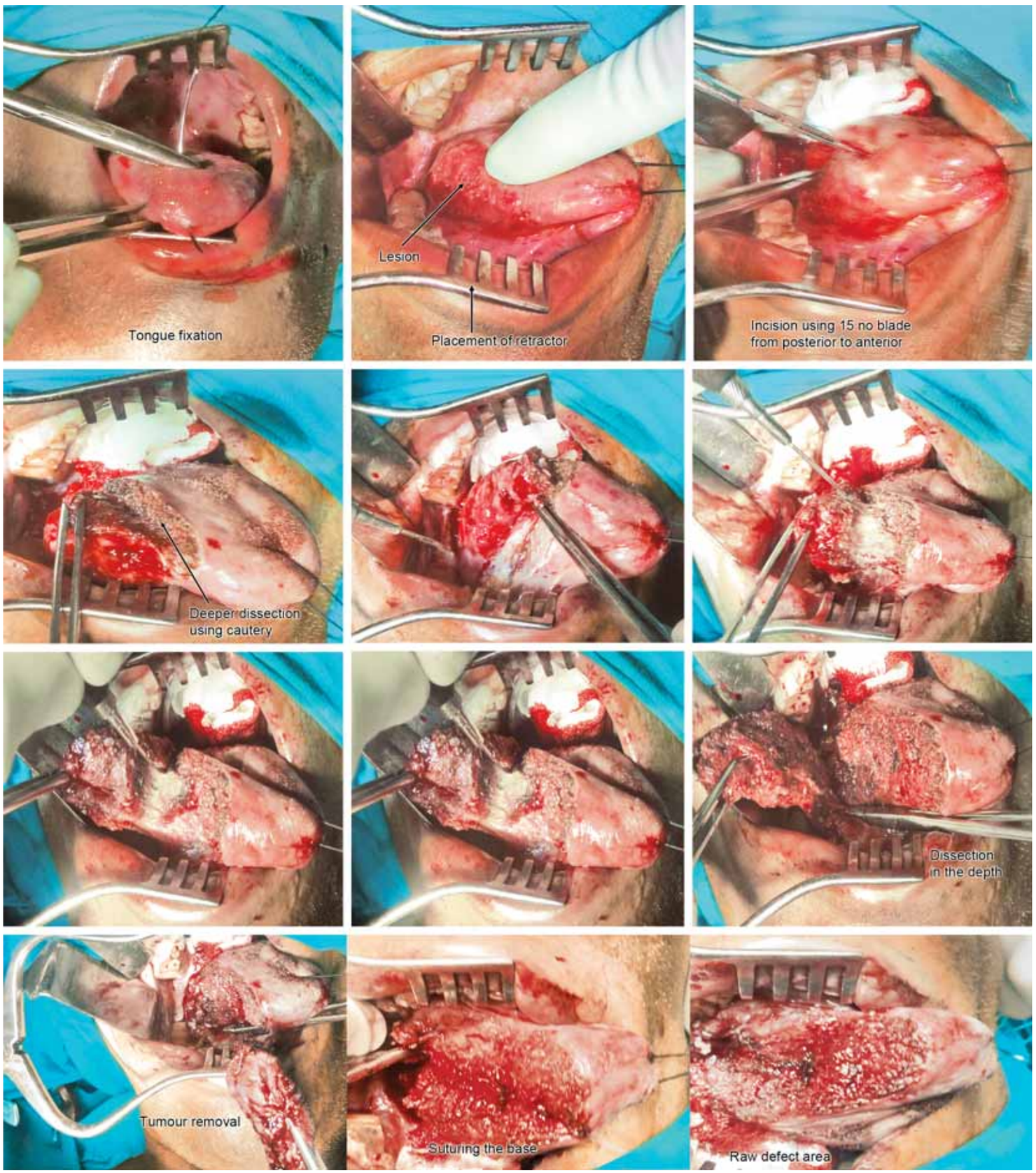


Fig. 14-81: Partial glossectomy is done if lesion is 1-2 cm in size over the lateral margin.


Tongue fixation
Lesion
Placement of retractor
Incision using 15 no blade
from posterior to anterior
Deeper dissection
using cautery
Dissection
in the depth
Tumour removal
Suturing the base
Raw defect area

Figs 14.82(1)

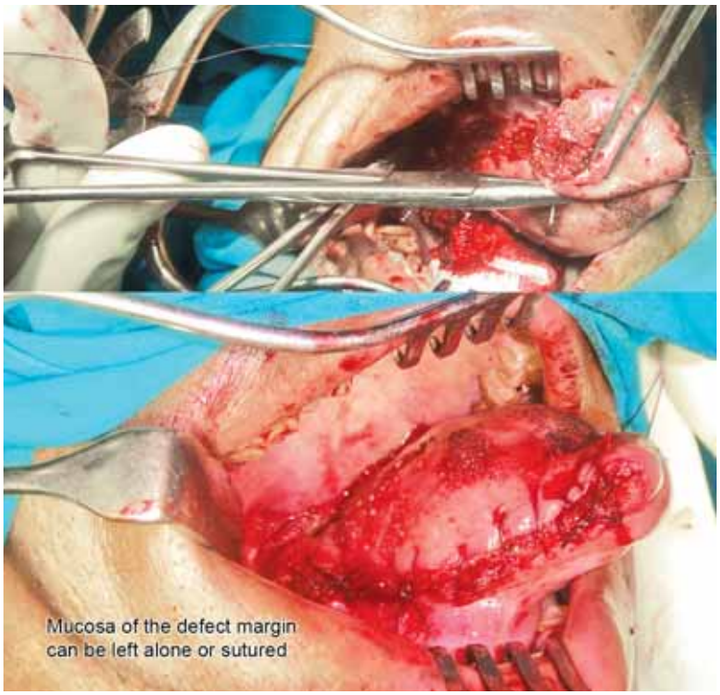


Fig. 14.82(2)

Figs 14-82(1 and 2): Partial glossectomy technique.

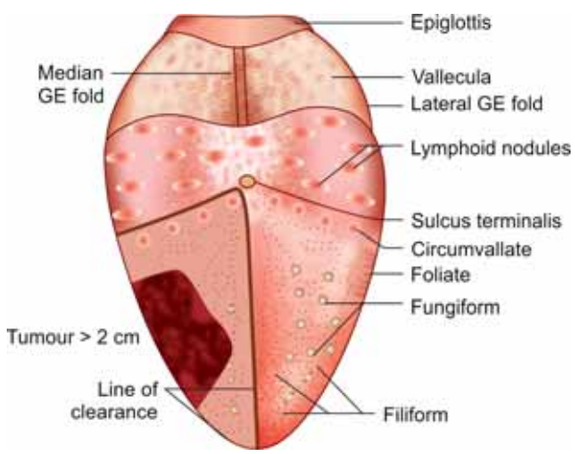


Fig. 14-83: Hemiglossectomy is done if lesion is more than 2 cm in lateral margin.

Approach to Hard Palate Cancers

Surgical Anatomy

Roof of the mouth is formed by hard palate and soft palate. *Hard palate* is firm anterior part of the roof of the mouth ending opposite 3rd molar anterior to fovea palatine. *Soft palate* is mobile posterior part of roof of the mouth. Junction between hard and soft palate is called as *vibrating line*. Small rounded elevation of tissue in the midline behind the central incisors is called as *nasopalatine papilla* which is over incisive foramen through which nasopalatine nerve traverses to supply anterior hard palate. Slightly elevated central line is called as *palatine raphe*. Here mucosa is firmly adherent to underneath periosteum without any fat and so it is harder area of hard palate. Sides of hard palate contain fat and minor salivary glands (there are around 350 minor salivary glands in posterior hard palate). Series of elevations in hard palate are called as *palatine rugae* useful for food positioning and aiding tongue to produce specific sounds. Hard palate is partition between nasal and oral cavity. Anterior 2/3rd is formed by palatine process of maxillae; posterior 1/3rd is by horizontal plates of palatine bones. Anterolateral margins continue with alveolar arches and gums. Posterior margin attaches to soft palate.

Soft palate is redder than hard palate due to its vascularity. There is no bone in soft palate behind vibrating line. Soft palate vibrates or moves. It is mobile muscular fold. It has got anterior and posterior surfaces, superior and inferior margins. Uvula is small fleshy part projecting from center of the posterior margin of the soft palate. Pair of pits on either side of the centre of the soft palate just behind the vibrating line is called as *fovea palatini* to which palatine mucous glands opens. Side of the uvula has got anterior and posterior folds. Anterior palatoglossal arch contains palatoglossus muscle which ends as anterior pillar of fauces (in front of tonsils). Posterior palatopharyngeal arch contains palatopharyngeus muscle which ends as posterior pillar of fauces (behind tonsils). Soft palate contains mucous glands and taste buds. Soft palate contains following muscles – tensor veli palati; levator veli palati; musculus uvulae; palatoglossus; palatopharyngeus. All muscles except tensor palati are supplied through pharyngeal plexus by cranial part of accessory nerve; tensor palati is supplied by the mandibular nerve. General sensory nerves are derived from middle and posterior palatine nerves which are branches of maxillary nerve and from glossopharyngeal nerve. Gustatory special sensations are carried through lesser palatine nerve →greater petrosal nerve →geniculate ganglion of facial nerve→nucleus of solitary tract. Secretomotor fibres are derived from superior salivatory nucleus through greater palatine nerve and lesser palatine nerves. Paralysis of the soft palate (vagus nerve lesions) causes nasal regurgitation of liquids, nasal twang in voice and flattening of palatal arch.

Maxillectomy

Surgical Anatomy

Maxilla is the 2nd largest bone of the face (after mandible). Two maxillae form upper jaw with formation of face, nose, mouth, orbit infratemporal and pterygopalatine fossae. Maxilla has got a body and 4 processes – frontal, zygomatic, alveolar and palatine. Body is pyramidal in shape with base directed medially towards nasal surface and apex directed laterally at zygomatic process. Anterior surface contains incisive fossa and canine fossa. Above the canine fossa there is infraorbital foramen with infraorbital vessels and nerve. Posterior surface forms the anterior wall of the infratemporal fossa. Posterior superior alveolar nerve and vessels are near the centre of the surface. Posteroinferiorly rounded maxillary tuberosity articulates with pyramidal process of the palatine bone. Maxillary tuberosity gives origin to superficial head of medial pterygoid. Anterior wall of the pterygopalatine fossa is above the maxillary tuberosity and is grooved for maxillary nerve. Superior surface forms the floor of the orbit; its medial border forms nasolacrimal canal with lacrimal bone; its medial border articulates with lacrimal, labyrinth of ethmoid, orbital process of palatine bone; superior surface has got infraorbital groove, canal and foramen to transmit infraorbital nerve and vessels. Medial surface forms lateral wall of the nose; posterosuperiorly there is hiatus for maxillary sinus. Above the hiatus parts of ethmoidal and lacrimal air

sinuses are present. Inferior nasal meatus is below the hiatus. Medial surface below the hiatus articulates with perpendicular plate of palatine bone forming greater palatine canal for greater palatine vessels and anterior, middle and posterior palatine nerves. Nasolacrimal groove is present in front of the hiatus to form nasolacrimal canal with the lacrimal bone and inferior nasal concha to transmit nasolacrimal duct to the inferior meatus of the nose. The pyramidal shaped large cavity of 3.5 × 3.5 × 2.5 cm dimension, the maxillary sinus (maxillary antrum) has its base medially and apex laterally. Maxillary sinus opens into the middle nasal meatus with two openings. Roof is formed by the floor of the orbit; floor is formed by alveolar process of maxilla. Floor has got conical elevations by roots of upper molar and premolar teeth. Root of canine tooth projects into the anterolateral wall. Maxilla articulates above to nasal, frontal and lacrimal bones; medially to ethmoid, inferior nasal concha, vomer, palatine bones and opposite maxilla; laterally to zygomatic bone. Maxilla ossifies in membrane from 3 centres - one for maxilla just above the canine fossa during 6th week of intrauterine life; one of the two for premaxilla arise just above the incisive fossa during 7th week of intrauterine life and another at ventral margin of nasal septum during 10th week. Mucosa of the maxillary sinus is lined by squamous epithelium.

Procedure (Fig. 14-84)

Endotracheal general anaesthesia is used. Weber Ferguson incision is made. Entire thickness of upper lip, cheek and lower eyelid is elevated as a lateral flap. The periosteum on the floor of the orbit is elevated. Orbital contents are protected by placing a spatula between the periosteum and the bone. Ala of the nostril is drawn medially after separating from the bone. Nasal process of maxilla is divided at its junction with the nasal bone. Later it separated from the lacrimal and ethmoid bones towards inferior orbital fissure. After dividing zygomatic bone, mouth is widely opened with a gag. Alveolus and hard palate are divided in midline and then from pterygoid process. Maxillary artery and nerve are cut; soft tissues are divided. Gauze pack is placed. Cheek flap is placed on the pack and sutured. Often ligation of external carotid artery in continuity is needed to prevent haemorrhage. In olden days, 7 days prior to surgery ECA used to be ligated. With proper prosthesis and obturator cosmetically it sounds good.

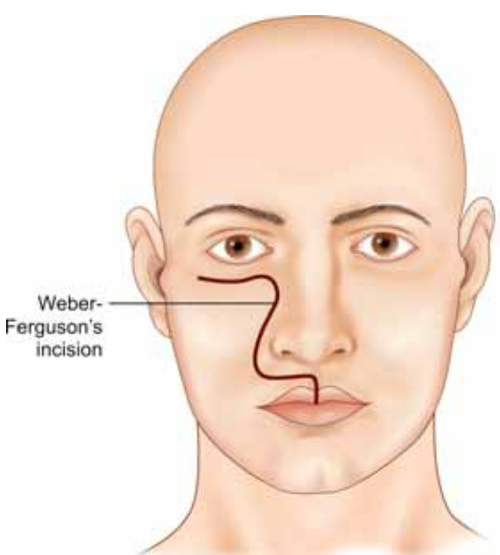


Fig. 14-84: Weber Ferguson incision for maxillectomy.

Maxillectomy Procedure – Types

Partial maxillectomy: It is removal of portions of maxilla, incisive bone, palatine bone with or without portions of the zygomatic and lacrimal bones.

Premaxillectomy: It is unilateral or bilateral with removal of incisive bone and perhaps rostral maxilla.

Central maxillectomy: Here maxilla and portions of hard palate resected.

Caudal maxillectomy: Here maxilla, hard palate, zygomatic, and lacrimal bones removed.

Hemimaxillectomy: It is removal of entire maxilla on one side extending dorsally to ventral orbit.

Orbitectomy: It is removal of orbit with or without caudal maxilla and vertical mandibular ramus.

Maxillectomy can be –

Unilateral rostral – Done when lesions are confined to hard palate on one side. Here one layer closure is done.

Bilateral rostral – Done in bilateral lesions of rostral hard palate.

Lateral – Done in laterally placed midmaxillary lesions; it needs viable buccal mucosa for closure of flap.

Bilateral – Done in bilateral palatine lesions. Defect closure needs formal reconstruction. Closure dehiscence and oronasal fistula is common.

SURGERY FOR LIP LESIONS

Lip being a *complex anatomical structure* needs comprehensive approach to excise the lesion and reconstruct it. Upper lip reconstruction is *more difficult* and demanding as it *involves* in oral competence, speech and phonation. Dynamically upper and lower lips are independent. Lower lip functions in many axes. Thickness, location, size of the lip is important. Mucosa, muscle and skin should be approximated each separately as an individual layer. Defect <30% will be closed with local advancement flaps; defects > 60% need complicated complex approaches. Grafting, local flaps, regional flaps, free flaps are the options. Grafting is not ideal as it creates scarring and poor cosmesis. Contracture, microstomia, adynamic flap in relation to dynamic flap, often need of a second surgery like reconstruction of the commissure are the *problems*.

Simple cyst of the lip derived from mucus gland is excised under local anaesthesia (xylocaine without adrenaline) and sutured primarily using fine absorbable sutures either continuously or intermittently **(Fig. 14-85)**.

Surgical Anatomy of Lip

Lip is the area between the nasolabial folds from the gingivolabial sulcus to the labiomental fold. Vermilion is coverings of lip margin. Its wet part comes into contact with opposite lip; dry part is external lip. Orbicularis oris which origins from modiolus and inserts to philtrum maintains the oral competence. Its horizontal fibres compress the lip; oblique one everts the lip. Elevation of the upper lip is achieved by levator labii superioris, zygomaticus major and levator

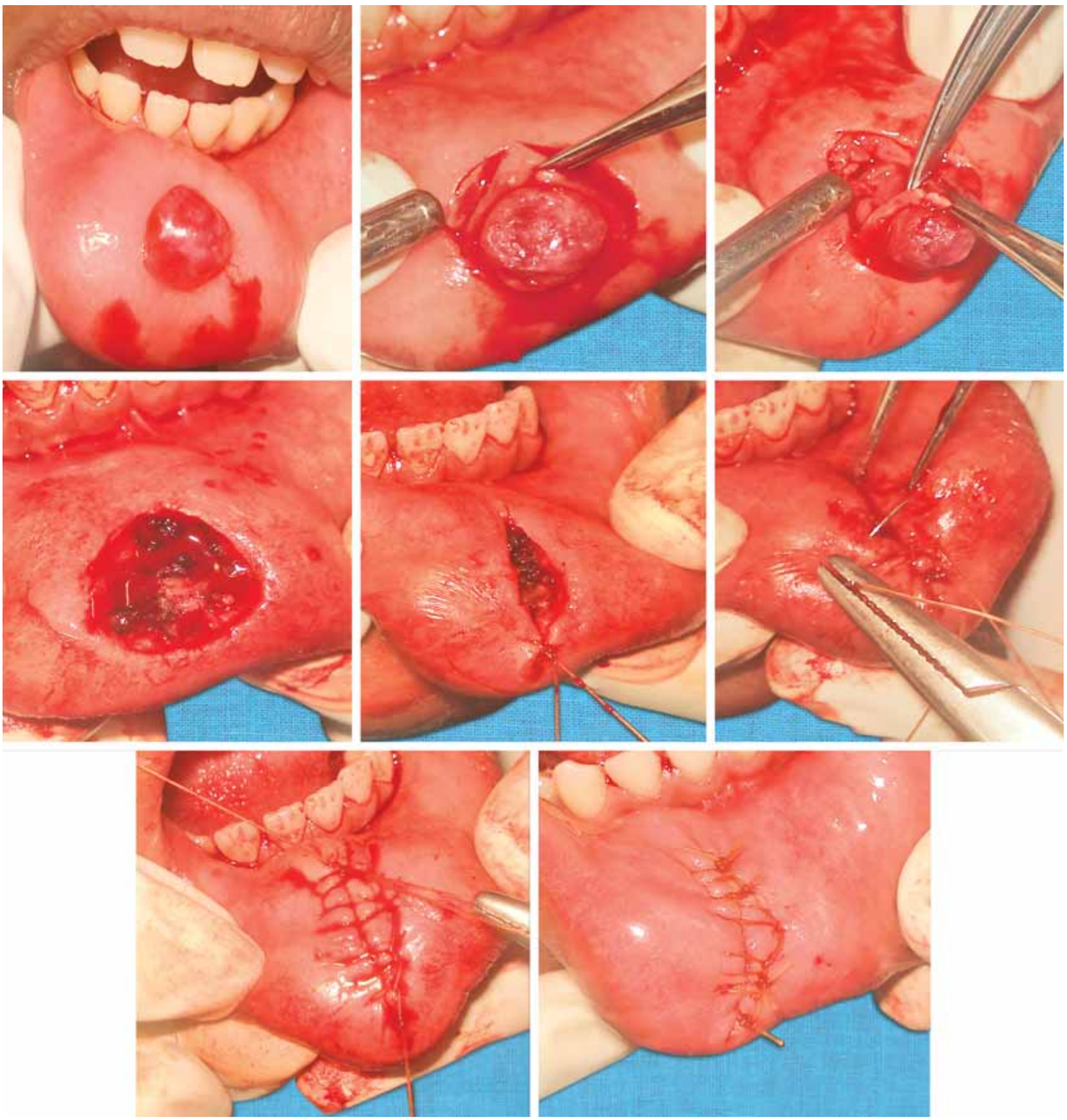


Fig. 14-85: Simple cyst in the lip is excised under local anaesthesia and sutured primarily.

anguli oris. Lower lip depression is brought about by depressor labii inferioris; movement of commissure below and lateral is brought about by depressor anguli oris. Central lip is elevated by mentalis. Muscles around mouth are – orbicularis oris, levator labii superioris, zygomaticus major and minor, levator anguli oris, depressor anguli oris, depressor labii inferioris, mentalis, risorius and buccinators. Motor supply of orbicularis oris is by facial nerve – buccal branch. Depressors are supplied by marginal mandibular branch. Sensory supply of upper lip is infraorbital nerve a branch of ophthalmic division of trigeminal nerve, lower lip is by mental nerve, a branch of mandibular division of trigeminal nerve. Blood supply of lip is by superior and inferior labial arteries, branches of facial artery. Upper and lateral parts of lower lip drain into submandibular lymph nodes; central lower lip drains to submental lymph nodes **(Fig. 14-86)**.

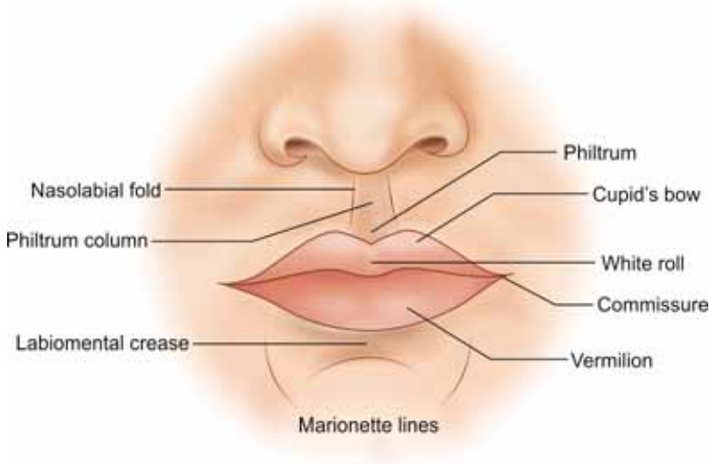


Fig. 14-86: Surgical anatomy of the lip.

Principles in lip surgeries are – restoration of oral competence to achieve control of secretions, drinking, eating and speech; cosmetic achievement of lip; achieving good muscular function; scar placement; prevention of microstomia; creating adequate labial buccal sulcus to prevent drooling. It is impossible to achieve perfect normal lip in texture. Only optimum lip can be achieved by reconstruction.

Indications for lip reconstruction are – carcinoma of lip after wide excision; trauma; dog bite; vasculitis; septic necrosis of lip; congenital anomaly.

Anaesthesia for lip surgery—general or local field block can be used. Upper lip is entirely anaesthetized using bilateral infraorbital nerve block using 26 G needle at a point lateral to alar base and medial to nalolabial fold 7 mm below the infraorbital margin of the medial limbus. This nerve can also be blocked intraorally. Lower lip can be anaesthetised by regional block of mental nerve. Local anaesthetic agent is infiltrated 1 cm lateral to the canines into buccal sulcus.

Defect Less Than One-third of the Lip

Primary Closure

Excision of lower lip up to 1/3rd is sutured primarily without causing any microstomia. Vermilion border of the lip should be kept in opposition. Lip is sutured in layers; deeper layer with 3 zero vicryl; outer layer with 3 zero polypropylene sutures. It is used in upper lip lateral defect and lower lip defects **(Fig. 14-87)**.

Skin grafting, ear composite graft and Abbe flaps are used for upper lip central defects less than 1/3rd.

Defects between One-third to Two-third of the Lip

Here primary closure will cause microstomia, speech, eating and drinking problems. So it should be avoided.

In the upper lip central defect skin grafting, composite graft of ear, Abbe flap, perialar crescent, cheek advancement flaps are used. *In the upper lip lateral defect* Abbe-Estlander flap, perialar crescent, cheek advancement flap, nasolabial flap, reverse Karpandzic flaps are used.

In the lower lip central defect Abbe flap, Schuchardt flap, Webster flaps are used. *Lower lip lateral defect* is covered with Estlander flap, Gillies flap, Karapandzic flap, or McGregor flaps **(Fig. 14-88)**.

Defect More than Two-third of Lip

In upper lip defect – Abbe-Estlander with perialar crescent, cheek advancement flap; nasolabial flap; reverse Karapandzic flap; forehead flap; deltopectoral flap; radial forearm free flap are used **(Fig. 14-89)**.
In lower lip defect - Abbe-Estlander flap, Webster flap; Bilateral Gilles flap; deltopectoral or radial forearm flaps are used **(Figs 14-90 and 14-91)**.

Different Procedures

Estlander's (Abbe-Estlander's) rotation flap of upper lip is based on upper labial artery. It is used when defect is less than half of lip

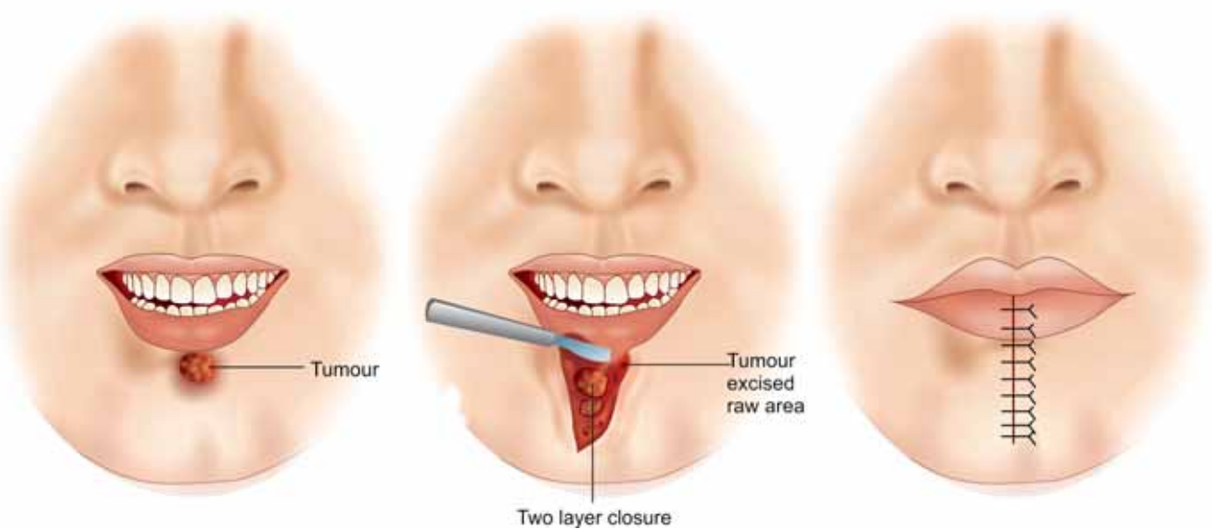
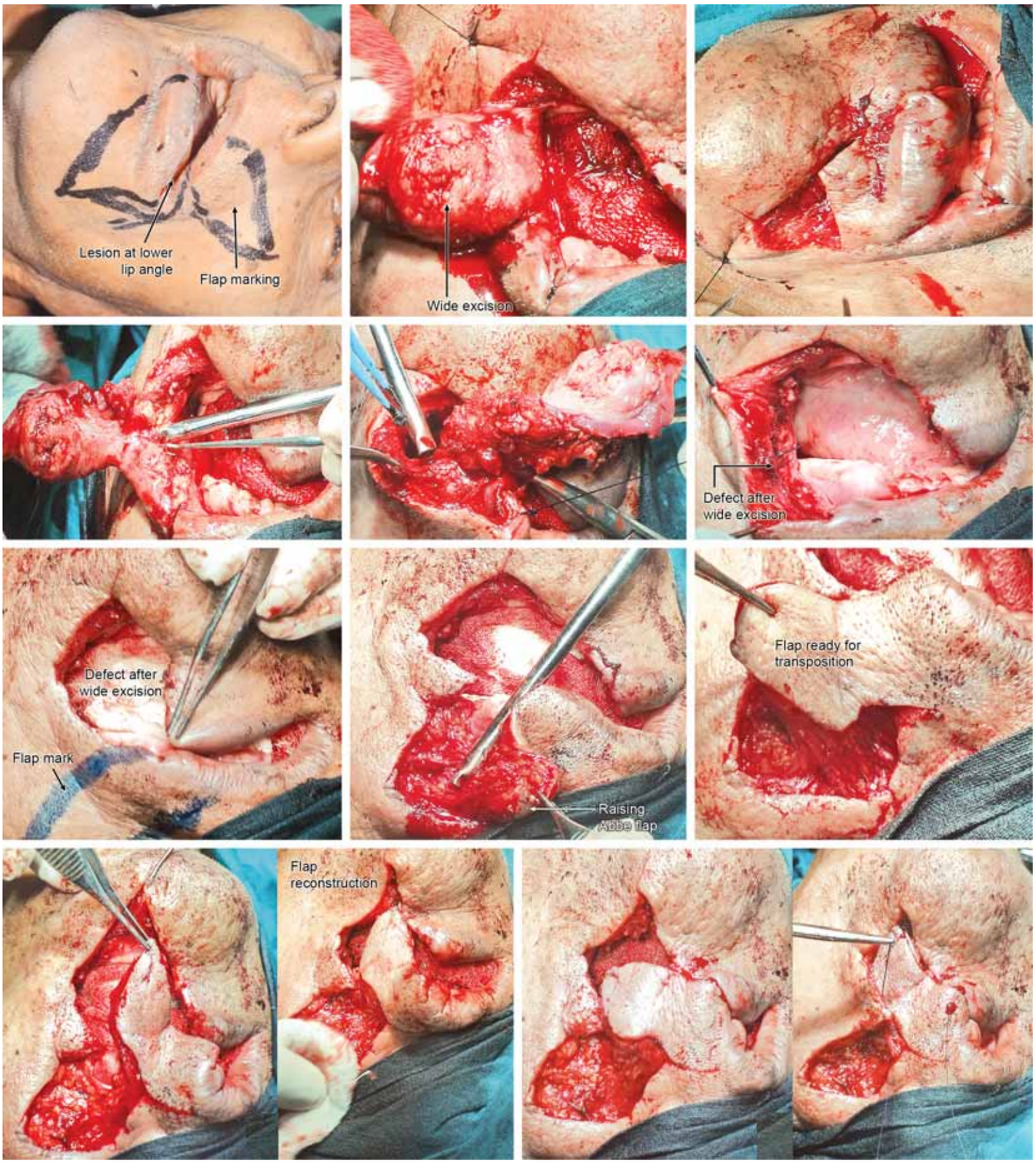
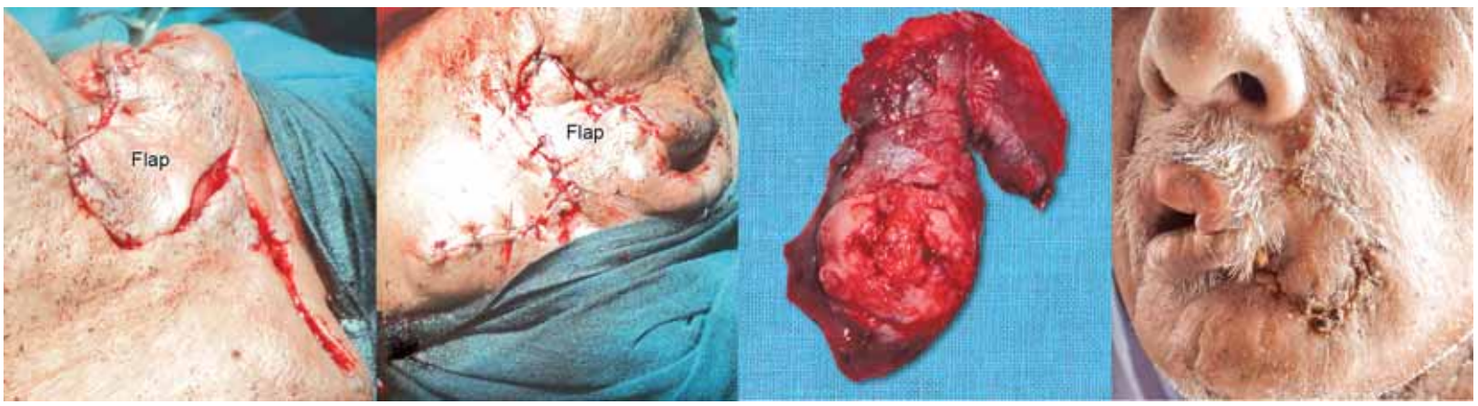


Fig. 14-87: Primary closure of the defect in the lip is possible when defect is less than 1/3rd.


Lesion at lower lip angle
Flap marking
Wide excision
Defect after wide excision
Defect after wide excision
Flap mark
Raising Abbe flap
Flap ready for transposition
Flap reconstruction

Figs 14.88(1)



Figs 14.88(2)

Figs 14-88(1 and 2): Abbe–Estlander flap – reconstruction of the defect in the lip after wide excision. Here 2nd stage base division is not done.

Fig. 14-89: Forehead flap can be used for defect after excision of upper lip lesion of more than 2/3rd in size.

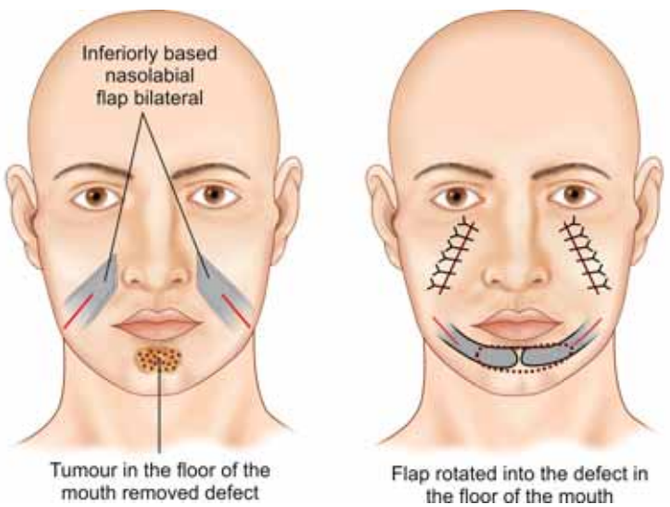


Fig. 14-90: Nasolabial flap can be used in large central defect.

but more than 1/3rd. It is done in lateral lip defects, upper or lower, involving commissure. Flap is denervated and so sensation is absent and drooling of saliva is possible **(Fig. 14-92)**.

Frie's modified Bernard facial flap is done using lateral facial flaps. It is used when defect is more than ½ of lip, midline defect and for commissure reconstruction. Two triangles are excised and cheek flap is rotated and advanced. Vermilion is constructed using advancement of oral mucosa **(Fig. 14-93)**.

Different microvascular flaps are used to cover the defect. Free radial artery flap also can be used.

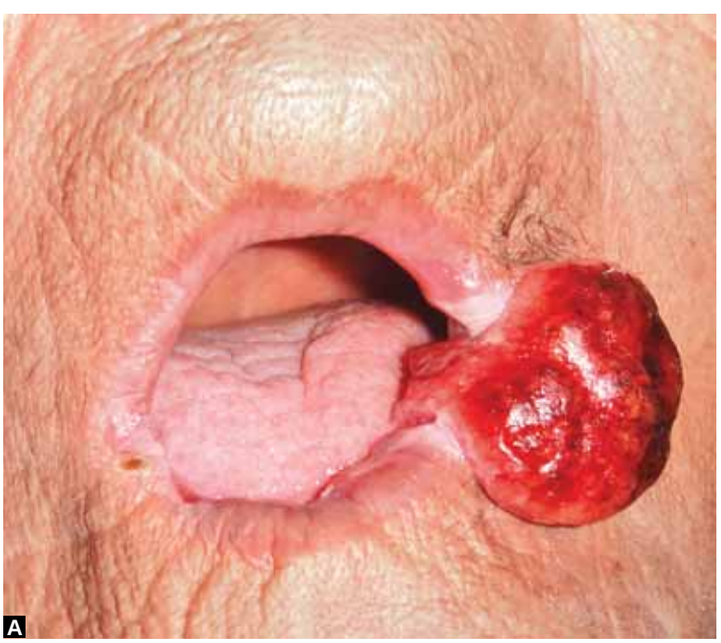
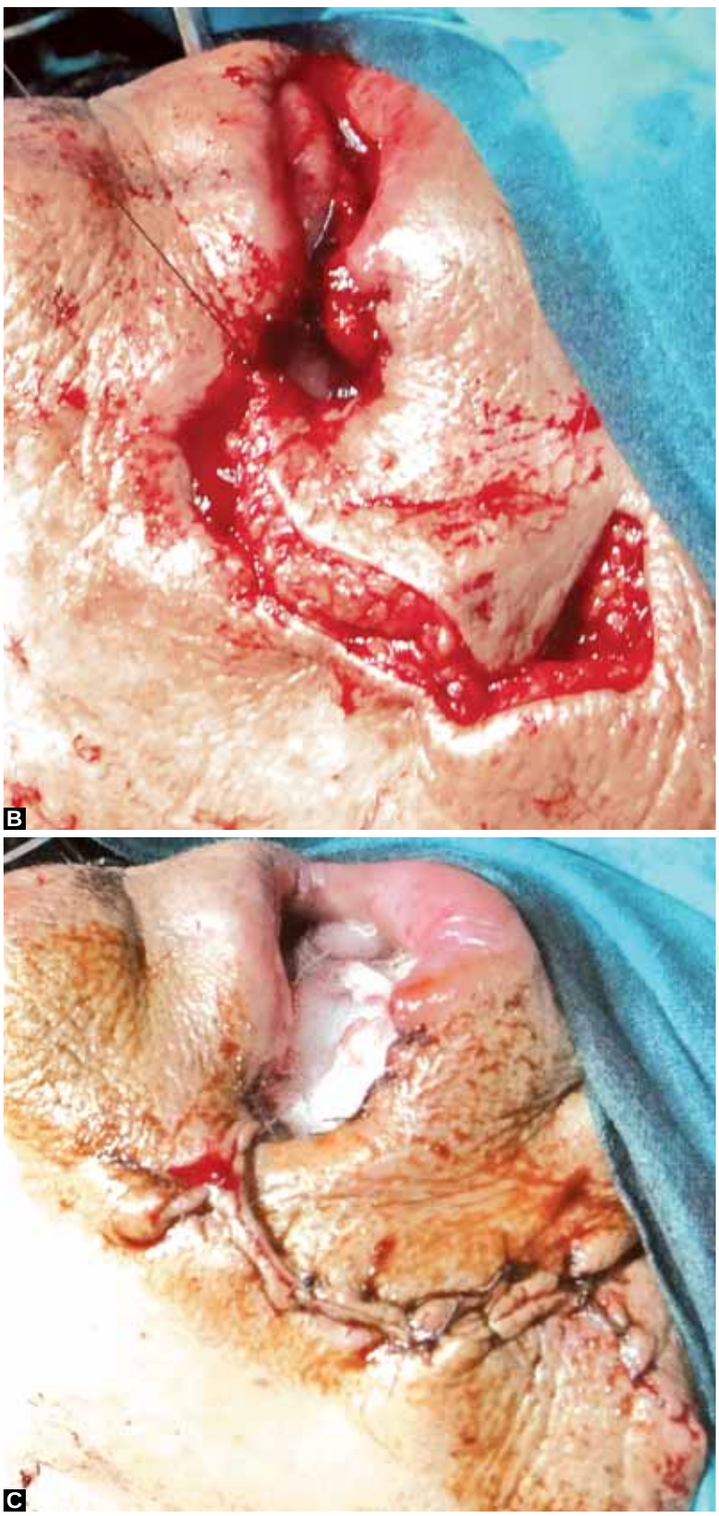


Fig. 14-91A



Figs 14-91B and C

Figs 14-91A to C: Abbe-Estlander flap.

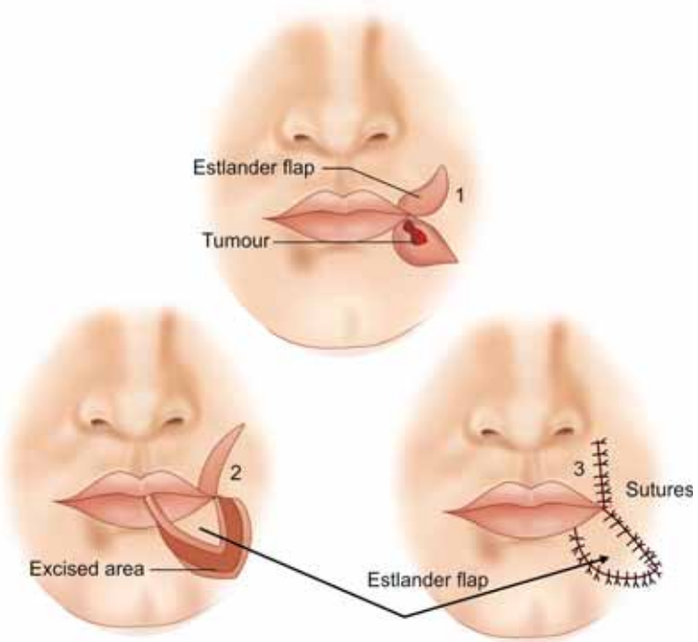


Fig. 14-92: Abbe–Estlander flap for lateral defects in the lip.

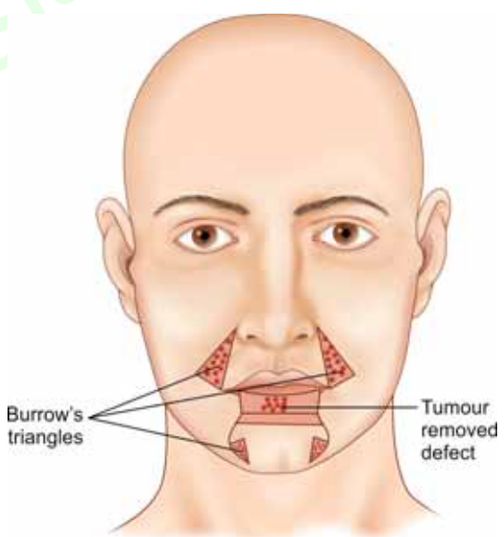


Fig. 14-93: Bernard lateral flaps for central defect.

Nasolabial flap is used when defect is more than ½ of lip and lateral or defect is in the floor of the mouth.

Cheek flap can be rotated when lesion is near the angle of the mouth.

Abbe flap (switch flap) is used in upper/lower lip lesion – central defect. It is taken from lower/upper lip with inferior/uperior labial artery as base. It is transfer of myocutaneous lower/upper lip to upper/lower lip in two staged technique. In first stage myocutaneous full thickness lip flap is elevated with labial artery pedicle to suture into the upper / lower lip defect. Pedicle is divided after 2 – 3 weeks and rotation is completed (switch) with suturing of the further flap **(Fig. 14-94)**.

"W' flap plasty – It is done for lower lip middle tumour which is less than 1/3rd of the lip **(Fig. 14-95)**.

Gillies fan flap – It is a cheek flap usually bilateral but can be unilateral. Incision is full thickness around commissures extending into nasolabial fold and upper lip up to upper lip vermilion border. Flap which is based on labial vessels is advanced towards the defect. Vermilion is reconstructed with tongue mucosal flap which is divided in 3 weeks. Flap is denervated and so sensation is absent and drooling of saliva is possible **(Fig. 14-96)**.

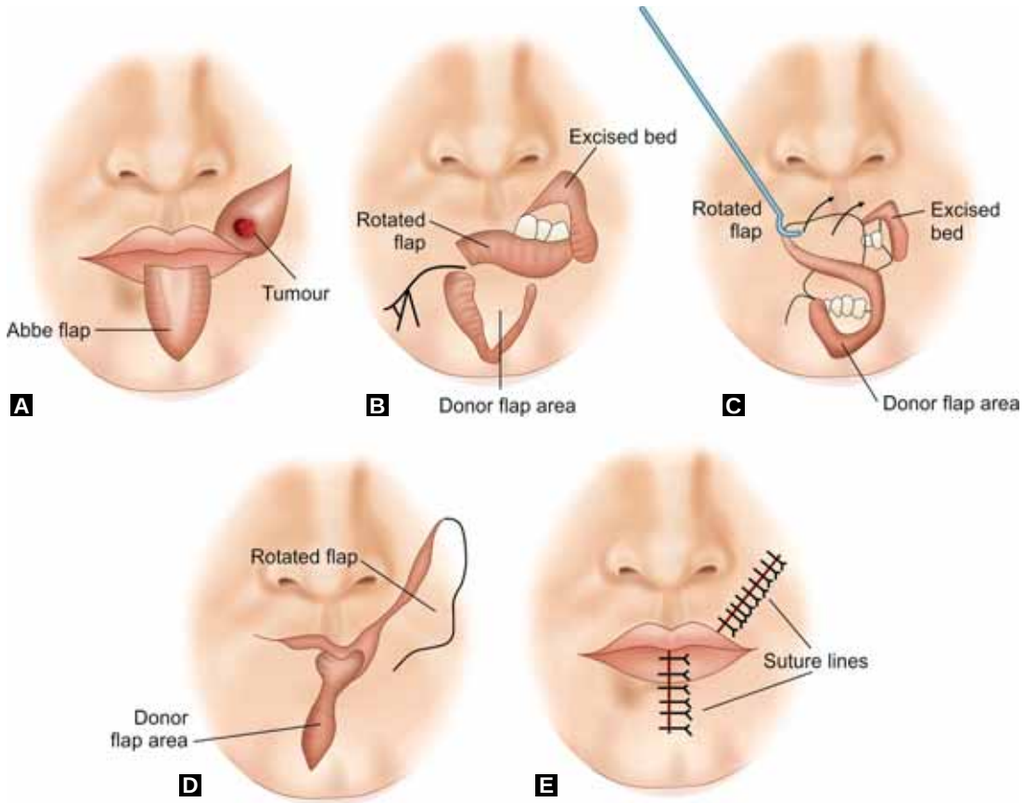


Fig. 14-94: Abbe switch flap.

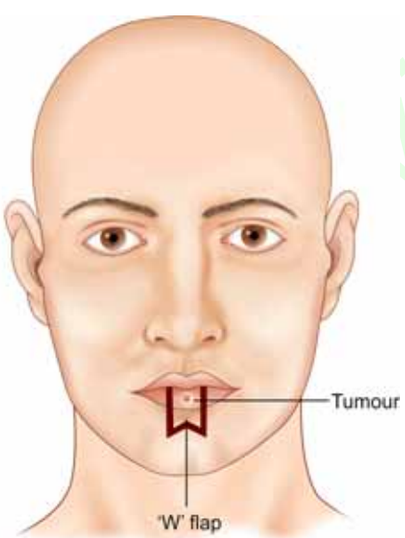


Fig. 14-95: 'W' flap is used for lower lip central defect which is less than 1/3rd of the lip.

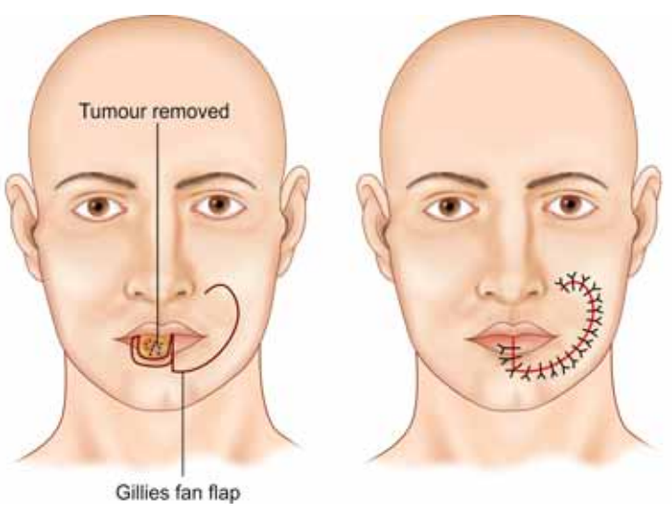


Fig. 14-96: Gillies fan flap is a cheek flap which can be unilateral or bilateral.

Karapandzic flap – It is modified (myocutaneous) version of the Gillies flap used for lower lip defect with less angulation towards upper lip. It preserves motor and sensory supply of flap and so drooling is avoided. Reverse Karapandzic flap is used for upper lip defect.

McGregor and Nakajima flaps modified Gilles flap (denervated) pivot around commissure which prevents microstomia but drooling of saliva can occur.

Zisser technique – Cheek tissue is moved medially after excising two upper and lower triangles later to upper and lower lip. Horizontal incision is made along the commissure to advance de-epithelialised two triangles.

Platz and Wepner method is similar like Zisser's where nasolabial and submental areas are excised triangularly to advance superior and inferior cheek flaps.

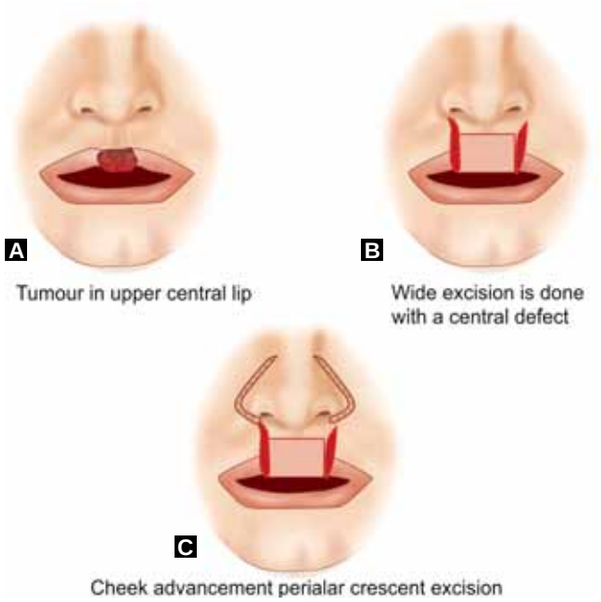


Fig. 14-97: Cheek advancement with perialar crescent excision.

Johansen 'step ladder' procedure is used for extensive carcinoma of lower lip.

Cheek advancement with perialar crescent excision is done for wide upper lip defect **(Fig. 14-97)**.

Other regular flaps like forehead flap, deltopectoral flap also can be used.

Upper Lip Reconstruction

Due to presence of philtrum, upper lip reconstruction is more demanding than lower lip. Wound close to philtrum if primarily sutured, will shift the philtrum to the lesion side.

Lateral defect less than 1/3rd is either closed primarily or V Y flap or nasolabial flap is used. In males nasolabial flap being hairless may be problematic for upper lip.

Central lip defect needs reconstruction of Cupid's bow to prevent flattening. Abbe lip switch flap, skin graft, ear cartilage composite grafts are required to reconstruct Cupid's bow.

Defects between 1/3rd to 2/3rd are corrected using Abbe flap, perialar excision cheek advancement flap.

Defect more than 2/3rd in upper lip is repaired by bilateral reverse Karpandzic flaps, bilateral nasolabial flaps, and forehead flap. First two flaps denervate the lip and may precipitate drooling of saliva. But insensate lower lip is more problematic than insensate upper lip as saliva collects in lower lip and drooling occurs from gravity across the lower lip. Other methods used are perialar crescent excision and cheek advancement; radial forearm free tissue flap with microvascular and nerve anastomosis (anterior cutaneous nerve of forearm to mental nerve).

Lower Lip Reconstruction

It is easier to reconstruct the lower lip than upper as lower lip is devoid of central structure.

Defect less than 1/3rd is closed primarily. One should avoid formation of dog ear or incision crossing the labio mental fold. W flap can be used in central defect less than 1/3rd.

Defect between 1/3rd to 2/3rd is covered using Abbe switch flap from upper lip lateral 1/3rd. 1/4th or 2 cm of upper lip tissue can be transferred. Width of donor lip needed is 1/2 of width of the recipient defect. Recipient site attains pain, temperature, touch and sweating functions in 2 years. Upper lip donor defect can be reconstructed additionally using perialar excision and cheek advancement if needed. *Schuchardt technique* may be used with a modified wedge resection with advancement of the lip contralateral to the lip switch. Webster flap with triangular excisions of skin along the nasolabial crease of the upper lip to mobilise cheek can be used. *Johansen stepwise/stepladder excisions* of 2-4 fold skin around labiomental fold can be used. This avoids microstomia. Unilateral advancement is done for smaller defects; bilateral advancement is done for larger defects.

*Defect more than 2/3rd i*s corrected using bilateral Karpandzic flap or McGregor flap or Webster modification of Bernard burrow flap. Here cheek is advanced medially by triangular excision of skin. Nasolabial fold skin is excised triangularly. Inferiorly based nasolabial Fujimori gate flap, bipedicled tongue flaps, deltopectoral flap and free flaps are other flaps used.

Vermilion Reconstruction

White roll is the mucocutaneous junction. Any defect even of 1 mm size in vermilion is easily seen. White roll should be marked using 25 G needle tip dipped in methylene blue prior to injecting the local anaesthetic drug. One should not place sutures directly on white roll as healing erythema will mask the white roll. Sutures on either side of the white roll should be placed one on vermilion side other on cutaneous side. White roll should cross 90° while placing the incision. Resection of the entire vermilion from the white roll to wet-dry junction of vermilion is called as *lip shave/ total vermilionectomy* which is done for premalignant conditions and actinic lip involvement. Buccal mucosa is advanced above orbicularis oris as bipedicled flap. V Y advancement of labial or buccal mucosa is commonly used. Mental nerve runs in submucous gland plane and so plane of dissection is between submucous gland plane and orbicularis oris. Lip switch or tongue flaps are also often used. Ventral tongue flap is used in females to facilitate application of the lipstick; dorsal tongue flap is used in males. Full thickness palatal mucosal graft and tattooing are other options for vermilion reconstruction.

Commissure Reconstruction

It is done using Estlander flap, Fries technique, Zisser procedure, or Platz and Wepner technique **(Fig. 14-98)**.

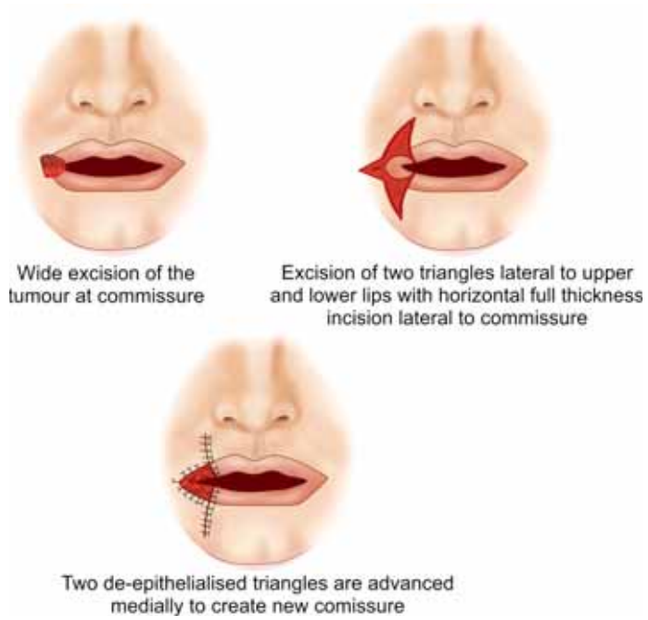

Wide excision of the tumour at commissure
Excision of two triangles lateral to upper and lower lips with horizontal full thickness incision lateral to commissure
Two de-epithelialised triangles are advanced medially to create new comissure

Fig. 14-98: Zisser commissure reconstruction method.

Chapter

15

Surgery for Thyroid and Parathyroid

SURGICAL ANATOMY OF THYROID (*THYROID – 'SHIELD LIKE'*)

Development

Thyroid gland develops (*origin)* from columnar cells of pharyngeal floor as a median down growth between 1st and 2nd pharyngeal pouches; point which later forms foramen caecum at the base of primitive tongue (*thyroid primordium*). These columnar cells form a tube which gets canalised to form thyroglossal duct. While descending downwards (*by migration*) it gets displaced forward by developing hyoid bone and below the hyoid bone it descends further slightly towards left side which eventually bifurcates into one on each side to form two lateral lobes. Part present at its junction of bifurcation forms isthmus. Once gland is formed remaining portion of the duct obliterates; part of the duct on left side forms pyramidal lobe.

Origin → migration → obliteration of duct mostly except lower most part which forms pyramidal lobe → Differentiation of the gland, isthmus and pyramidal lobe.

Neural crest → along the ultimobranchial body → incorporation of parafollicular C cells in the thyroid adjacent to follicles.

Ectopic thyroid tissue can occur and may be the only thyroid tissue which is present along the line of the duct in the posterior tongue (lingual thyroid) or suprahyoid region. It is identified by radioisotope scanning.

Thyroglossal cyst occurs due to persistence of a portion of the thyroglossal duct. Entire duct and centre portion of the body of the hyoid bone has to be removed with removal of suprahyoid portion of the duct up to the foramen caecum.

Agenesis of one lateral lobe or both can occur. Only existing one lateral lobe may present as toxic or nontoxic solitary nodule.

Anatomy (Thyroid Means – Shield)

It is a butterfly shaped, brownish red coloured, vital endocrine gland situated in the central compartment of neck. It is located in anterior triangle of neck, 5 (height) × 3 (depth) × 1.5 (width each lobe) cm in size weighing about 20-25 gram (slightly more in women). Gland may get enlarged during menstruation and pregnancy. It has got right and left lateral lobes occupying the thyroid space between trachea and oesophagus medially and carotid sheath laterally extending from middle of thyroid cartilage to 6th tracheal ring. Right lobe is larger than left. Isthmus is connecting part between two lateral lobes extending from 2nd to 4th tracheal rings. Isthmus is around 1.5 ×1.5 cm in size. It is absent in 10% of individuals. Gland extends from C5 to T1 vertebral level behind; from middle of thyroid cartilage to 5th/6th tracheal rings in front. Thyroid space is between trachea and oesophagus medially and carotid sheath laterally. Normal gland is soft and supple. *Pyramidal lobe* is an extension of gland upwards on the surface of the cricoid towards left side which often extends above to the hyoid bone as a fibrous or muscular strand from the junction of isthmus and left lateral lobe. It is present in only 33% (1/3rd) of individuals. Fibromuscular extension to hyoid bone is called as *levator glandulae thyroideae*. Gland is invested by pretracheal fascia. It is supported by a strong condensed vascular connective tissue between lateral lobe and cricoid cartilage on each side called as *Berry's ligament*. True thyroid capsule is peripheral condensed connective tissue and blood vessels are deeper to it. True capsule is covered by false capsule which is derived from pretracheal layer of deep cervical fascia. It is thin in front; thick behind and forms Berry's ligament above and behind. Surgical avascular plane is located between true and false capsule. (In prostate, surgical cleavage plane is located deep to true capsule) **(Figs 15-1 to 15-5)**.

Each lateral lobe has got lateral, medial and posterolateral surfaces; anterior and posterior borders; apex and base. Lateral surface is covered by sternocleidomastoid, sternohyoid and omohyoid; and sternothyroid in deeper plane. Medial surface is related to trachea, oesophagus, cricothyroid and inferior constrictor; external laryngeal and recurrent laryngeal nerves. Anterior jugular veins run on the anterior surface in front of muscles **(Fig. 15-6)**.

Deep fascia of neck has got four compartments – investing layer; prevertebral fascia; pretracheal fascia; carotid sheath.

Muscles in the anterior aspect of the neck are classified as –

Suprahyoid muscles

- Stylohyoid
- Geniohyoid
- Mylohyoid.

Infrahyoid muscles – Strap muscles

- Sternohyoid – in front

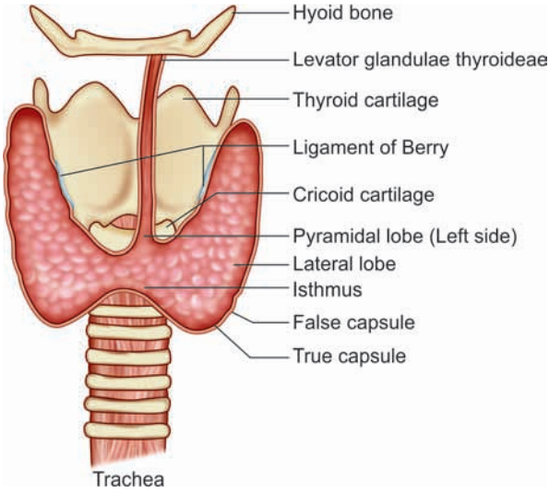


Fig. 15-1: Parts of the thyroid with their locations and relations. Two lateral lobes; one isthmus; one pyramidal lobe.

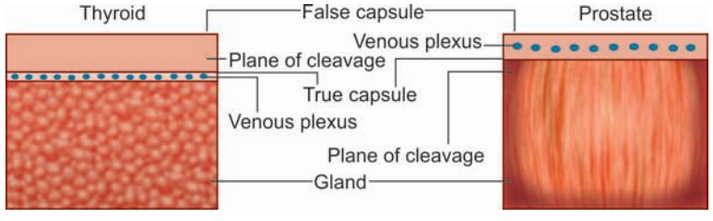


Fig. 15-2: Surgical avascular plane in thyroid is located between true and false capsule. In prostate surgical cleavage plane is located deep to true capsule.

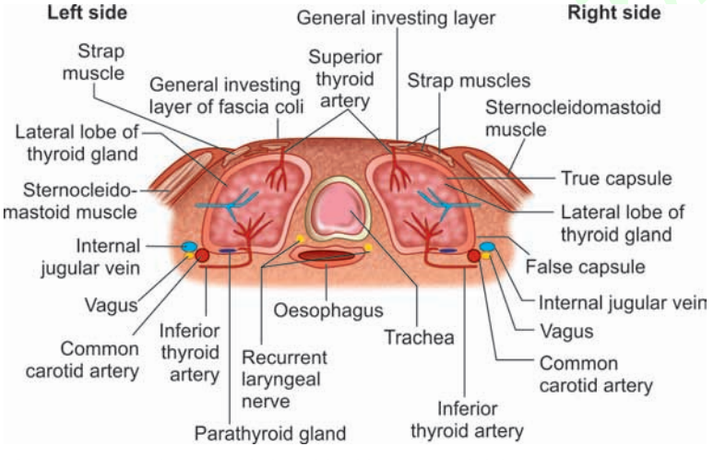


Fig. 15-3: Fascia around thyroid with true and false capsules.

- Omohyoid - in front
- Sternothyroid – deep to above muscles
- Thyrohyoid – deep to above muscles

Arterial supply is –

1. ***Superior thyroid artery*** which is a branch of external carotid artery enters the gland near the superior pole as a larger anterior superficial branch and a smaller posterior branch. It is accompanied by external laryngeal nerve, a branch of superior laryngeal nerve (a branch of vagus), which supplies cricothyroid muscle.

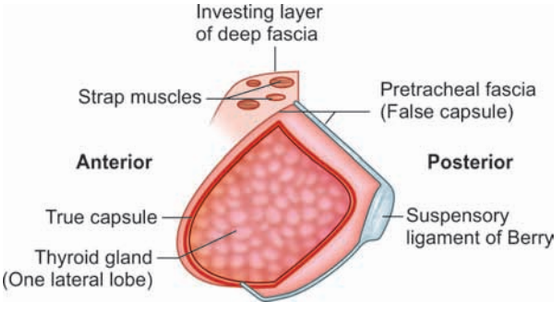


Fig. 15-4: True and false capsules of thyroid and suspensory ligament of Berry.

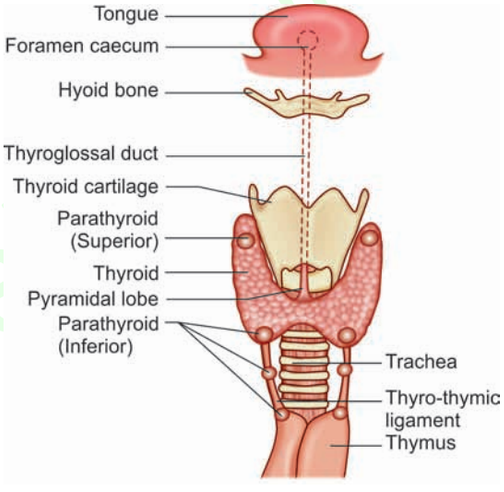


Fig. 15-5: Anatomy of thyroid gland, thyroglossal duct and parathyroids.

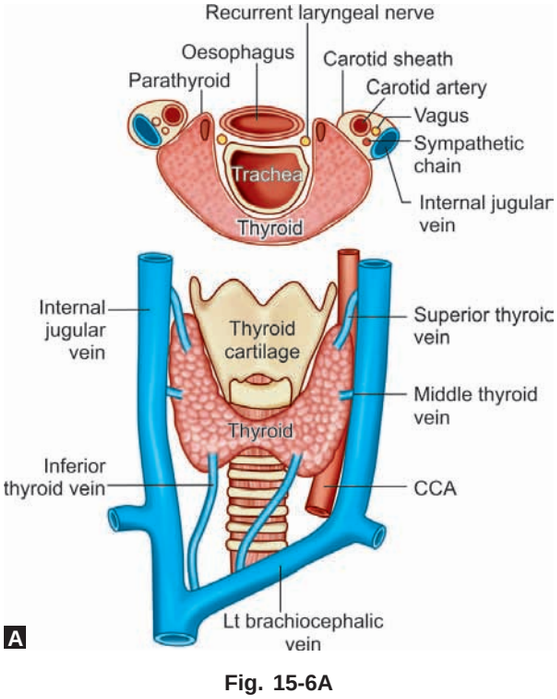


Fig. 15-6A

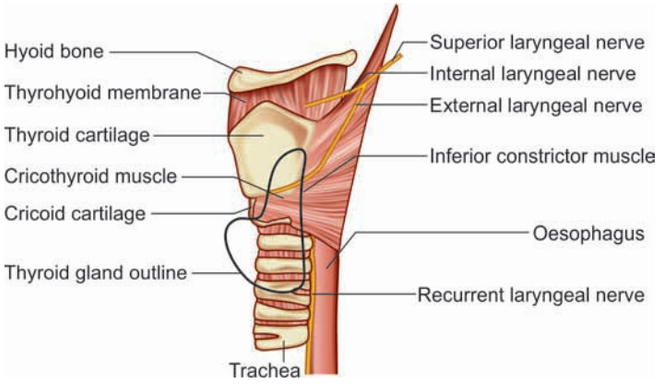


Fig. 15-6B

Figs 15-6A and B: Relations of thyroid gland–diagrammatic look.

2. ***Inferior thyroid artery*** is a branch of thyrocervical trunk of subclavian artery runs upwards, medially then downwards behind the carotid sheath and middle cervical sympathetic ganglion, in front of vertebral vessels divides into 4-5 terminal branches which pierce the pretracheal fascia separately to supply and enter the lower pole of the thyroid. Its ascending branch also supplies the parathyroid glands (both lower and upper).

3. *Thyroidea ima* artery (3-10%) also called as lowest thyroid artery arises from arch of aorta or brachiocephalic artery enters the gland and isthmus.

4. *Accessory thyroid art*eries arise from tracheal and oesophageal arteries also supply the gland **(Fig. 15-7)**.

Venous supply is by –

1. *Superior thyroid vein* from upper pole accompanying the artery to join IJV or common facial vein.

2. *Middle thyroid vein* is a short, wide, thin walled vein begins from mid-lateral aspect of the lateral lobe running a short distance in front or behind the carotid artery, immediately enters into the IJV. Secure ligation of the vein is needed and if it tears, it may extend into IJV causing torrential haemorrhage. As it is the one that holds the gland posteriorly, it should be ligated first to mobilise the gland. Occasionally this vein may be absent. One should also remember that there is no middle thyroid artery.

3. *Inferior thyroid veins* begin at lower pole of isthmus form a plexus in front of trachea later joining the respective brachiocephalic vein. These veins are not accompanied with inferior thyroid artery. Occasionally both inferior thyroid veins form a common trunk – thyroidea ima vein which joins left brachiocephalic vein.

4. *Kocher's 4th thyroid vein* may be present occasionally between middle and inferior thyroid vein, joins either IJV or middle thyroid or inferior thyroid vein.

Note:
Anterior jugular vein is a small but variable vein begins at submental region below the chin, descends vertically in superficial fascia 1 cm from midline. At 2.5 cm above the sternum, it pierces the deep investing fascia to enter the suprasternal space. Here it is connected by a communicating vein to opposite side called as jugular venous arch. Later the vein runs laterally deep to sternocleidomastoid towards its posterior border up to the clavicle to join the external jugular vein. Anterior jugular vein is variable – may be absent; may be in midline; may be quite large drained by common facial vein. This vein is important in thyroid surgeries even though it is not related to venous drainage of thyroid gland **(Fig. 15-8)**.

Nerve Supply

It is mainly from middle cervical ganglion partly from superior and inferior cervical ganglion.

Lymphatic Drainage

(1) *Primary nodes* are trachea- prelaryngeal nodes (*Delphian*), pretracheal and paratracheal nodes, oesophageal nodes, and mediastinal nodes (brachiocephalic also called as superior mediastinal nodes). (2) *Secondary nodes* are deep cervical, supraclavicular and occipital nodes **(Fig. 15-9)**.

Note:
Recurrent laryngeal nerve is in trachea-oesophageal groove in relation to Berry's ligament and is very important structure in thyroidectomy. Parathyroid glands are four in number, two on each side – often embedded in thyroid gland. Removal of all four glands in thyroidectomy may lead into severe hypoparathyroidism and hypocalcaemia.

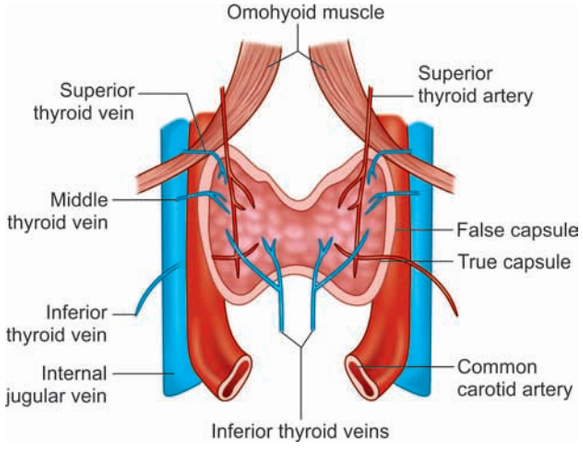


Fig. 15-7: Vessels of the thyroid gland.

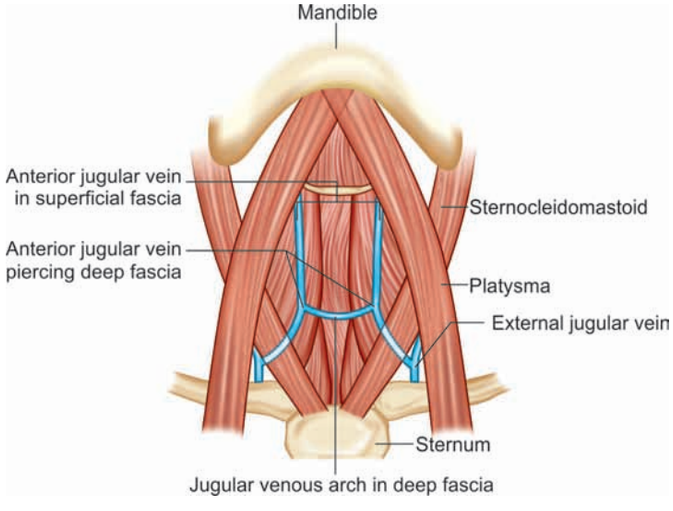


Fig. 15-8: Anatomy of anterior jugular vein.

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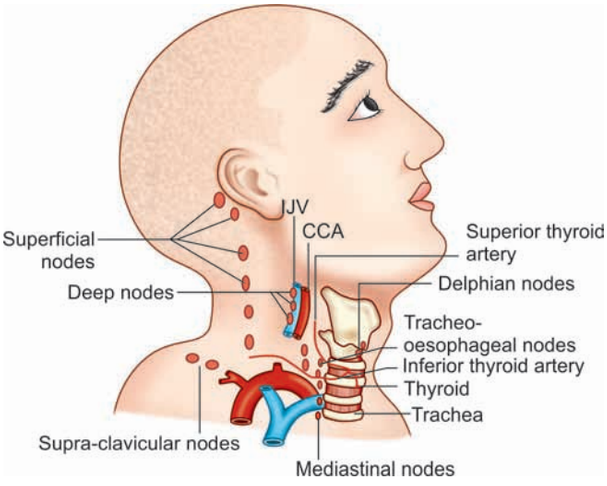


Fig. 15-9: Lymphatic drainage of thyroid gland.

Anatomy and Relations of Nerves with Thyroid Gland

External Laryngeal Nerve

External laryngeal nerve is a branch of superior laryngeal nerve. Vagus gives superior laryngeal nerve branch from its inferior ganglion of vagus which is at the level of greater cornu of hyoid bone, which in turn divides into internal laryngeal and external laryngeal nerves. Internal laryngeal nerve pierces the thyrohyoid membrane and gives sensory supply to larynx above the vocal cord and hypopharynx. External laryngeal nerve runs close to superior thyroid vessels to supply cricothyroid muscle which is tensor of vocal cord. It may get injured while ligating superior pedicle causing defective pitch of the voice. So the upper pedicle of thyroid should be ligated close to gland but after identification and dissection of the nerve **(Fig. 15-10)**.

Recurrent Laryngeal Nerve

Recurrent laryngeal nerve is a branch of vagus which hooks around *ligamentum arteriosum* on the left with arch of aorta and right

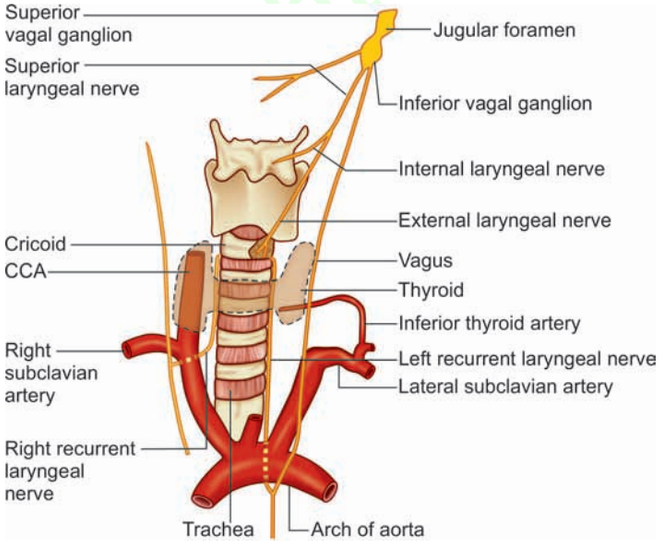
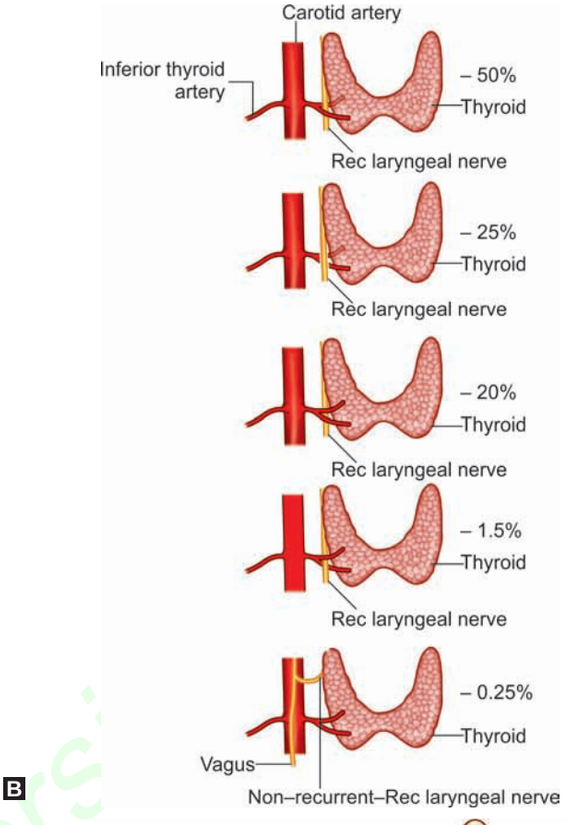


Fig. 15-10A



Figs 15-10B and C

Figs 15-10A to C: Anatomy of recurrent laryngeal nerve and external laryngeal nerve.

subclavian artery on the right side. It runs in the tracheo-oesophageal groove near the posteromedial surface close to thyroid gland. Nerve lies in between branches of inferior thyroid artery. On the right side, the nerve runs between branches of the artery in approximately 50% of patients, anterior to the artery in 25% and posterior in 25%. On the left, the nerve runs posteriorly to the artery in 50% of patients, in 35% the nerve runs between branches, in 15% it is anterior to the artery. So the nerve is always near the artery, but the exact relationship cannot be determined. Hence inferior thyroid artery should be ligated away from the gland (old theory, not practiced now). Anomalies of the nerve should be remembered. In 5% of cases nerve passes through the gland. Nerve may be much more away from the gland. Nerve may be closely

adherent to gland posteriorly. Nerve may lie within the ligament of Berry (25%). Redd in 1943 described 28 variations in RLN relation to inferior thyroid artery. In his observation – RLN is deep to artery in 40%; superficial in 20% and in between branches in 35%; only in 17% of cases pattern were same in both sides.

Nonrecurrent laryngeal nerve may be present in 1 to 5 in 1,000 cases with a horizontal course. In 5 of 1000 patients, a nonrecurrent laryngeal nerve is found on the *right side*. This arrangement occurs when a retroesophageal right subclavian artery arises from the dorsal side of the aortic arch. *The non-recurrent laryngeal nerve branches* from the vagus at approximately at the level of the cricoid cartilage and directly enters the larynx without looping around the subclavian artery. A left-sided non-recurrent laryngeal nerve can occur only when a right-sided aortic arch and ligamentum arteriosum are concurrent with a left retroesophageal subclavian artery.

RLN supplies all muscles (abductors, adductors) of the larynx except cricothyroid and also sensory supply of larynx below the vocal cords **(Fig. 15-11)**.

Muscles of the Larynx

- Cricothyroid – It is the only muscle which is located on the external aspect of the larynx. It is supplied by external laryngeal nerve. It is tensor and mild adductor of the vocal cord.
- Abductors of the vocal cord – Posterior cricoarytenoids.
- Adductors of the vocal cord – Lateral cricoarytenoids, transverse arytenoid, thyroarytenoids and cricothyroids.
- Relaxant of vocal cords – Thyroarytenoids and vocalis.
- Muscles which close the laryngeal inlet – Oblique arytenoids and aryepiglottic.
- Muscles which open the laryngeal inlet – Thyroepiglotticus **(Fig. 15-12)**.

Positions of vocal cord –

Median; paramedian (1.5 mm); normal; cadaveric/neutral (3.5 mm); gentle abduction (7 mm); completely abducted (9.5 mm).

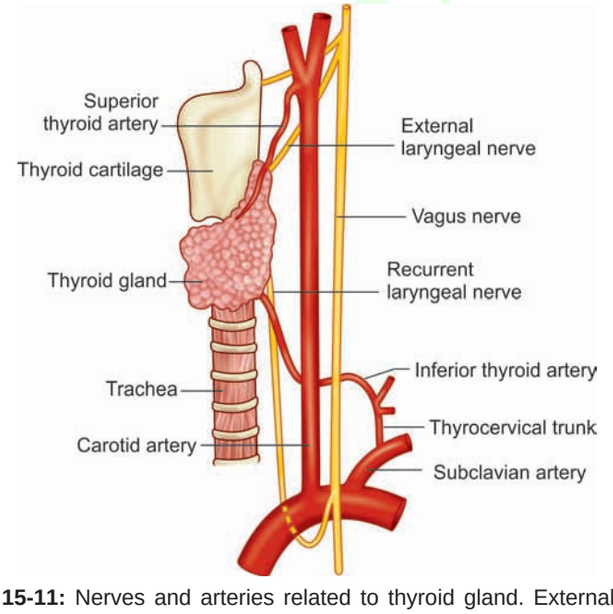


Fig. 15-11: Nerves and arteries related to thyroid gland. External and recurrent laryngeal nerves and superior and inferior thyroid arteries are important structures while doing thyroidectomy. Parathyroid glands are also equally important.

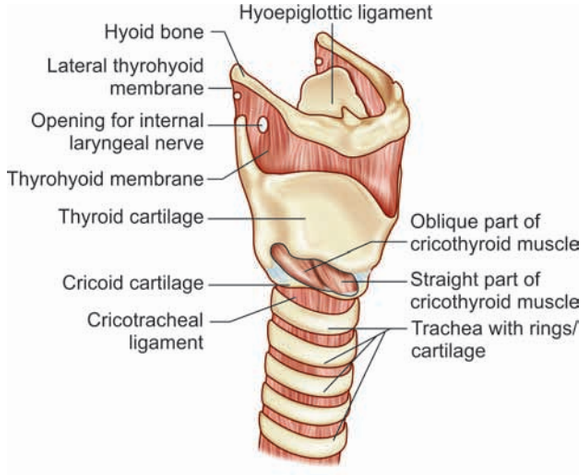


Fig. 15-12: Thyroid and cricothyroid cartilages with cricothyroid muscle. Cricothyroid has got straight and oblique parts. Straight originates from arch of cricoid cartilage to posteroinferior margin of the thyroid lamina. Oblique part runs from cricoid cartilage to inferior horn of thyroid cartilage. Cricothyroid is supplied by external branch of superior laryngeal nerve. Branch is closely associated with superior thyroid vessels.

Assessment of voice change

- Pitch of the voice- whether raised/lowered or pitch locked
- Breath support during speaking is adequate or not
- Ability to alter the rapidity of speech – slow/fast/medium
- Altered laryngeal and neck muscle tension
- *Indirect laryngoscopy*- with tongue pulled out using gauze, warmed ILS is introduced into the oral cavity to see vocal cords. Patient is asked to say 'e' to see the vocal cord movements

Rule of '2' in thyroid

- 2 lobes
- 2 origins – Thyroglossal duct, C cells neural crest
- 2 capsules – true, false
- 2 arteries
- 2 nerves related deep
- 2 tubes related deep
- 2 muscles related deep
- 2 lymphatic drainage area – central and lateral
- 2 parathyroids each lateral lobe
- 2 triangles – BHEARS; JOLLS
- 2 hormones (T3/T4; Calcitonin)

Jolls triangle	**BHEARS triangle**
Formed by midline; strap muscles; sup thyroid pedicle. Its floor is cricothyroid. It contains external laryngeal nerve.	RLN; CCA; inferior thyroid artery; at anteromedial aspect of the thyroid.

Hyoid Bone

It is U shaped bone located in the middle of the anterior aspect of the neck between chin and thyroid cartilage. It develops from 2nd and 3rd branchial arches. It is suspended by tips of the styloid processes of two temporal bones by stylohyoid ligament. It lies at the level of base of the mandible in front and 3rd cervical vertebra behind. It provides attachment to tongue and floor of the mouth above; larynx below; epiglottis and pharynx behind. It has got central body and two pairs of greater and lesser cornua.

Anterior surface of the body is convex and is directed forwards and upwards. Posterior surface of body is directed backwards and downwards. There is a transverse ridge in the body which divides the body of the bone into upper and lower parts and deep cervical fascia is attached to it. Geniohyoid, mylohyoid, genioglossus, hyoglossus, sternohyoid, omohyoid and thyrohyoid muscles are attached to body. Thyrohyoid membrane is attached to upper border from behind and below. Pretracheal fascia is attached to lower border. Greater cornua gives origin to middle constrictor medially and hyoglossus laterally; insertion of stylohyoid muscle; attachment of fibrous loop (pulley) of central tendon of the digastric muscle. Two small conical spike like projections lesser cornua give attachments to stylohyoid ligaments one on each side.

Thyroid moves upwards during deglutition –

- During 1st stage of deglutition
  ↓
- Hyoid moves upwards by constrictor action
  ↓
- Pulls pretracheal fascia upwards
  ↓
- Pulls ligament of Berry
  ↓
- Pulls thyroid upwards

Note:

All structures enclosed in pretracheal fascia will move with deglutition –

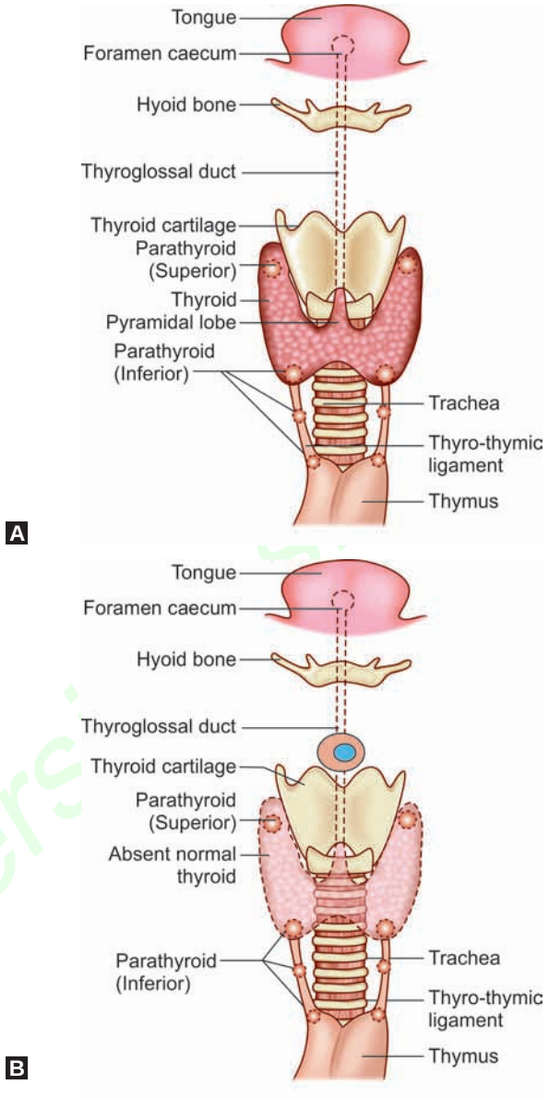
- Thyroglossal cyst
- Pretracheal lymph nodes
- Subhyoid bursa

EXCISION OF THYROGLOSSAL CYST

Thyroglossal cyst is due to congenital incomplete regression of the thyroglossal duct along its pathway, persisting as tubulodermoid cystic swelling in the midline towards left which causes a 'tug' while protruding the tongue and also moves upwards while swallowing. Often gland will be present only in the wall of the cyst with empty thyroid fossa. Ultrasound neck, radioisotope study, T3, T4, TSH and FNAC of cyst is needed before surgical removal. Entire track up to the foramen caecum of tongue (at the junction of middle and posterior third of the tongue) should be excised to prevent recurrence or fistula formation **(Fig. 15-13)**.

Technique (Sistrunk Operation) (Fig. 15-14)

It is done under general anaesthesia. Position is supine with neck extended. Through transverse neck incision placed over the cyst, skin flap is raised above along with platysma. Care should be taken not to open the cyst. Deep fascia is opened vertically in midline. Cyst with surrounding tissues is dissected up to the hyoid bone. Sternohyoid and thyrohyoid muscles are separated and retracted. Cyst is mobilized upwards along with the track. Track is densely adherent to the body of hyoid bone above. Hyoid bone is separated from the thyrohyoid membrane through a clean fascial plane without fear of opening the pharyngeal wall. Geniohyoid and mylohyoid muscles superiorly and sternohyoid inferiorly are divided off from the hyoid. Central 1 cm part of the hyoid bone is resected along with intact track within it. Track with adjacent tissues is dissected above up to the foramen caecum. Adjacent tissues also should be removed because of possibility of multiple tracks which otherwise lead to recurrence or fistula formation. Often anaesthetist is asked to apply digital pressure over base of the tongue near foramen caecum to facilitate the dissection and to confirm the reach up to the foramen caecum. Track is ligated at foramen caecum using 3 zero vicryl and removed. Recurrence rate by removal of only track without central hyoid is 25%. Removal of track with central hyoid reduces the recurrence rate to 5%. Haemostasis is maintained using bipolar cautery. A suction drain is placed.



Figs 15-13A and B: Thyroglossal cyst when present commonly normal lateral lobes will be present. But occasionally normal lateral lobes may be absent and only thyroid tissue existing in these patients will be in the wall of the thyroglossal cyst.

Complications of Neck Injury

Complications are recurrence, thyroglossal fistula formation, haemorrhage/haematoma formation and infection. Occasionally two transverse incisions are needed to allow proper dissection

THYROIDECTOMY

Thyroidectomy is a surgery of *precision, patience and perfection*.

Principles are –

- Absolute haemostasis. Bipolar cautery should be used. Minimise/avoid using monopolar cautery in main dissection as lateral heat may damage RLN or parathyroid blood supply.

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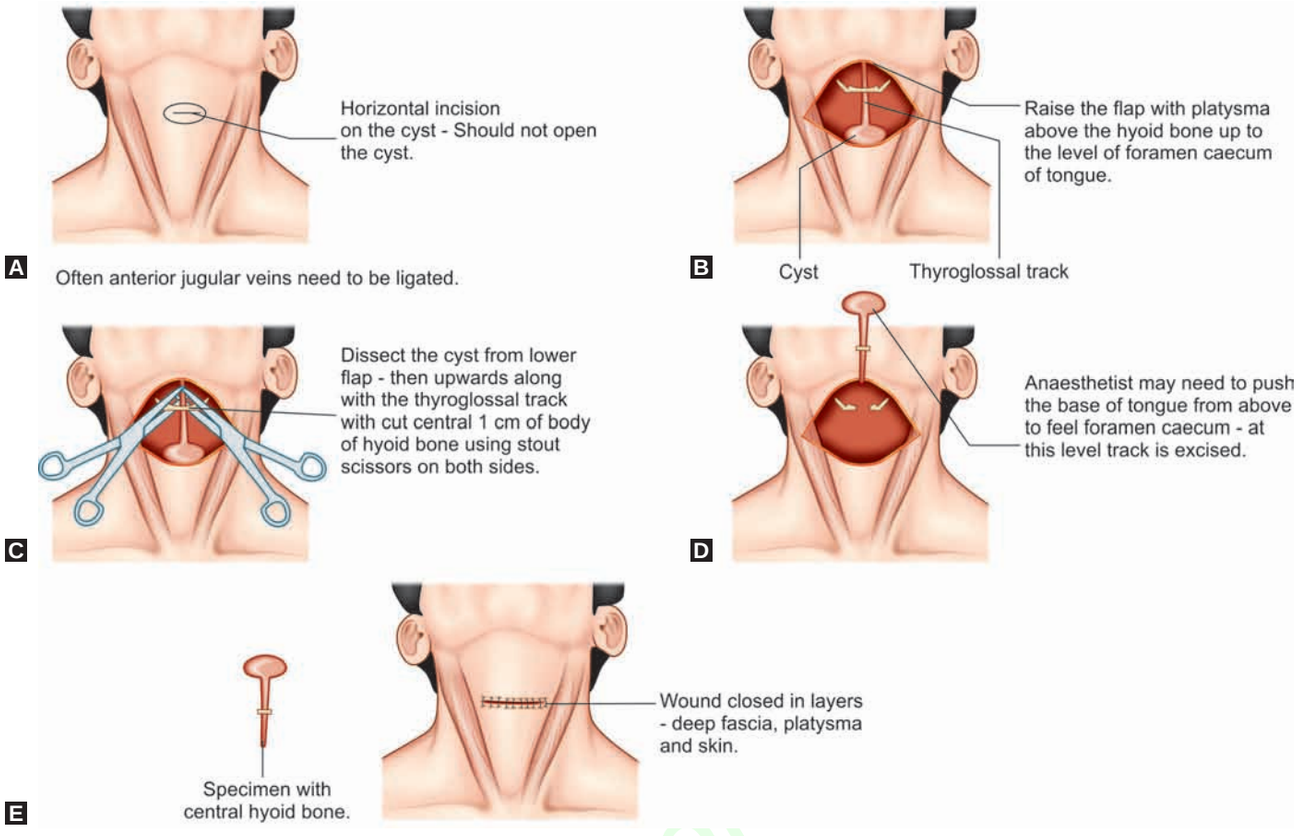
Horizontal incision on the cyst - Should not open the cyst.
A
Often anterior jugular veins need to be ligated.
Raise the flap with platysma above the hyoid bone up to the level of foramen caecum of tongue.
B
Cyst
Thyroglossal track
Dissect the cyst from lower flap - then upwards along with the thyroglossal track with cut central 1 cm of body of hyoid bone using stout scissors on both sides.
C
Anaesthetist may need to push the base of tongue from above to feel foramen caecum - at this level track is excised.
D
Wound closed in layers - deep fascia, platysma and skin.
Specimen with central hyoid bone.
E

Fig. 15-14: Thyroglossal cyst excision steps – A to E.

- Prevention of injury to recurrent laryngeal nerve and external laryngeal nerve.
- Preservation of parathyroid glands.
- Cosmesis.
- Meticulous technique.
- RLN and ELN should be identified during dissection. All vessels should be ligated individually. One should avoid mass ligation even though it is commonly practiced.
- Middle thyroid vein, superior thyroid artery and vein then inferior thyroid vessels are ligated in order.

Preoperative preparation

- Blood grouping, cross matching and required blood should be kept ready.
- Indirect laryngoscopy. Patient is asked to tell 'E' to check the abduction of vocal cord. IL scope should be soaked in warm water to prevent fogging and blurring of the IL scope.
- Serum calcium estimation; T3, T4, TSH; Thyroid antibodies, endocrinologist's opinion.
- ECG and cardiac fitness especially in toxic goiter.
- Radioisotope iodine scan; FNAC.

Different Types of Thyroidectomies

Hemithyroidectomy

It is removal of one lateral lobe with entire isthmus. It is done in benign disease involving only one lobe like solitary nodule thyroid either toxic or nontoxic (adenoma/colloid goitre of one lobe/ colloid cyst). After hemithyroidectomy, if histology report comes as differentiated malignancy either papillary or follicular then completion thyroidectomy is done immediately within one week. If histology report comes after one week then completion thyroidectomy is done after 3 weeks. Reexploration is not advisable in 2nd and 3rd weeks **(Fig. 15-15)**.

Subtotal Thyroidectomy

It is removal of most of both lateral lobes including isthmus, except around 8 gram of tissue (or tissue equal to pulp of little finger) in lower

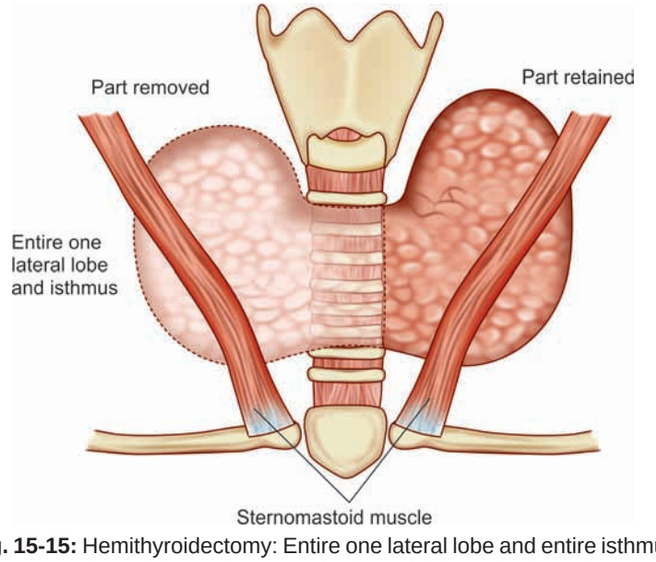

Fig. 15-15: Hemithyroidectomy: Entire one lateral lobe and entire isthmus are removed retaining entire opposite lateral lobe. It is done in solitary nodule/toxic or non-toxic adenoma in one lobe.

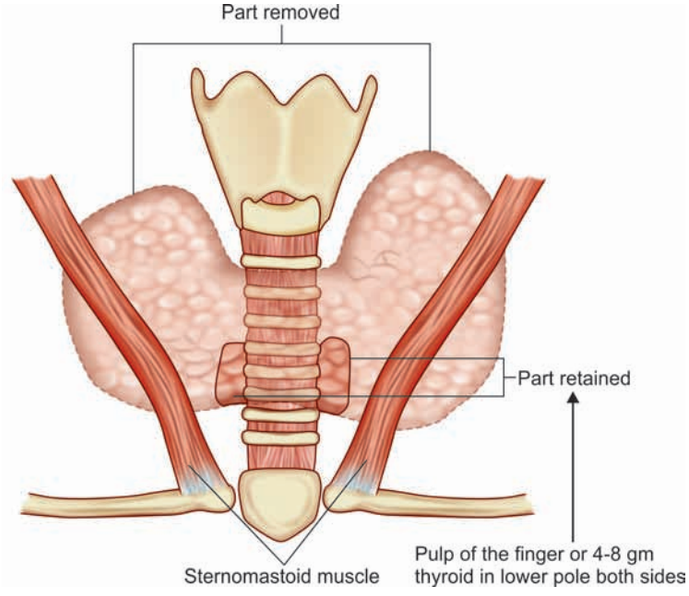

Fig. 15-16: Subtotal thyroidectomy.

pole. It is done in toxic thyroid and often in nontoxic multinodular goitre. It reduces the incidence of hypoparathyroidism and injury to recurrent laryngeal nerve **(Fig. 15-16)**.

Partial Thyroidectomy (Thomas)

It is removal of mobilised gland in front of trachea including entire isthmus. It was the procedure done earlier in nontoxic multinodular goitre. It is at present *not commonly used* **(Fig. 15-17)**.

Near Total Thyroidectomy

Here both lateral lobes except small tissue in lower pole are removed. It is to safeguard the recurrent laryngeal nerve and *parathyroid blood supply*. It is advocated in papillary carcinoma of thyroid (usually in young individuals). Isthmus is entirely removed. Tissue is retained either in one or both sides **(Fig. 15-18)**.

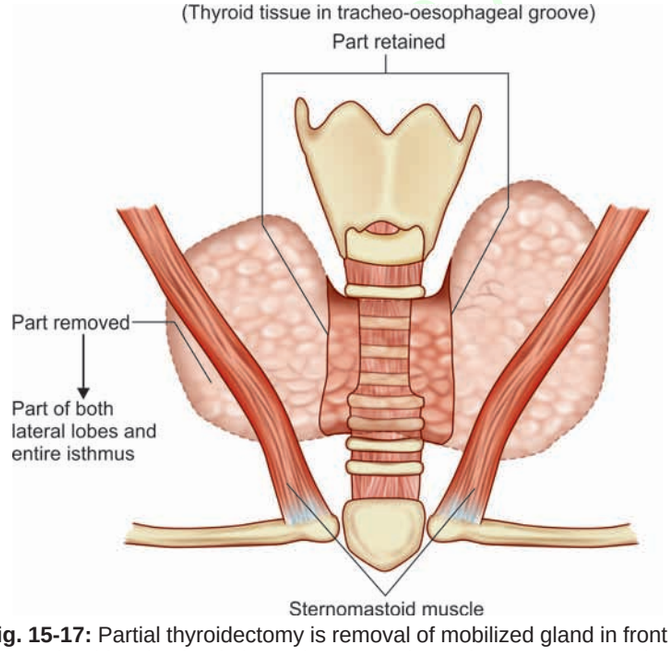

Fig. 15-17: Partial thyroidectomy is removal of mobilized gland in front of the tracheal level. Glands in trachea-oesophageal grooves are retained. It is not commonly done now.

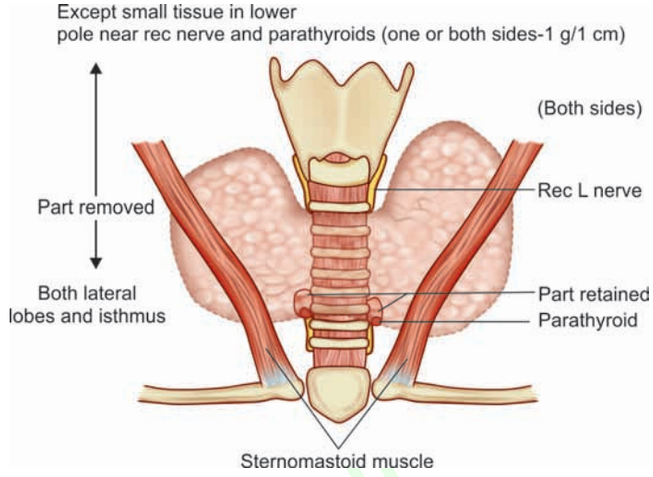

Fig. 15-18: Near total thyroidectomy.

Total Thyroidectomy

Here entire gland is removed without retaining any tissue. It is the *present procedure of choice in most of the thyroid diseases* except benign disease limited to one lateral lobe. It is done at present in nontoxic multinodular goitre, toxic goitre, carcinoma thyroid (follicular/medullary/papillary/operable/anaplastic) **(Fig. 15-19)**.

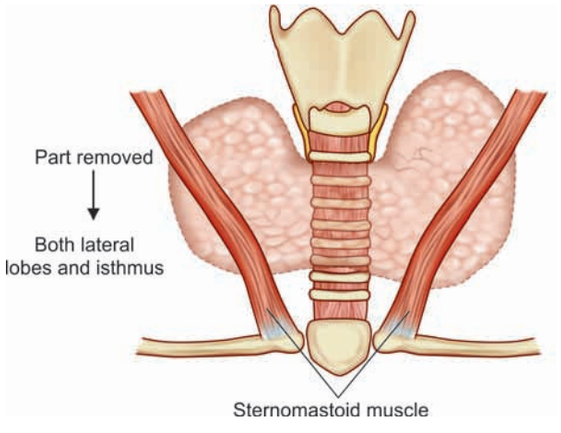

Fig. 15-19: Total thyroidectomy. It is done in follicular carcinoma and medullary carcinoma of thyroid.

Hartley Dunhill Operation

It is removal of one entire lateral lobe, isthmus and partial/subtotal removal of opposite lateral lobe. It is used in nontoxic multinodular goitre **(Fig. 15-20)**.

Isthmectomy

It is done in advanced carcinoma or occasionally in Riedel's thyroiditis to treat severe stridor due to tracheal narrowing.

Note: Isthmus should be removed in entirety in any type of thyroidectomy, and if it is retained partially it gets adherent to wound in front creating a cosmetically poor scar **(Fig. 15-21)**.

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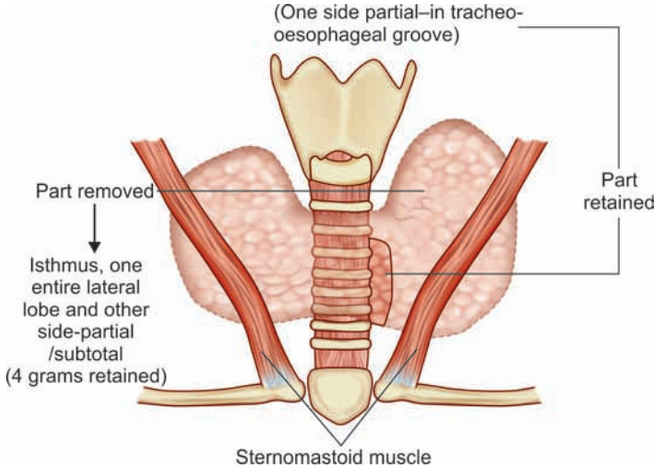

(One side partial–in tracheo-oesophageal groove)
Part removed
Part retained
Isthmus, one entire lateral lobe and other side-partial /subtotal (4 grams retained)
Sternomastoid muscle

Fig. 15-20: Hartley Dunhill operation.

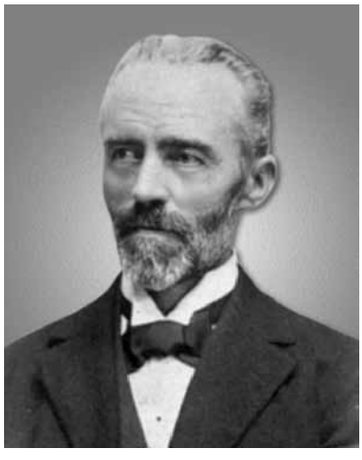


Fig. 15-21: Emil Theodor Kocher – Father of thyroid surgery.

Procedure (Fig. 15-21)

Anaesthesia

General anesthesia is used. Occasionally local anaesthesia can be used in patients who are not fit for general anaesthesia. Oesophageal stethoscope often may be required to place in case of retro/para-oesophageal goitres.

Position

Neck is extended by placing sandbag/round bolus/Dunhill pillow/folded sheet/*inflatable thyroid pillow*/inflatable intravenous fluid cuff underneath the shoulder. Ring should be kept under the occiput. Both arms are kept beside patient's body and hands are tugged/tucked under the patient's buttock. Cotton pads are placed under the elbow to prevent ulnar nerve compression. Head end of the table is elevated to 15° to improve venous return so as to reduce venous congestion in the neck and so oozing (reverse Trendelenburg/Rose/Barking dog/Kocher's position). This increases the risk of air embolism due to negative pressure created in neck veins. Veins should be ligated securely and then only cut. Any doubtful air in IJV should be aspirated immediately **(Fig. 15-22)**.

Anaesthetists are on the head end away from the field of surgery with sides kept free for surgeon, assistant and scrub nurse.

Cleaning of the area – neck, face, chest up to nipples is done. Draping is done on all sides. *Double towel* is placed under the head and one of the towels (outer one) is covered over the outer part of the endotracheal tube. Sterile transparent plastic drape is ideal if available. Surgeon stands on right side, assistant on left side and scrub nurse on right side at foot end of the patient. Energy sources like cautery (both unipolar and bipolar)/ ligaseal/harmonic, etc. are kept ready. Suction apparatus with fine suction tip is needed **(Fig. 15-23)**.

Incision

Horizontal crease incision is placed two fingerbreadth (2-3 cm) above the sternal notch extending from posterior border of one sternocleidomastoid to opposite side. Incision is marked by placing stretched thread or silk over the skin. It can be marked using marking ink. Often few surgeons use 60 ml of 1 in 400000 adrenaline saline to inject into the superficial fascia to reduce bleeding while raising the flap. Skin is incised using no 15 blade. In women with heavy breasts incision is placed slightly at higher level than usual as subsequent scar may be dragged downwards close to sternum creating ugly scar. Platysma is identified and incised slightly at higher level than skin to prevent it getting adherent to scar at a later period **(Fig. 15-24)**.

Raising the Flaps

Upper flap (*subplatysmal flap*) is raised up to thyroid cartilage (platysma is absent in the midline); lower flap up to sternoclavicular joint/clavicular heads and suprasternal notch **(Figs 15-25 and 15-26)**.

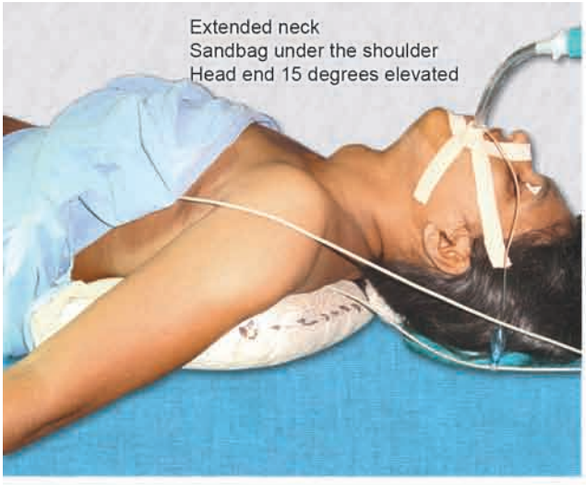
Rising of flap is done either using cautery or no. 15 blade or curved sharp scissor or blunt gauze dissection using finger. All bleeders are fulgurated properly. Care should be taken not to injure anterior jugular veins running on either side of the midline. There may be chance of air embolism if it is injured. In the lower part of the wound near lower flap both anterior jugular veins communicate through a communicating vein which if injured may cause bleeding and air embolism. In such situation anterior jugular veins distal to the communicating vein level should be ligated to prevent air embolism. Later veins are ligated proximally **(Fig. 15-27)**.

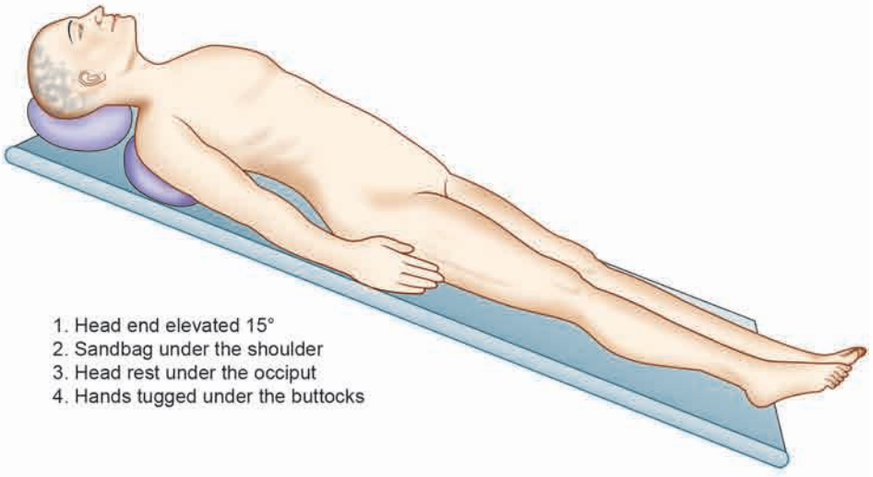
Retraction of the Flaps

A self-retaining Joll's thyroid retractor is placed. Silk skin sutures to upper and lower flaps can be placed to retract instead of Joll's retractor. Hamburger–Brennan–Mahorner self-retaining retractor can also be used **(Figs 15-28 to 15-30)**.

Dissection

Deep fascia is incised vertically in midline/median raphe. Strap muscles are retracted (sternohyoid and omohyoid are in outer plane; sternothyroid is in deeper plane). Midline plane is blood less. Incision is done and plane is opened using either cautery or 15 no blade or fine scissor. Strap muscles are retracted laterally using a deep retractor. If gland is large and if there is difficulty in mobilising gland then strap muscles can be cut between two Kocher's clamps at their upper part (as nerve supply to strap muscles is at lower part through ansa hypoglossi) **(Figs 15-31 and 15-32)**.


Extended neck
Sandbag under the shoulder
Head end 15 degrees elevated


1. Head end elevated 15°
2. Sandbag under the shoulder
3. Head rest under the occiput
4. Hands tugged under the buttocks

Area of cleaning for thyroidectomy

Double towel to
drape head end

Double sterile towel draping

Completed draping with 15°
head end elevation

Figs 15-22(1)

Figs 15-22(2)

Figs 15-22(1 and 2): Position of the patient in thyroidectomy. Neck is extended by placing the sandbag under the shoulder. 15° head up position is used. After cleaning, draping is done using double sterile towels to the head.

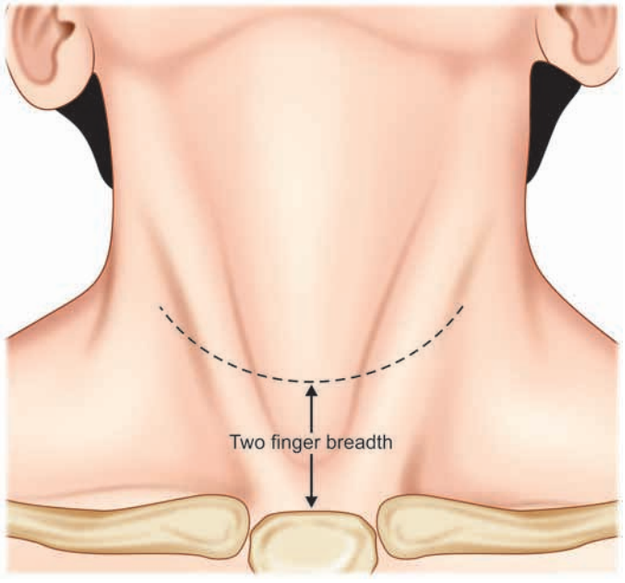


Fig. 15-23: Position and cleaning the area.

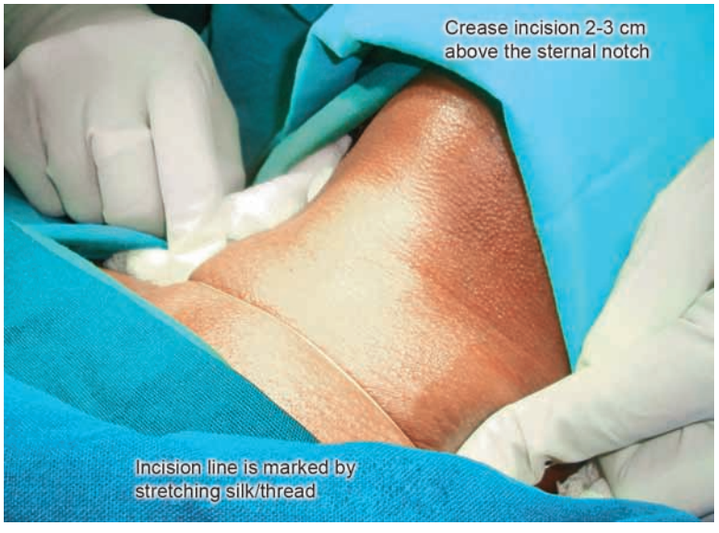


Fig. 15-24: Incision for thyroidectomy.

Thyroid fossa lateral and deep to the lateral lobe is dissected using blunt (peanut) and sharp dissection. Lateral lobe of the thyroid is held using gauze or Babcock's forceps to retract medially. Short stout middle thyroid vein is identified and ligated securely (double ligation is better) using 3 zero silk/vicryl. Blind dissection (should be avoided) near middle thyroid vein may tear or avulse it from IJV causing torrential haemorrhage. This allows proper mobilization of the gland to identify parathyroid glands and recurrent laryngeal nerve **(Fig. 15-33)**.

Gland is now retracted downwards and laterally to expose the superior pole. It is dissected with sharp and peanut dissections. Superior thyroid artery and vein supplies the gland from superior pole. This space in front of cricothyroid is called as cricothyroid *space of Reeves*. In this space external laryngeal nerve which is just proximal to superior pole deviates towards cricothyroid muscle. Cricothyroid muscle is tensor of vocal cord which maintains the pitch of the voice. This nerve should not be injured. So artery and vein are *individually*

Fig. 15-25: Subplatysmal plane is used while raising the flap in thyroidectomy.

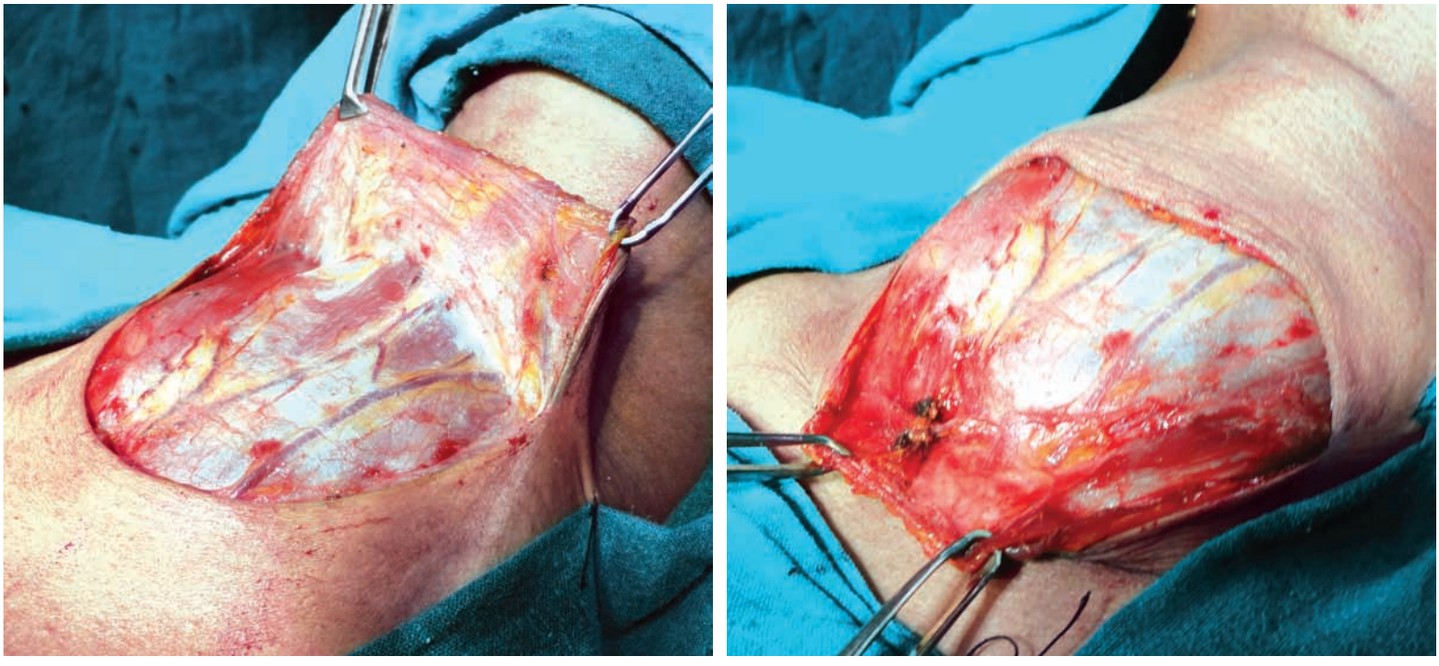


Fig. 15-26: Raising of upper flap and lower flaps in subplatysmal plane.

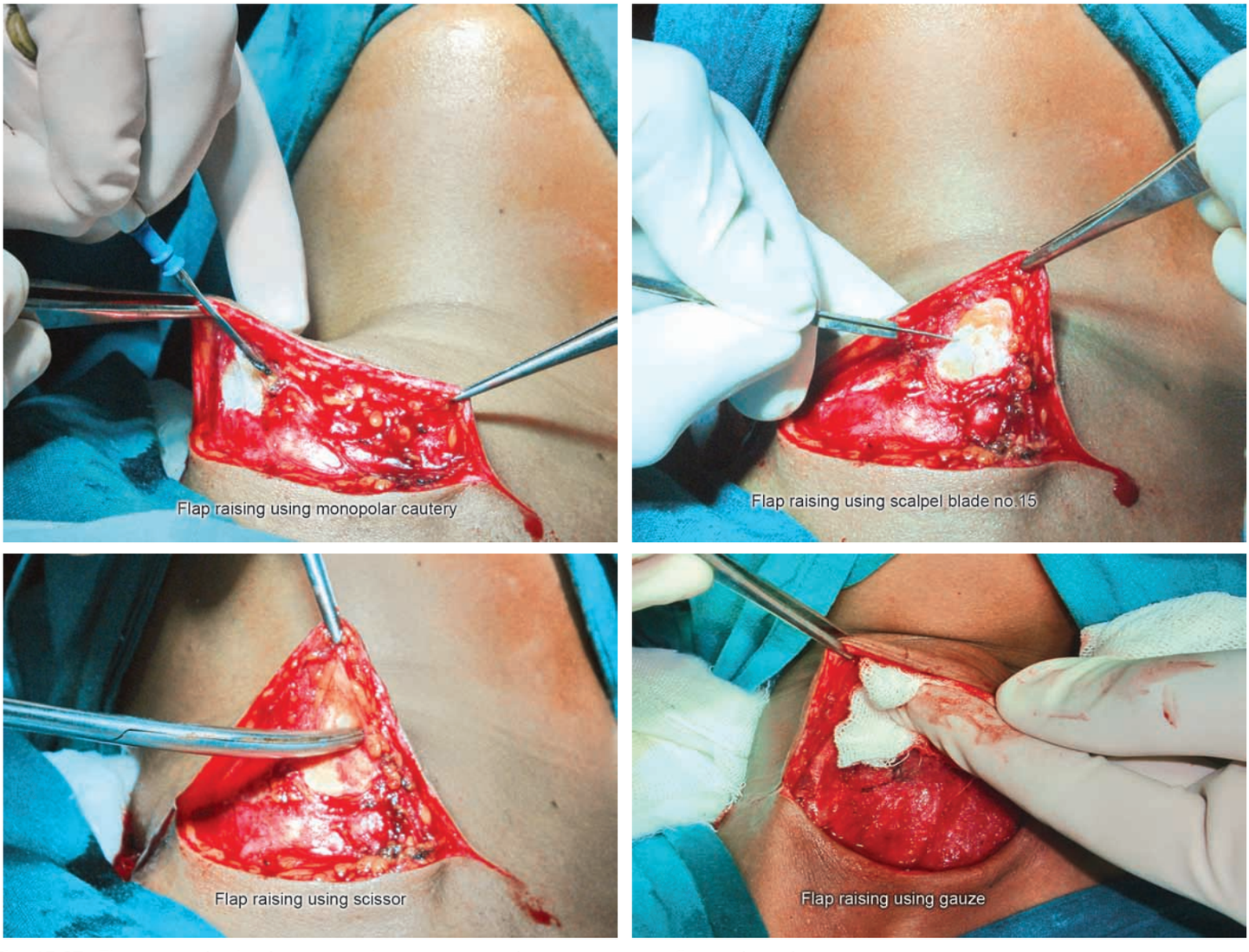

Flap raising using monopolar cautery
Flap raising using scalpel blade no.15
Flap raising using scissor
Flap raising using gauze

Fig. 15-27: Flaps are raised using monopolar cautery or scissor or gauze or finger dissection.

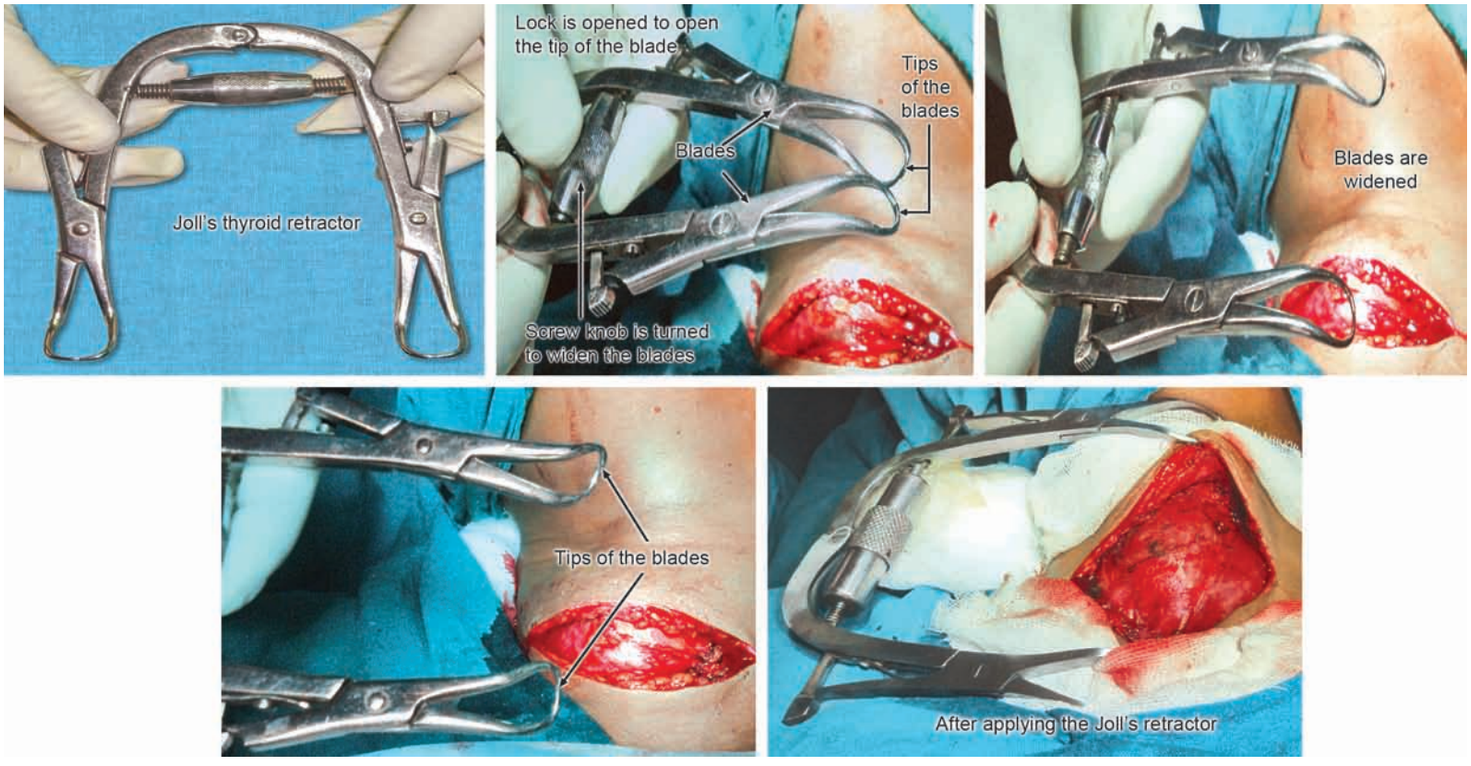

Joll's thyroid retractor
Lock is opened to open the tip of the blade
Tips of the blades
Blades
Screw knob is turned to widen the blades
Blades are widened
Tips of the blades
After applying the Joll's retractor

Fig. 15-28: Joll's thyroid retractor is commonly used to retract the upper and lower flaps.

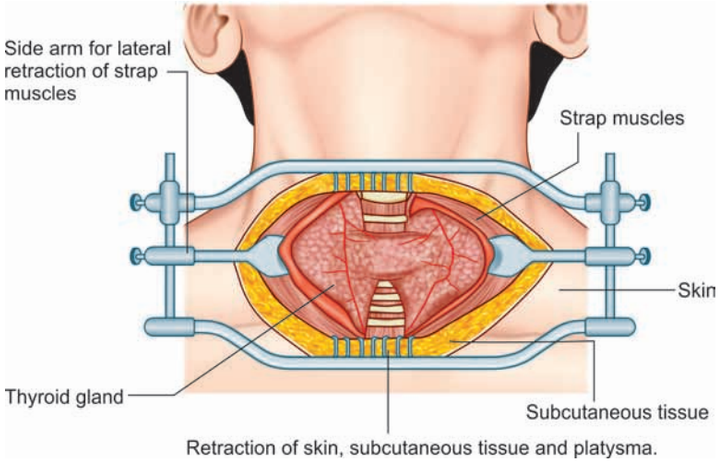


Fig. 15-29: Hamburger – Brennan – Mahorner self retaining retractor with side arm to retract strap muscles.

Fig. 15-30: Retraction of the elevated flaps in thyroidectomy using silk sutures.

ligated close to the gland to avoid injuring the nerve. Individual ligation of artery and vein also prevents rare problem of AV fistula. Artery should have 2 or 3 zero vicryl ligatures proximally. Often clips/ligaseal device are used to the vessel. Slipping of the ligature postoperatively can cause life threatening haemorrhage or compressing haematoma. *Often by many*, superior pedicle is ligated en mass. Prior to this Kocher's grooved director when available is passed underneath so that deeper tissues are safeguarded while cutting the pedicle. It is *advisable to identify the external laryngeal nerve* with careful dissection to safeguard it to prevent developing *altered pitch of voice (timber of voice)*.

Inferior pole of the thyroid is exposed and inferior thyroid veins are ligated adjacent to gland. Often thyroid ima venous plexus may be present in front of the trachea in midline which should be ligated properly **(Fig. 15-34)**.

Both blunt and sharp dissection using peanut, fine scissor, mosquito forceps with gentle traction over the gland medially will expose the recurrent laryngeal nerve and parathyroid glands. Recurrent laryngeal nerve passes behind the inferior thyroid artery in tracheooesophageal groove. But one should be aware of different variations which can cause nerve injury. Inferior thyroid artery arises from thyrocervical trunk of subclavian artery, running upwards, downwards and then medially under the carotid artery to reach the gland in front of the recurrent laryngeal nerve. To control any bleeders in this region *bipolar cautery* should be used (*never unipolar*). Branches of inferior thyroid artery while entering the gland should be ligated using 3 zero vicryl or silk. Ligating inferior thyroid artery or its branches close to gland avoids injury to the artery of parathyroid from inferior thyroid artery (*capsular dissection or orange peel dissection)*. Olden day's classical method of ligating the inferior thyroid artery away from the gland just after crossing behind the carotid artery (ligation in continuity using absorbable suture – catgut) is *not commonly practiced* now **(Fig. 15-35)**.

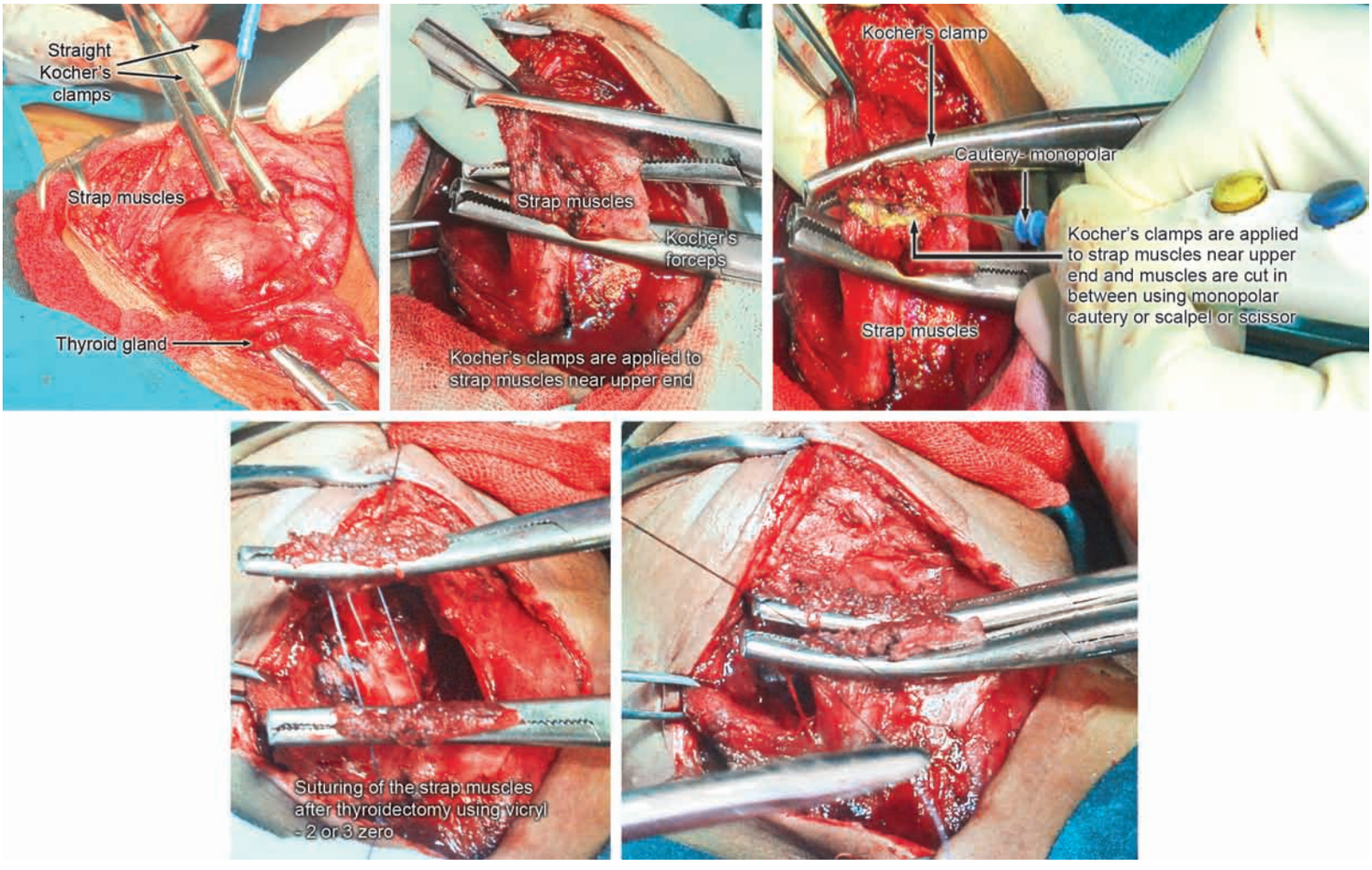

Straight Kocher's clamps
Strap muscles
Thyroid gland
Strap muscles
Kocher's forceps
Kocher's clamps are applied to strap muscles near upper end
Kocher's clamp
Cautery- monopolar
Kocher's clamps are applied to strap muscles near upper end and muscles are cut in between using monopolar cautery or scalpel or scissor
Strap muscles
Suturing of the strap muscles after thyroidectomy using vicryl - 2 or 3 zero

Fig. 15-31: Cutting the strap muscles near upper end and later after thyroidectomy apposition of the strap muscles using vicryl.

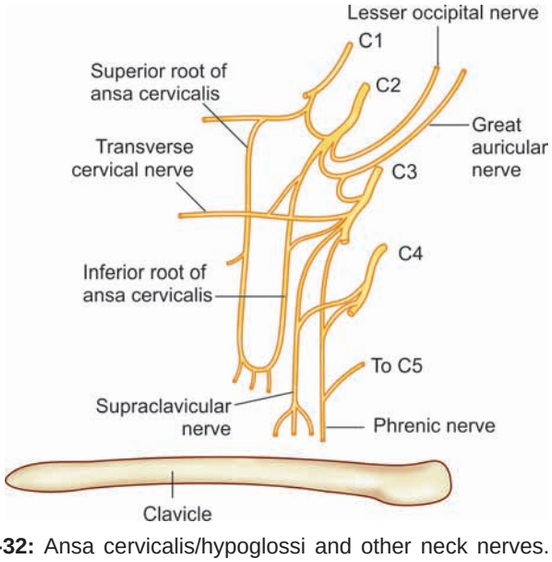


Fig. 15-32: Ansa cervicalis/hypoglossi and other neck nerves.

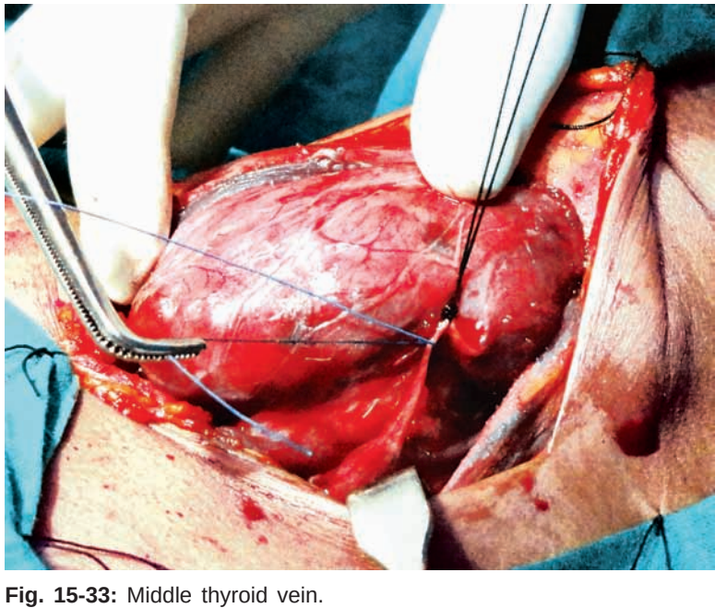


Fig. 15-33: Middle thyroid vein.

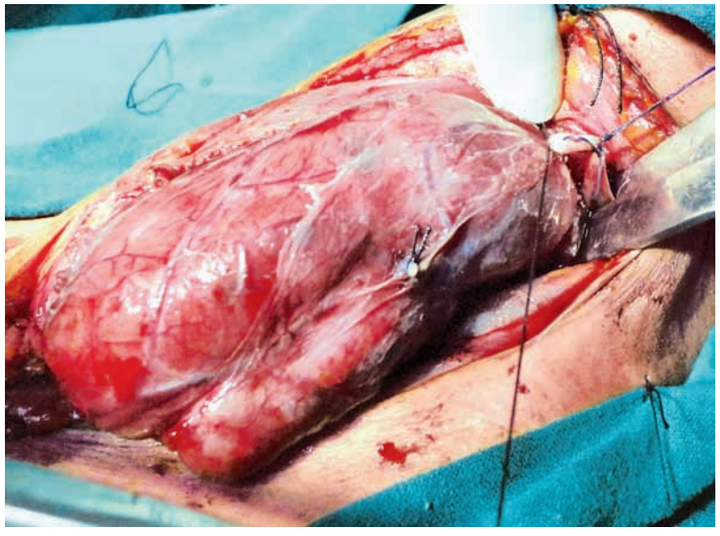


Fig. 15-34: Ligation of superior thyroid artery is done close to the gland individually after identifying the external laryngeal nerve.

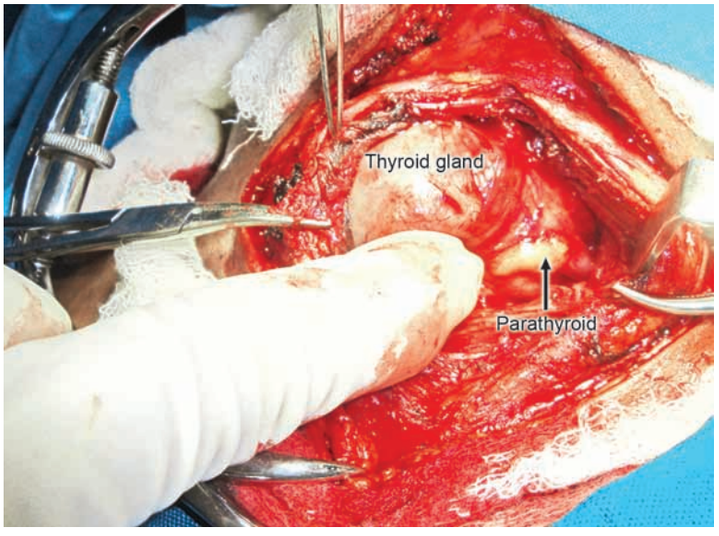
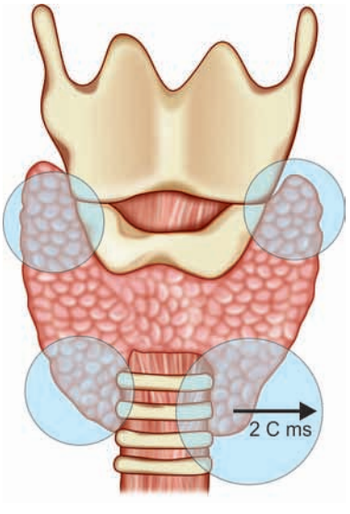
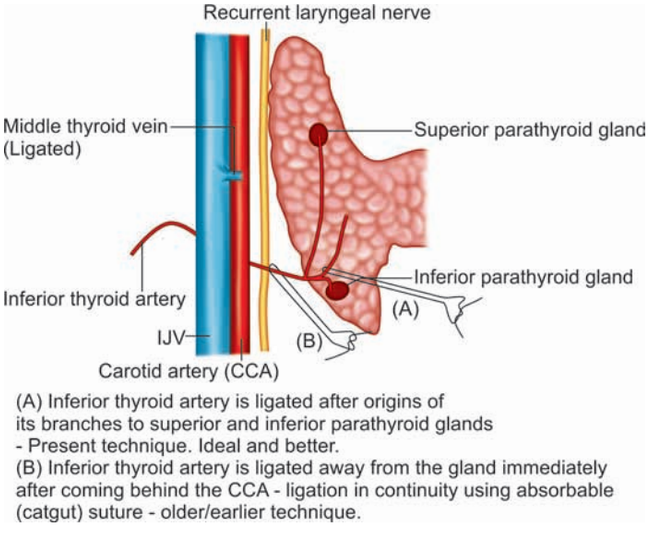


Fig.15-35C

Figs 15-35A to C: Location of parathyroids and their variations should be remembered. Parathyroids should be retained during thyroidectomy. It is also important to retain their blood supply also.



A



(A) Inferior thyroid artery is ligated after origins of its branches to superior and inferior parathyroid glands - Present technique. Ideal and better.
(B) Inferior thyroid artery is ligated away from the gland immediately after coming behind the CCA - ligation in continuity using absorbable (catgut) suture - older/earlier technique.

B

Figs 15-35A and B

Berry's ligament which is adherent to thyroid is cut with care to mobilise the gland properly medially as recurrent laryngeal nerve is very close to the Berry's ligament. RLN should be identified unlike older concept ('nerve not seen is not damaged' is *disproved*; present concept is '*nerve not seen is damaged'*) **(Fig. 15-36)**.

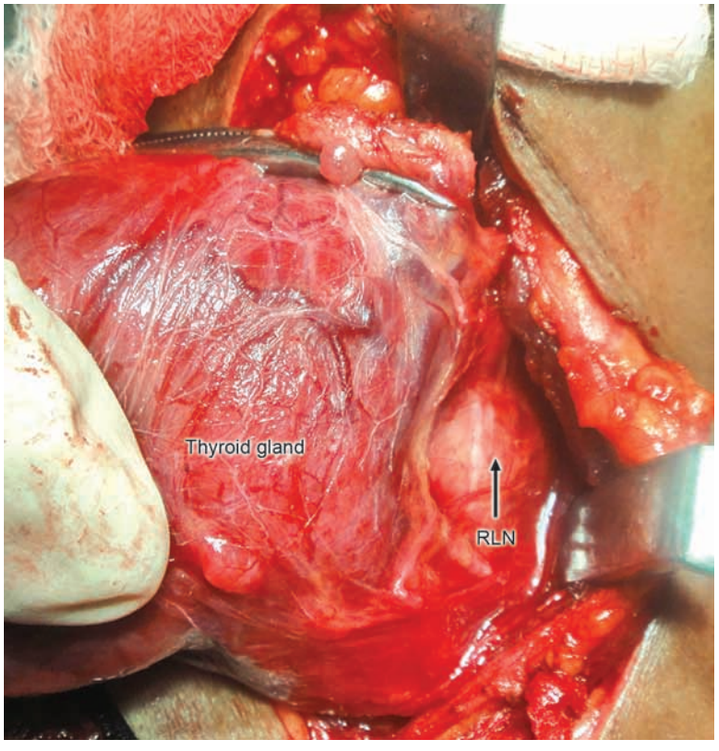
Parathyroid glands vary in their position on the surface of the gland but can be easily identified by its different colour (golden yellow/caramel like). Glands should be dissected off the thyroid with their blood supply. ⅓ of one gland is sufficient to maintain the function (calcium metabolism by releasing PTH). Ideally *all four parathyroids should be preserved*. Due to vasospasm of vessels of the parathyroids temporary hypoparathyroidism is common but reversible. Unnecessary handling of parathyroids should be avoided. Handling of the gland makes it congested. Viability of parathyroid can be checked by carefully incising it using fine scalpel. Doubtful gland should be sliced adequately and transplanted into same side sternocleidomastoid muscle.

Inferior pole vessels are individually ligated.

Opposite lateral lobe is also dissected similarly. It is surgeon's choice to decide on which side to stand while dissecting on opposite side. In difficult thyroids it is often preferred to go to opposite side and dissect the gland.

Thyroid is dissected from anterior surface of trachea using cautery or fine scissor. If part of the gland is retained in the tracheooesophageal groove (subtotal) it should be oversewn using 3 zero vicryl. Fine clamps are placed in series on the thyroid capsule. Gland is transected using no 15 blade. Retained gland is undersewn using vicryl continuous locking sutures. Anterior part of this retained gland is sutured to trachea **(Fig. 15-37)**.

In hemithyroidectomy, one lateral lobe and entire isthmus is removed. Junction of isthmus and opposite lateral lobe is clamped using haemostat/Kocher's clamp and gland is cut. Clamped retaining gland is under run using vicryl **(Fig. 15-38)**.



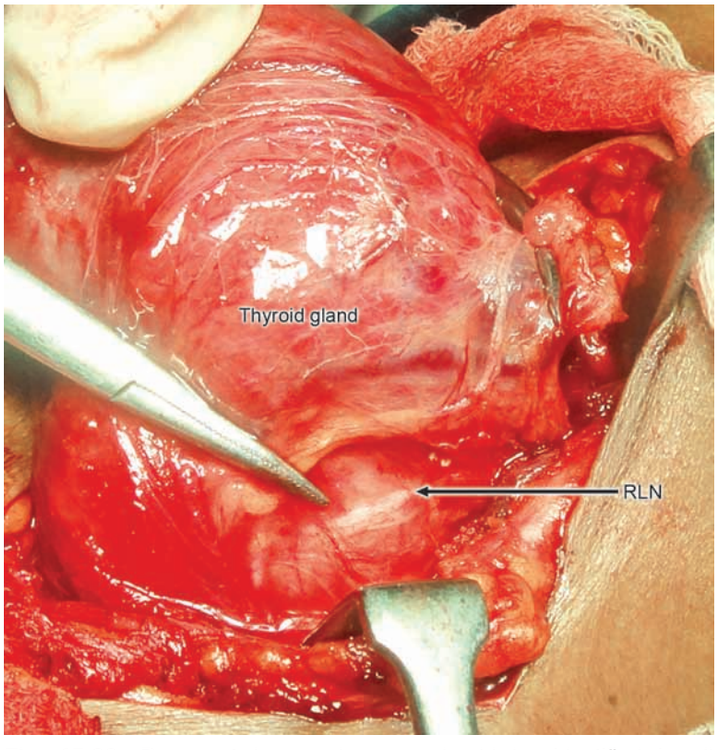


Fig. 15-36: Recurrent laryngeal nerve should be identified in all thyroidectomies.

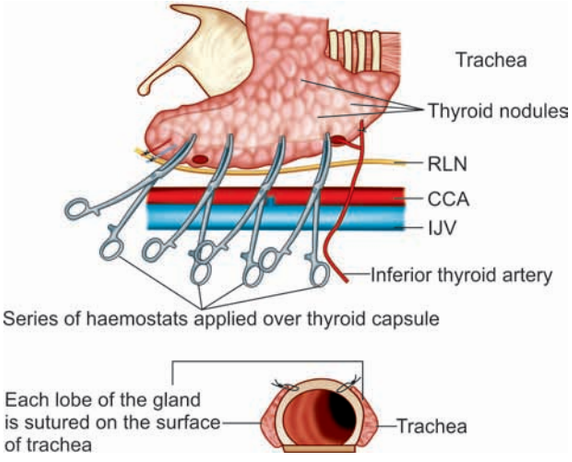


Fig. 15-37: Partial or subtotal thyroidectomy is done by applying series of haemostats on the thyroid capsule to facilitate the removal of the gland in front. Retained gland is under run using vicryl sutures.

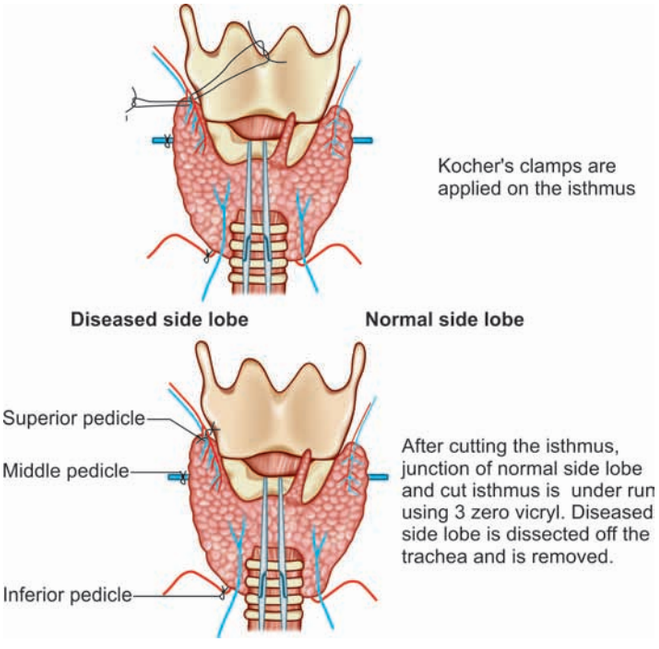

Kocher's clamps are applied on the isthmus
Diseased side lobe
Normal side lobe
Superior pedicle
Middle pedicle
Inferior pedicle
After cutting the isthmus, junction of normal side lobe and cut isthmus is under run using 3 zero vicryl. Diseased side lobe is dissected off the trachea and is removed.

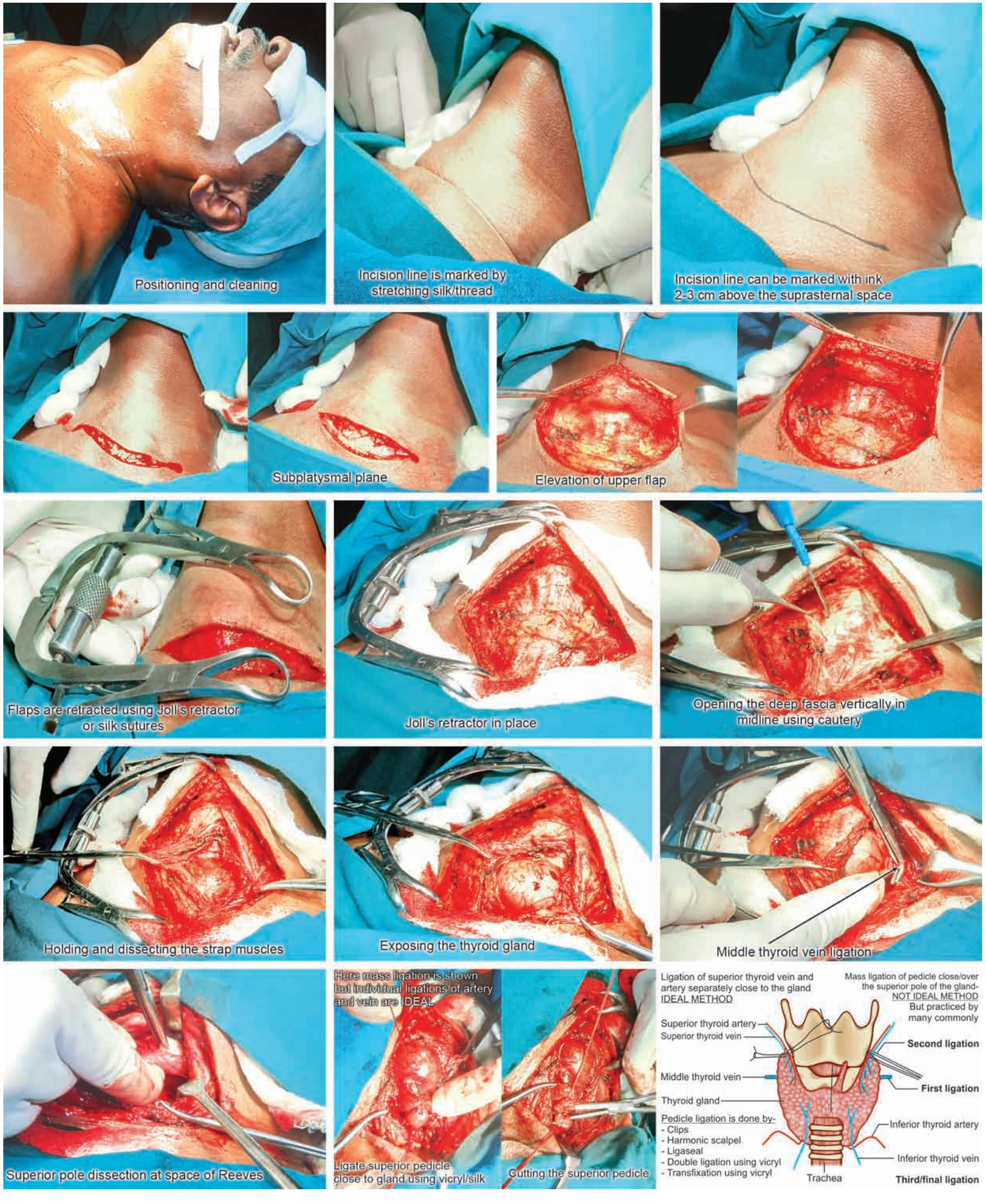
Fig. 15-38: Isthmus at its junction to retaining lobe of the thyroid gland is transected between clamps and retaining cut part of the thyroid tissue is under run using vicryl.

Proper haemostasis is done using bipolar cautery. Pedicles are inspected again for their security **(Fig. 15-39)**.

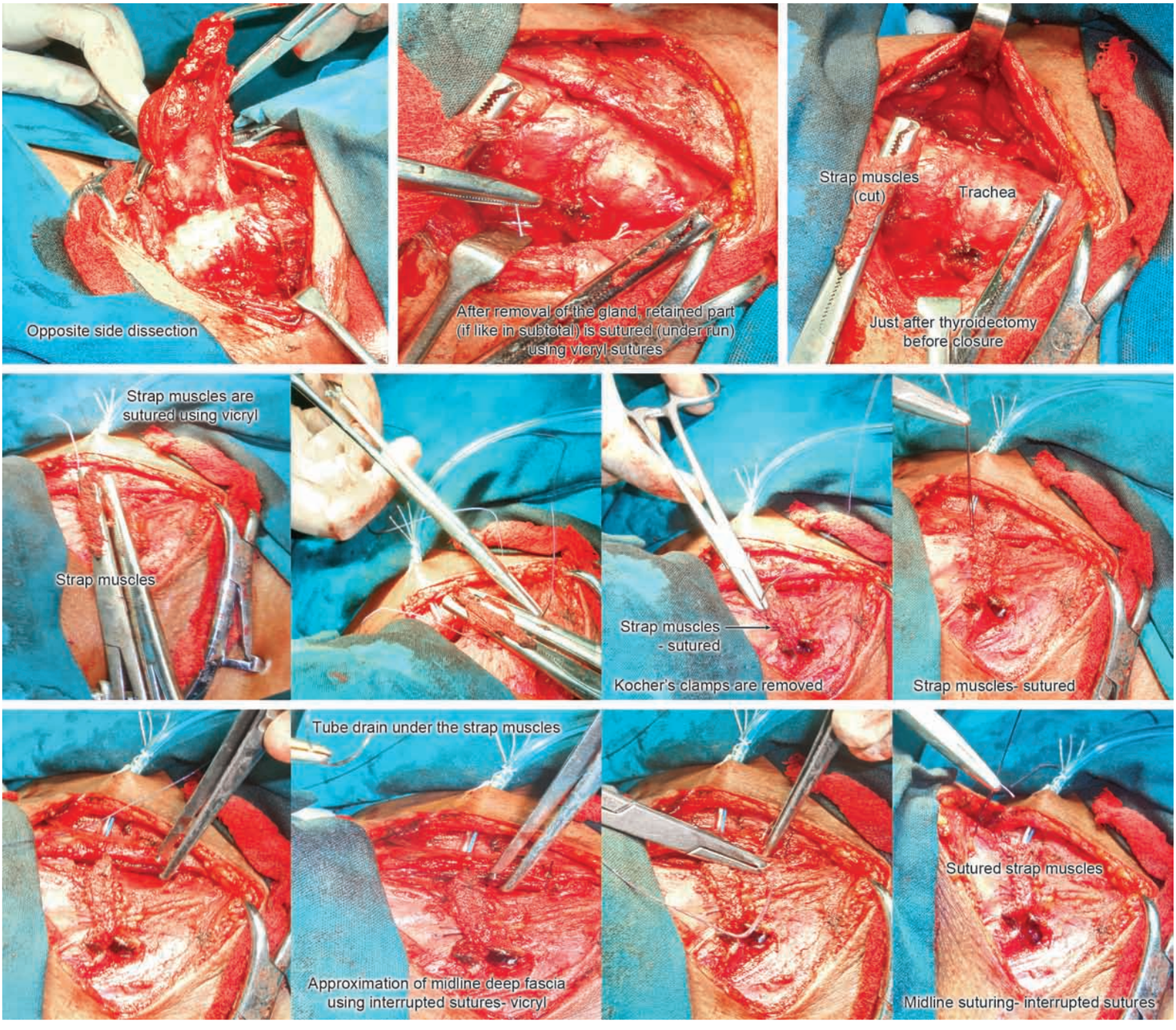
Closure

Sandbag is removed. Again haemostasis is confirmed. Often stretched neck prevents bleeding from small veins but once sandbag is removed they may bleed which should be controlled. Traditionally suction drain is placed which is brought out through a separate stab incision or one of the ends of the main wound. Drain should pass under the strap muscles to reach the thyroid fossa. If proper haemostasis is done drain can be avoided. Controversy still surrounds the use of drains after thyroid surgery. Strap muscles are approximated using interrupted 3 zero vicryl sutures. Platysma is sutured using 3 zero vicryl interrupted sutures. Subcuticular absorbable 3 zero monocryl suture is used for skin. Dressing with pressure using dynaplast is the usual practice. But a dressing that covers the wound *may mask* haematoma formation, delaying its recognition. Placing soft light dressing or without any dressing may be ideal even though it is not practiced by most surgeons **(Fig. 15-40)**.

The *prevention of postoperative bleeding* depends on good intraoperative hemostasis. Hemostasis in thyroid surgery is achieved by means of clamp and tie, surgical clips, diathermy - unipolar initially


Positioning and cleaning
Incision line is marked by stretching silk/thread
Incision line can be marked with ink 2-3 cm above the suprasternal space
Subplatysmal plane
Elevation of upper flap
Flaps are retracted using Joll's retractor or silk sutures
Joll's retractor in place
Opening the deep fascia vertically in midline using cautery
Holding and dissecting the strap muscles
Exposing the thyroid gland
Middle thyroid vein ligation
Superior pole dissection at space of Reeves
Here mass ligation is shown but individual ligations of artery and vein are IDEAL
Ligate superior pedicle close to gland using vicryl/silk
Cutting the superior pedicle
Ligation of superior thyroid vein and artery separately close to the gland
IDEAL METHOD
Superior thyroid artery
Superior thyroid vein
Middle thyroid vein
Thyroid gland
Pedicle ligation is done by-
- Clips
- Harmonic scalpel
- Ligaseal
- Double ligation using vicryl
- Transfixation using vicryl
Mass ligation of pedicle close/over the superior pole of the gland-
NOT IDEAL METHOD
But practiced by many commonly
Second ligation
First ligation
Inferior thyroid artery
Inferior thyroid vein
Trachea
Third/final ligation

Figs 15-39(1)


Opposite side dissection
After removal of the gland, retained part (if like in subtotal) is sutured (under run) using vicryl sutures
Strap muscles (cut)
Trachea
Just after thyroidectomy before closure
Strap muscles are sutured using vicryl
Strap muscles
Strap muscles - sutured
Kocher's clamps are removed
Strap muscles- sutured
Tube drain under the strap muscles
Approximation of midline deep fascia using interrupted sutures- vicryl
Sutured strap muscles
Midline suturing- interrupted sutures

Figs 15-39(2)

Figs 15-39(1 and 2): Technique of thyroidectomy.

and bipolar in the depth, ultrasonic coagulating-dissection such as a harmonic scalpel (HS) or electrothermal bipolar vessel sealing systems (EBVSS) **(Figs 15-41 and 15-42)**.

Thyroidectomy with Lymph Node Dissection for Carcinoma Thyroid

Level VI (cervico - central/pretracheal and tracheooesophageal) nodes are removed routinely in all thyroid cancers. Frozen section biopsy of level III deep cervical node is done. If it is involved, a modified radical neck dissection preserving IJV, accessory nerve and sternocleidomastoid muscle is done. Same thyroid incision extended laterally and above towards mastoid process is usually sufficient to do additional lymph node dissection. For bilateral neck dissection, incision is extended on both sides. Sympathetic chain and hypoglossal nerve above will come into picture during dissection which should be preserved.

In medullary carcinoma of thyroid, central node dissection, often modified radical neck dissection with dissection of upper mediastinal nodes (level VII) and thymus is done. Meticulous dissection is needed to preserve recurrent laryngeal nerve and parathyroids.

In any malignancy with clinically significant palpable neck nodes confirmed by FNAC modified radical neck dissection is done along with total thyroidectomy.

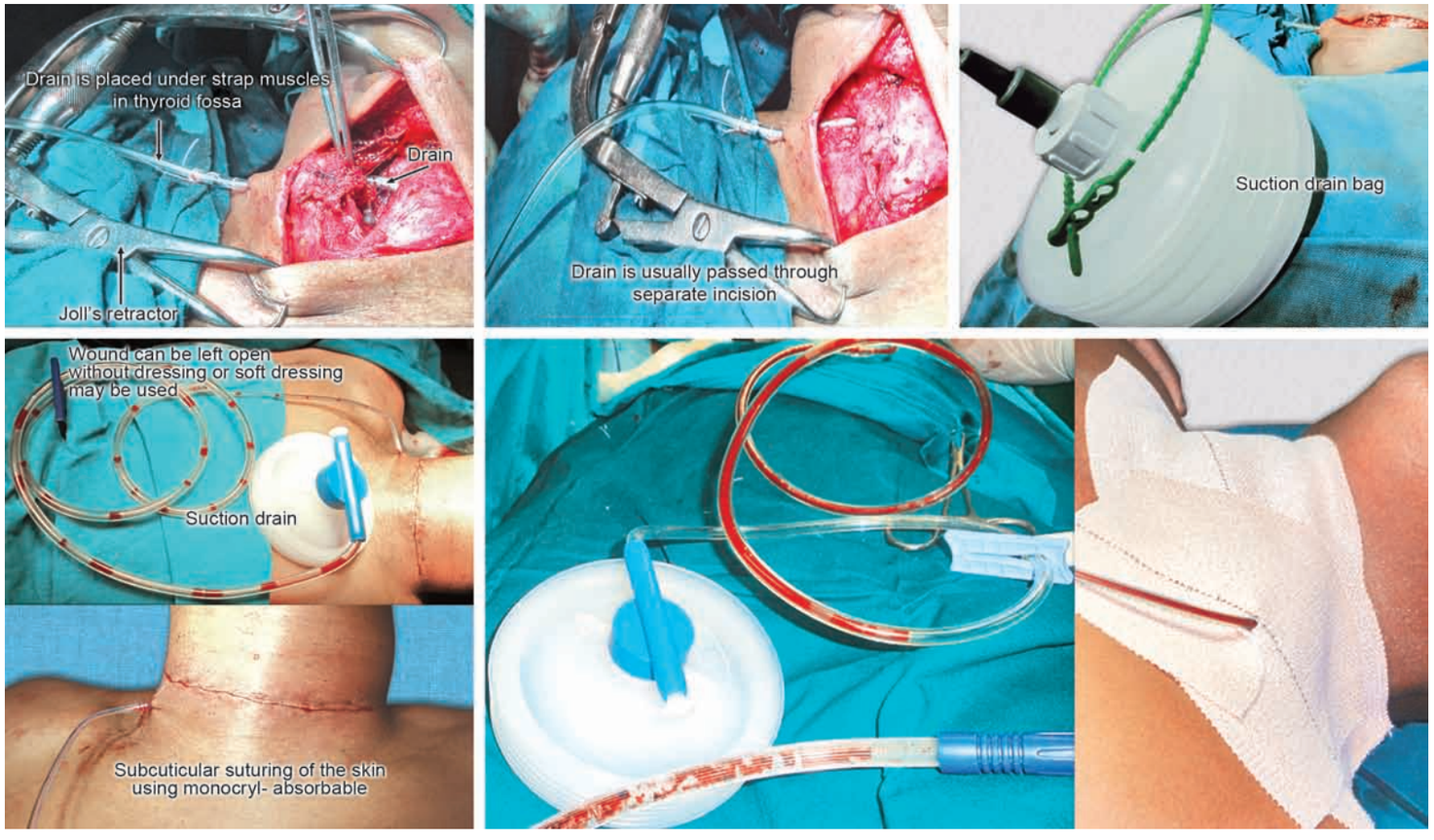

Drain is placed under strap muscles in thyroid fossa
Drain
Joll's retractor
Drain is usually passed through separate incision
Suction drain bag
Wound can be left open without dressing or soft dressing may be used
Suction drain
Subcuticular suturing of the skin using monocryl- absorbable

Fig. 15-40: Placing the drain in thyroidectomy. Wound is left open or soft dressing may be placed. Compression dressing is commonly used even though practiced is not necessary/ideal.

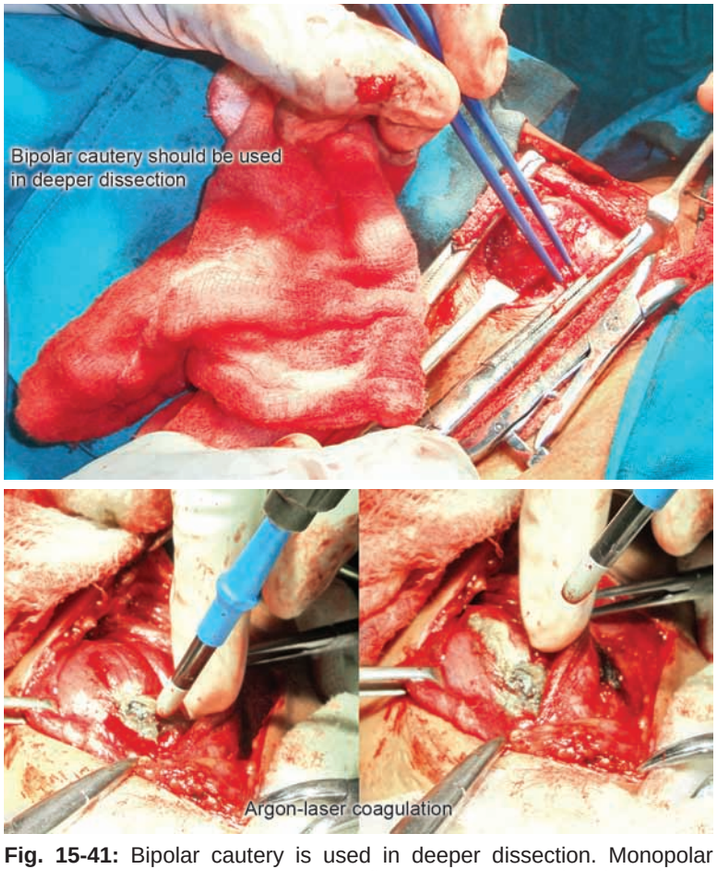


Fig. 15-41: Bipolar cautery is used in deeper dissection. Monopolar cautery is used only during raising flaps and incising the deep fascia in midline. Often argon laser coagulation may be used on the surface.

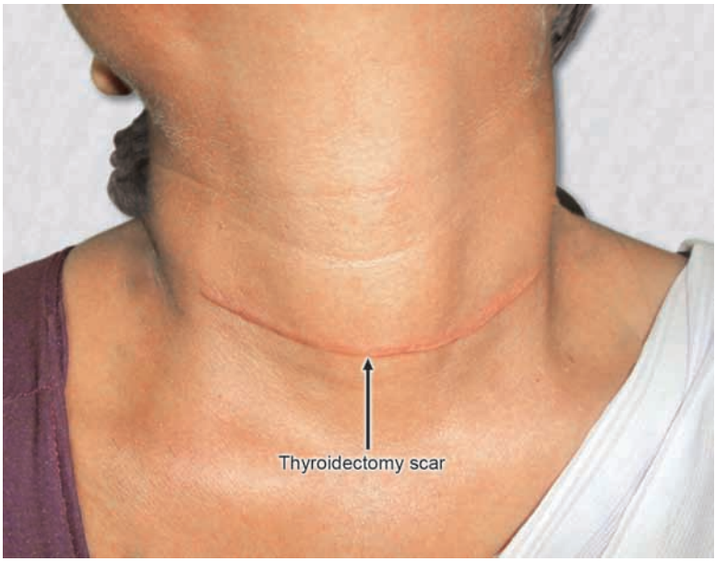


Fig. 15-42: Thin linear scar usually forms after thyroidectomy which is cosmetically acceptable.

Lateral Approach Thyroidectomy

Lateral approach is used in large thyroid enlargement/recurrent thyroid disease/often thyroid carcinoma instead of classical neck approach. After lengthy skin incision, plane is created between anterior border of sternomastoid muscle and lateral to strap muscles to proceed with surgery. Often sternocleidomastoid muscle may need to be removed.

Removal of Retrosternal Goitre

Usually there will be enlarged neck thyroid of similar pathology. As retrosternal thyroid receives its blood supply from neck it is usually delivered to thyroid incision of neck with blunt dissection and removed. Occasionally in large/vascular/adherent retrosternal goitre a median sternotomy may be added to remove it.

Postoperative Care

Patient is kept in postoperative room with head end tilted 30° upwards. Once patient is fully awake with normal breathing (in 4-6 hours), patient is shifted to ward. Patient should be observed for bleeding, formation of haematoma, stridor, drop in O_2 saturation, tachycardia or tachypnoea. Tetany may be observed in 3-4 days. *Hungry bone syndrome* can cause severe hypocalcaemia in immediate postoperative period. Drain is removed in 24–48 hours depending on the quantity of collection in drain.

Remember in thyroidectomy

- Middle thyroid vein is present only in 30% of cases.
- Bipolar cautery or harmonic scalpel (harmonic wave) are better to control bleeding and to prevent injury to RLN
- RLN should be identified in both sides. Variations should be remembered.
- Parathyroids should be retained and also their blood supply.
- Parathyroid autotransplantation may be needed if their blood supply is compromised.
- Rapid influx of serum calcium into bones in immediate postoperative period may cause severe hypocalcaemia – hungry bone syndrome which is initially corrected by IV calcium gluconate – 10 ml of 10%. It is more commonly observed in patients with beta blockers. It is due to sudden drop in PTH level after surgery.
- Tension haematoma under strap muscles is very dangerous and should be relieved by removing sutures from the skin and strap muscles. It can be life saving with immediate intervention otherwise it can be life threatening.
- Permanent hypoparathyroidism is rare (0.5-1%) even though temporary hypoparathyroidism and hypocalcaemia is common (25%) which is corrected well with calcium for certain period of 3-6 months.
- External laryngeal nerve injury is more common than RLN injury. There is loss of tension of vocal cords causing reduced power and range in voice (pitch).
- Thyroid insufficiency develops in 25-45% cases. It is confirmed by doing serum T3, T4 and TSH after 2, 3 and 6 months.

COMPLICATIONS OF THYROIDECTOMY

Complications can be intraoperative or immediate/in early postoperative period or late postoperative.

Haemorrhage (1%)

It may be due to slipping of ligatures either of superior thyroid artery or other pedicles or of small veins. It is often precipitated by vigorous coughing or retching in postoperative period. It causes tachycardia, hypotension, and breathlessness, tracheal compression due to progressive tension haematoma formation in thyroid fossa under sutured strap muscles causing severe respiratory obstruction, cyanosis, hypoxia, respiratory failure and cardiac arrest. Tension haematoma is a condition which is often missed in postoperative ward by the monitoring nurse or intensivist. Early identification of the problem with immediate bedside removal of skin and *deeper sutures* prevents further compression of the trachea relieving the respiratory obstruction. US of neck may be useful but unnecessary time should not be wasted just to do sonology. It is essentially life saving procedure which is often failed to undertake causing mortality. Later patient is shifted to operation theatre and wound is inspected under anaesthesia; bleeding vessel is caught and securely ligated. Often transfusion of blood is also required.

Respiratory Obstruction

It may be due to haematoma or due to laryngeal oedema or due to tracheomalacia or due to bilateral recurrent laryngeal nerve palsy. Evacuation of clot, emergency tracheostomy is required. *Fiberoptic laryngoscopy* is useful to assess the vocal cord palsy.

Recurrent Laryngeal Nerve Palsy

It can be *transient or permanent*. During extubation anaesthetist should be asked to visualise the movements of vocal cord to confirm that there is no recurrent laryngeal nerve injury. It should be documented both by anaesthetist and surgeon in the case sheet. Distressing change in voice should be assessed and treated by *steroid* (in case of neuropraxia), *speech therapy* and counseling. In malignant condition it is better to inform the patient about voice change as there would be possible need for transecting the nerve to clear the disease. However in benign diseases, nerve should be retained with all care. If nerve injury is identified on table during the procedure it *should be repaired* using microscope with 9 zero polypropylene sutures. Incidence of transient RLN palsy is 3%. It usually recovers in 3 weeks to 3 months. Permanent palsy is rare but do can occur. RLN palsy can be – unilateral; bilateral; unilateral combined RLN and external laryngeal nerve palsy; bilateral combined RLN and external laryngeal nerve palsy **(Fig. 15-43)**.

Unilateral RLN palsy causes median or paramedian vocal cord position. Here all intrinsic muscles of larynx except cricothyroid on one side are paralysed. Cricothyroid, which is the only retained muscle is a weak adductor of the vocal cord causing median or paramedian

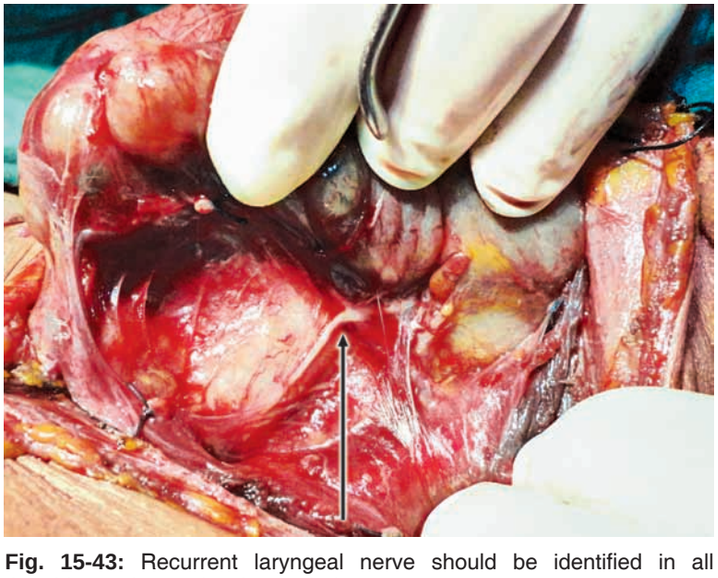


Fig. 15-43: Recurrent laryngeal nerve should be identified in all thyroidectomies and safeguarded.

position of vocal cords (*Wagner–Grossman hypothesis)*. Abductor fibres (nerve supply of posterior cricoarytenoid) of the RLN which are phylogenetically newer are more susceptible and paralysed than adductors (*Semon's law)*. It causes change in voice (hoarseness) which gradually gets corrected by compensatory action of opposite vocal cord. Speech therapy will benefit for these patients. Short course of steroid in immediate postoperative period is used. 33% of unilateral RLN palsy patients are asymptomatic. Aspiration and airway obstruction will never occur **(Fig. 15-44)**.

Unilateral combined RLN and superior laryngeal nerve palsy - All muscles of larynx on one side is paralysed. Vocal cord will be in cadaveric position, 3.5 mm from the midline. It leads into hoarseness of voice, ineffective glottis causing aspiration, ineffective cough and respiratory congestion. Treatment is speech therapy, Teflon injection to paralysed vocal cord, placement of muscle/cartilage implant to paralysed cord, arthrodesis of cricoarytenoid joint.

Bilateral RLN palsy – Both side intrinsic muscles of larynx are paralysed except cricothyroids. Unopposed actions of both cricothyroids cause vocal cord in median/paramedian position. Condition causes voice change, severe dyspnoea, airway block and respiratory arrest. Treatment: Emergency tracheostomy; lateralisation of cord by arytenoidectomy; vocal cord lateralisation, cordectomy by open or laser method; sternohyoid implantation; thyroplasty.

Bilateral combined RLN and superior laryngeal nerve palsy – Here there will be total paralysis of the intrinsic muscles of larynx and total laryngeal anaesthesia, causing aphonia (no voice), severe glottis incompetence causing aspiration, absence of cough, retention of lung secretions leading into severe distress. It is treated by emergency tracheostomy, fixing epiglottis to arytenoids, vocal cord plication and often by total laryngectomy.

Assessing the vocal cord palsy – It is done by indirect laryngoscopy, direct fibreoptic endoscopy, laryngeal electromyography (EMG). EMG may be useful to distinguish vocal fold paralysis from injury to the cricoarytenoid joint secondary to intubation. EMG may help in assessing the prognosis of the patient with RLN injury. Thick connective tissue called the *Berry ligament* attaches the thyroid to the trachea at the level of the second or third tracheal ring. This is the most common site of injury to the RLN. The nerve may run deep to the ligament, pass through it, or even penetrate the gland a short distance at this level. Retraction of the thyroid lobe may result in traction injury and make the nerve susceptible to transection. The path of the nerve must be clearly identified. An endotracheal-tube electrode and an RLN-postcricoid-laryngeal surface electrode may be used in difficult thyroid surgeries to have continuous electrophysiologic monitoring to reveal the location of RLN. Proper identification of the RLN minimises the risk of injury. During thyroidectomy, when the nerve is identified and dissected, the reported RLN injury rate is 0-2.1%; if surgery is repeated (re-thyroidectomy) it is 2-12%; if the nerve is not identified it is 4-6.6%. Intraoperative haemostasis and a thorough understanding of the anatomy are essential for identifying and preserving the nerve.

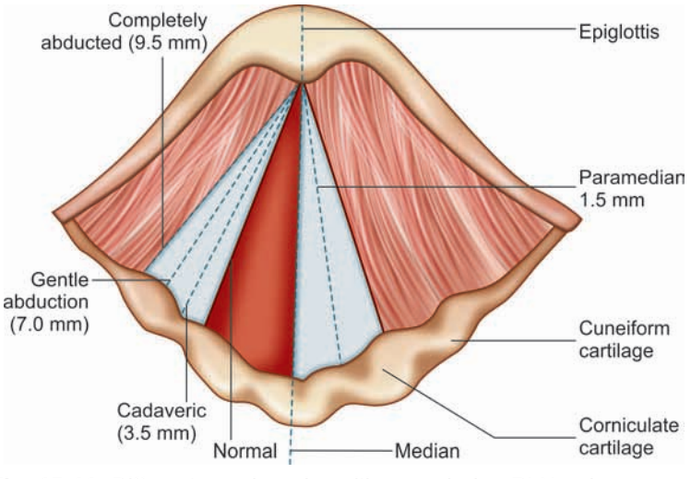


Fig. 15-44: Different vocal cord positions and also RLN palsy.

Bilateral RLN palsy	***Most dangerous.***
Bilateral combined RLN and superior laryngeal N palsy	*Dangerous*.
Unilateral RLN palsy	Not dangerous.
Unilateral combined palsy	Not dangerous.

For unilateral vocal cord paralysis corrective procedures are not done until at least 6 months after thyroidectomy because a reversible injury improves by that time. If the nerve was definitely transected during surgery, treatment for the paralysed fold may be performed sooner than this.

Medialisation of the vocal cords is the most commonly performed. Medialization of the impaired vocal fold improves contact with the contralateral mobile fold. It is done by injection laryngoplasty or laryngeal framework surgery. Type I thyroplasty is probably the most common procedure. A window in the thyroid cartilage is created at the level of the true vocal fold. An implant is then placed to push the vocal fold medially. Medialization with an injection of absorbable gelatin sponge may be performed before 6 months. But gelatin sponge gets absorbed after sometime and is a temporary treatment.An implant made of silicone or polytetrafluoroethylene is permanent. The implant may be removed if nerve function recovers later.

Reinnervation procedures are done for permanently injured RLN. These procedures maintain/restore tone of the intrinsic laryngeal muscles. When the true vocal fold atrophies after denervation, it loses contact with the contralateral fold and the voice weakens. By preventing atrophy, re-innervation procedures help to improve the patient's voice.

Primary neurorrhaphy is done immediately to repair the transected RLN.

In bilateral vocal-cord paralysis, initial treatment involves obtaining an adequate airway by *emergency tracheotomy*. Often first endotracheal intubation is done; neck is explored to ensure that there are no reversible causes of nerve injury; if RLNs show good preservation, a trial of extubation may be performed after several days. Intravenous steroids are used. If nerve function has not recovered after a second trial of extubation, tracheotomy is certainly needed.

In bilateral vocal cord paralysis in order to improve airway patency, *cordotomy and arytenoidectomy* are the common procedures done. These procedures enlarge the airway and allow de-cannulation of a tracheostomy. However, the patient must be counseled that his or her voice will likely worsen after surgery.

Hypoparathyroidism—Types

Types		
Temporary	More common (2-50%) average 10%	Usually lasts for 2 months maximum up to 6 months.
Permanent	Less common (0.4-13%) average 1%	Permanent – continues beyond 6 months.
Hungry bone syndrome	Common (5-13%)	Severe, rapid begins in immediate postoperative period.

The parathyroid glands produce parathyroid hormone (PTH), which is involved in the regulation of serum calcium. PTH increases serum calcium levels by causing bone resorption, increasing renal absorption of calcium, and stimulating the synthesis of the biologically active form of vitamin D (1, 25-dihydroxy vitamin D). 1, 25-dihydroxy vitamin D increases serum calcium levels by increasing the intestinal absorption of calcium. PTH also increases renal excretion of phosphorous. Low PTH levels result in high serum phosphorous levels.

Inadequate production of PTH leads to hypocalcaemia. Hypoparathyroidism, and the resulting hypocalcaemia, may be permanent or transient. The rate of permanent hypoparathyroidism is 0.4-13%. Causes are - direct trauma to the parathyroid glands, devascularisation of the glands, or removal of the glands during surgery.

The rate of *temporary hypocalcemia* is reportedly 2-50%. The cause of transient hypocalcaemia after surgery is due to temporary hypoparathyroidism caused by reversible ischaemia to the parathyroid glands, hypothermia to the glands, or release of endothelin-1. Endothelin-1 is an acute-phase reactant which suppresses PTH production. Other hypothesis is - calcitonin release and hungry-bone syndrome. Calcitonin is produced by the thyroid C cells which inhibits bone breakdown while stimulating renal excretion of calcium (opposite of PTH).

Risk factors for hypocalcaemia after thyroidectomy include Graves disease, malignancy, type of procedure performed (total thyroidectomy, thyroidectomy with neck dissection, repeat thyroidectomy, subtotal thyroidectomy, near-total thyroidectomy).

Initially asymptomatic for 4-5 days, later develop circumoral paresthesia/numbness, change in mental status, tetany, carpopedal spasm,*Chvostek's sign* (tapping the region of the facial nerve in the preauricular area results in facial contractions), *Trousseau's sign* (carpal spasm that is elicited by inflating blood pressure cuff on the upper arm), laryngospasm (stridor), seizures, prolongation of QT on ECG, and cardiac arrest.

An effective method of evaluation of parathyroid function is to assess ionised calcium (or total calcium and albumin) levels in the perioperative period. A normal postoperative PTH level can accurately predict normocalcaemia after thyroid surgery. Immediate postoperative PTH level if <1.5 pmol/l and morning serum calcium <2.0 mmol/l, then patient is at risk of hypocalcaemia. Other causes like renal failure, hypomagnesaemia, medications should also be considered. Serum phosphorous levels are elevated in patients with hypoparathyroidism secondary to decreased renal excretion; this difference may help in distinguishing low PTH levels due to other etiologies of hypocalcaemia. PTH levels may be checked repeatedly till 6 months during the follow up period. Identifying the glands on table and maintaining their blood supply is essential and also crucial to prevent hypoparathyroidism. 77% of superior parathyroid glands were at the cricothyroid junction and intimately associated with the RLN; 22% were on the posterior surface of the upper lobe of the thyroid; 1% was behind the junction of the hypopharynx and upper oesophagus.

Location of the inferior parathyroid glands was variable. 42% were on the anterior or lateral surfaces of the lower lobe of the thyroid, hidden by vessels or creases in the thyroid; 39% were located within the superior tongue of the thymus. 15% were extra-thyroidal and lateral to the lower lobe; 2% were in the mediastinal thymus; another 2% were in other ectopic positions, such as in the carotid sheath.

The inferior parathyroid glands and the thymus both develop from the third branchial pouch, causing close association of these structures. The inferior parathyroid glands receive their blood supply from the inferior thyroid artery. The superior parathyroids also usually receive their blood supply from the inferior thyroid artery. The superior parathyroids may also receive their vascular supply from the superior thyroid artery, the anastomotic loop between the inferior and superior thyroid arteries, or direct branches from the thyroid gland.

The parathyroids should be identified and their blood supply should be preserved by ligating all vessels distal to them. The vessels are ligated as close to the thyroid gland as possible. The parathyroid glands are identified by their *caramel-like* colour and size. When blood supply of parathyroids is lost, they appear darkened. The surgical wound and the excised thyroid gland should be carefully examined for parathyroid tissue. The devascularised gland (pathologically confirmed with frozen-section), should be removed, cut into 1- to 2-mm pieces, and re-implanted into the sternocleidomastoid muscle or strap muscle. The location may be marked with a permanent suture or a metallic hemoclip for easier identification in any future surgeries.

Patients who have *asymptomatic hypocalcaemia* in the early postoperative period *should not* be treated with supplemental calcium. The hypocalcaemic state may stimulate the parathyroid glands to produce PTH.

Patients who have *symptomatic hypocalcaemia* in the early postoperative period or whose calcium levels continue to fall rapidly need treatment. In symptomatic patients, intravenous calcium gluconate 10 ml 10% solution (1 gm) is administered over 10 minutes. A calcium infusion is started at a rate of 1-2 mg/kg/h if symptoms do not resolve. Rate of infusion is decided by repeated analysis of serum calcium and clinical features. One to two grams of elemental oral calcium should be given each day. Calcium carbonate 1250 mg provides 500 mg of elemental calcium; the patient should take 2500-5000 mg/day. The patient needs vitamin D supplementation with calcitriol 0.25-1 mcg/d. The calcium supplementation should be divided 4-5 times per day rather than in a single dose to maximise absorption by the GI tract.

In 2 months, trial weaning of oral calcium can be made to identify whether the hypoparathyroidism is temporary. Need for calcium supplementation longer than 6 months, indicates *permanent* hypoparathyroidism.

Hungry Bone Syndrome

It occurs usually in patients with preoperative hyperthyroidism. They have increased bone breakdown in their hyperthyroid state. When a patient's thyroid hormone level drops acutely after surgery, stimulus to breakdown bone is removed. The bones are now "hungry" for calcium, remove calcium from the plasma rapidly.

It usually occurs after parathyroidectomy; thyroidectomy for toxic thyroid; prostate cancer patients on estrogen therapy. Sudden cessation of existing increased bone breakdown makes bones to absorb calcium, magnesium and phosphorus rapidly. Calcium levels in blood prior to operation cannot predict hungry bone syndrome. Hypocalcaemia, hypophosphataemia, hypomagnesaemia and hyperkalaemia are four typical features in these patients. Estimation and correction of all these four factors is essential. ECG changes can occur. Hyperkalaemia should be treated judicially. Magnesium infusion is needed. There is an unusually high need for calcium, with a low calcium excretion in the urine. Bone-specific alkaline phosphatase (ALP) continues to rise in the first few weeks indicating increased bone reconstruction. Supplementation of vitamin D and elemental calcium is needed during discharge for 6 months. Postoperatively they need calcitriol (gradually increased to 16 mg in 1 month, then gradually

can be reduced) with 2 gm calcium supplement. Monitoring is done by evaluating serum calcium, albumin, magnesium, and phosphorus and bone specific alkaline phosphatase.

Thyrotoxic Storm/Crisis

Thyrotoxic storm is an unusual complication of thyroid surgery. This condition may result from manipulation of the thyroid gland during surgery in patients with hyperthyroidism. It can develop preoperatively, intraoperatively, or postoperatively. It is observed in thyrotoxic patients who are inadequately prepared/controlled; it begins due to surgery (thyroidectomy) or any other stress or operations other than thyroidectomy. Thyrotoxic storm is potentially lethal and must be dealt with utmost care. It can be seen in toxic nodule or toxic nodular goitre or more commonly in Grave's disease. Mortality is more than 50%. There is exacerbation of hyperthyroidism with decompensation of organ systems.

Features

Features of thyrotoxic storm in the anaesthetised patient include evidence of increased sympathetic output, such as tachycardia and hyperthermia. In an awake postoperative patient features are nausea, tremor, severe dehydration, circulatory collapse, hypotension, hyperpyrexia, out of proportion tachycardia, cardiac arrhythmias/failure and altered mental status. Cardiac arrest may also occur. If treatment is not adequate, the patient may progress to coma. Prevention is by restoring the thyroid status as close to euthyroid as possible. Morbidity and mortality rates in adequately prepared patient are low.

Intraoperative Management

The first step in managing a thyrotoxic crisis during thyroidectomy is to stop the procedure. Intravenous beta-blockers, PTU, sodium iodine, and steroids are administered to control sympathetic activity, the release of thyroid hormone and hyperthermia. Cooling blankets and cooled intravenous fluids are used to reduce the patient's body temperature. Oxygen demand increases dramatically during a thyroid storm.

Treatment of thyrotoxic crisis postoperatively

- Injection hydrocortisone 500–1000 mg intravenously.
- Proper fluid therapy to maintain hydration, blood pressure.
- Control of hyperpyrexia by total body sponging, cooling blankets, cooled intravenous fluids, steroids (dexamethasone), antipyretic injections.
- Sedation using chlorpromazine.
- Digoxin and diuretic therapy with monitoring of blood pressure.
- Intravenous heparin in case of atrial fibrillation.
- Beta blockers – oral propranolol – 80 mg 4th to 6th hourly (through nasogastric tube if needed); or oral diltiazem. Heart rate should be kept below 100/minute. Often to achieve this intravenous esmolol may be needed. Refractory cases require reserpine therapy.
- Antithyroid drugs – orally. Propylthiouracil or methimazole or carbimazole is given. Lugol's iodine is given 4 hours after propylthiouracil. Injection propranolol also can be given.
- Plasmapheresis and charcoal plasma perfusion or exchange perfusion is used if patient does not respond in 48 hours.
- Intravenous injection of sodium iodide 1 gram is often used.
- ICU care, oxygen, ventilator support, cardiac monitoring; electrolyte/blood gas/liver and renal function/thyroid hormone estimation at regular intervals is needed.
- Prevention of second episode of crisis by continuing the therapy is needed.

External Laryngeal Nerve Injury

The superior laryngeal nerve has two branches—internal and external. The internal branch provides sensory innervation to the larynx. It enters the larynx through the thyrohyoid membrane and not at risk during thyroidectomy. The external branch supplies cricothyroid muscle after passing through cricothyroid space of *Reeves* and is at risk during thyroidectomy. This muscle causes elongation of the vocal folds (tensor). Injury to this branch causes inability to lengthen the vocal fold and creates a high-pitched sound. The external nerve is probably the nerve most commonly injured in thyroid surgery (0-25%).

Features

Most patients do not notice any change. Patient may present with mild hoarseness or decreased vocal stamina. However, for a singer or a person who professionally relies on his or her voice (teachers), paralysis of this nerve may threaten his or her career. The most damaging consequence is loss of the *upper* register.

Diagnosing an external laryngeal nerve injury with indirect or fiber-optic laryngoscopy is difficult. Posterior glottic rotation towards the paretic side and bowing of the vocal fold on the weak side may be noted. The affected vocal fold may be lower than the normal vocal fold. Use of videostroboscopy and laryngeal EMG will help to diagnose ELN paralysis. Videostroboscopy demonstrates an asymmetric, mucosal traveling wave. EMG demonstrates denervation of cricothyroid muscle.

Prevention and Treatment

The external branch of SLN travels inferiorly along the lateral surface of the inferior constrictor until it terminates at the cricothyroid muscle. This branch is intimately related to the superior thyroid artery, though its exact relation to the artery varies. Study suggests that the nerve may cross the superior thyroid artery more than 1 cm above the upper pole of the thyroid gland (42%), less than 1 cm above the upper pole (30%), or under the upper pole (14%). In some people, the nerve runs dorsal to the artery and crosses only its terminal branches after the artery has ramified (14%). The critical area, 1.5-2 cm from the thyroid capsule is described. In this area, the ELN is most intimately involved with the branches of the superior thyroid artery.

Most surgeons agree that identifying the ELN, in contrast to the RLN, is unnecessary even though by principle it is ideal and must. Instead the terminal branches of the superior thyroid artery are ligated as close to the thyroid capsule as possible to avoid nerve damage. Direct trauma to the cricothyroid muscle can cause fibrosis and poor muscle function, which may result in a presentation similar to that of a patient with an injury to the ELN, even when the nerve is preserved. Therefore careful dissection near this muscle is advised to avoid damage due to electrocautery. Treatment for ELN palsy is speech therapy.

Hypothyroidism

Systemic thyroid hormone levels are low in hypothyroidism. It may be *primary* due to thyroidectomy/radioactive iodine ablation/primary thyroid diseases or may be *secondary* due to hypopituitarism or *tertiary* due to hypothalamic diseases.

Presentation

Untreated hypothyroidism causes symptoms such as cold intolerance, fatigue, constipation, and muscle cramping, brittle hair, dry skin, sluggishness, hypothermia and weight gain. CVS manifestations are important which present as bradycardia, hypotension and conduction problems and pericardial effusion. Hypothyroidism secondary to thyroid surgery should never be left untreated long enough to elicit signs and symptoms of myxoedema (e.g. hair loss, large tongue, cardiomegaly). One should suspect, diagnose and promptly treat postoperative hypothyroidism.

Hypothyroidism will worsen the situation of critically ill patient causing severe pulmonary dysfunction, pleural effusion and hypothermia.

Renal insufficiency can occur in hypothyroidism and so renal function tests should be done.

Evaluation

The most useful laboratory test for detecting or monitoring hypothyroidism in a patient whohas undergone thyroidectomy is the measurement of thyrotropin, thyroid-stimulating hormone (TSH) levels. Total T4 and T3 levels may be useful to fine-tune the dosing of levothyroxine, but may be unhelpful in the typical postoperative patient. In primary type T4, free T4, free T3 are low; but TSH level is high. In secondary type, free T4 index, free T3 and TSH are all low. *Adrenal insufficiency* is associated with *secondary* type.

Features of myxoedema coma	*Precipitated by*	*Treatment*
Hypothermia – skin is *deadly cold* like a toad. Hypotension Hyponatraemia Hypoventilation Hypoglycaemia Bradycardia Loss of tendon reflexes Cardiopulmonary collapse Coma	Cold infection, trauma.	Drug of choice – IV T3 10 µg Levothyronine 300 µg IV; later 1000 µg orally – large dose. Glucocorticoids – IV Antibiotics Slow warming Fluid and electrolyte therapy Monitoring; ICU care; ventilator

Prevention

Hypothyroidism is an expected sequelae of total thyroidectomy. In goitre surgery, the extent of thyroidectomy is controversial. The main goal of surgery is to prevent recurrent hyperthyroidism because recurrent hyperthyroidism after surgery is more difficult to manage than permanent hypothyroidism. Because of this fact, the present authors recommend total thyroidectomy in this setting.

Treatment

Levothyroxine (about 1.7 mcg/kg/d) 100-150 µg/daily (single dose, morning) is started. Their thyrotropin level is checked in 4-6 weeks to adjust the dosage. Patients who are to receive postoperative radioiodine therapy with scanning must stop taking levothyroxine before the procedure. In cardiac patients initially 50 µg/day is started; later gradually increased to required dose.

In myxoedema coma, IV hydrocortisone, IV levothyroxine, IV levothyronine is started.

Types of hypothyroidism
Primary – Thyroidectomy or thyroid diseases like thyroiditis – free T4, T4, and free T3 are low; TSH is high.
Secondary – Hypopituitarism – TSH, free T3 are low.
Tertiary – Hypothalamic diseases.

Presentations
Asymptomatic.
Chronic hypothyroidism status.
Myxoedema coma – Acute presentation with loss of deep tendon refluxes, respiratory problem, cardiac irregularities, coma with 50% mortality.

Causes
- Agenesis or dysgenesis.
- Enzyme deficiency.
- Iodine deficiency.
- Hashimoto`s thyroiditis.
- Antithyroid drugs.
- Radioiodine.
- Drugs: Lithium, Amiodarone.
- *After thyroidectomy.*

Clinical features
- *General:* Tiredeness, weight gain, cold intolerance, goitre, hyperlipidaemia.
- *Cardiovascular:* Bradycardia, angina, cardiac failure, pericardial effusion.
- *Haematological:* Anaemia.
- *Dermatological:* Dry skin, vitiligo, alopecia, erythema.
- *Reproductive:* Infertility, menorrhagia, galactorrhoea.
- *Gastrointestinal:* Constipation, ileus.
- *Developmental:* Growth and mental retardation, delayed puberty.
- *Other features:* Carpal tunnel syndrome, myalgia, hoarseness, deafness, ataxia, depression, psychosis (myxoedema madness).

Infection

Infection is rare due to good aseptic methods. Perioperative antibiotics are used in many centres. Bleeding from vascular thyroids, haematoma, infected suture material are the causes of infection. In large malignant thyroid during thyroidectomy injury may occur to oesophagus which causes severe localised sepsis in the neck. Gastrografin study, CT scan/MRI may reveal the site and extent of the injury. Pus culture, starting higher generation antibiotics, nasogastric tube insertion, and endoscopic identification of the injured area are needed management in such rare patients. Usually they recover but may need to keep the nasogastric tube (feeding can be done through the tube) for few weeks.

Recurrent Thyrotoxicosis

Recurrent thyrotoxicosis is difficult to manage. It is more common with subtotal thyroidectomy (4-15%) than with total thyroidectomy. So at present, total thyroidectomy is commonly done for toxic thyroid. Management is proper anatomical assessment of the residual thyroid tissue by using radioisotope scan, MRI neck and radioactive iodine ablation of residual thyroid tissue if patient's age is more than 45 years or surgical reexploration and complete removal of residual thyroid tissue on both sides. It carries higher risk of injury to recurrent laryngeal nerve and parathyroids. Meticulous dissection, adequate exposure and proper retraction is needed.

Minor Complications

Small seromas can be left as such to resorb. Large seroma may require repeated aspirations. Wound infection and poor scar are other complications.

Minimally Invasive Video-assisted Thyroidectomy

Minimally Invasive Video-assisted Thyroidectomy (MIVAT) is becoming popular for small nodules and gland without thyroiditis. But it is costly.

The development of videolaparoscopic surgery in the last decade has allowed several operations to be performed with minimally invasive techniques. After the first parathyroidectomy procedure performed endoscopically in 1996, this minimally invasive approach was applied to thyroid surgery. MIVAT was described in 1998. The technique was described using a central access with a 1.5 cm incision and external retraction. Postoperative morbidity rates in patients seem to be equivalent to those of patients who have undergone conventional surgery.

Chao et al (2004) prospectively compared video-assisted thyroid lobectomy and conventional lobectomy in 116 patients with thyroid nodules. Transient RLN palsy occurred in 5 (8.5%) patients who underwent conventional surgery versus 3 (5.8%) patients in the video-assisted group; the difference was not significant. Patients in both groups were discharged home on the second postoperative day.

In a 5-year study, Miccoli et al (2004) selected 579 patients to undergo MIVAT.The operation consisted of total thyroidectomy in 312 patients and lobectomy in 267. The mean operative time was 41 minutes (range, 15-120 min) for lobectomy and 51.6 minutes (range, 30-140 min) for total thyroidectomy. The postoperative hospital stay was 24 hours (overnight discharge) for all patients. Complications included postoperative bleeding (0.1%), recurrent nerve palsy (1.3%), and definitive hypoparathyroidism (0.2%). Some have suggested that pain following VAT is less when compared to conventional thyroidectomy because of limited dissection, retraction, and injury to tissues.

MIVAT provides endoscopic magnification of nerves and vessels, potentially decreasing the risk of injury to these structures. The endoscopic technique cannot be used in nodules larger than 3.5cm because the specimen is too large to retrieve through the incision. In addition, this technique is not ideal for removing carcinomas in which an intact capsule is desired for oncologic reasons and for accurate histological assessment.

In summary, if the general principles of conventional thyroid surgery are followed, video assistance may help in identifying structures and in minimising the incision. Experienced surgeons may consider using this technique when the equipment and additional surgical staff is available for patients with small follicular nodules/adenomas, or well-differentiated papillary carcinoma, or when prophylactic thyroidectomy is being performed in oncologically needed patients.

PARATHYROID SURGERY

Surgical Anatomy of Parathyroid

Two pairs of parathyroids are located within the false capsule and posterior border of thyroid gland. Superior parathyroids develop from endoderm of 4th pharyngeal pouch and called as *parathyroid IV*; inferior parathyroids are called as *parathyroid III* (3rd pouch). Each parathyroid is lentiform/pea sized in shape with 6 × 4 ×2 mm in size weighing 50 mg and red brown in colour. Glands lie in close relation to anastomotic branch of superior and inferior parathyroid arteries. *Superior* usually lies in constant position at the middle of posterior border of the thyroid, *behind recurrent laryngeal nerve*. *Inferior* lies in variable positions – within the thyroid capsule below the inferior thyroid artery/outside the thyroid capsule above the inferior thyroid artery/within the thyroid substance in posterior border. Inferior is usually *in front of the recurrent laryngeal nerve*. Inferior parathyroid and thymus develop from 3rd pharyngeal pouch and so can also be occasionally located in mediastinum. Parathyroids receive their blood supply from inferior thyroid artery (80%) and anastomotic artery. Single end artery is the common method of supply **(Fig. 15-45)**.

Glands (chief cells) secrete parathormone (PTH) which controls the calcium metabolism.

PTH

- Increases absorption of the calcium from the gut.
- Mobilises calcium from the bone.
- Increases the calcium reabsorption from the renal tubules.
- Half life is 4 minutes.

Indications for Parathyroidectomy

Primary hyperparathyroidism – Criteria (2002) for surgical intervention are –raise in serum calcium level more than 1 mg/dl of upper limit of the normal calcium range; 24 hour urinary calcium if more than 400 mg; creatinine clearance when reduced more than 30%; bone density greater than two standard deviations below peak bone mass in lumbar spine/hip/lower end of radius; age below 50 years; when medical therapy is not possible.

Common cause for primary HPT is single benign parathyroid adenoma (85%). 95% of such adenomas are single in one gland. 5% cases are having double adenomas each one in two glands. Proliferation causing hyperplasia involving all four glands (15%) also causes primary HPT. This type may be associated with MEN syndrome type I and IIA. Slow growing invasive parathyroid carcinoma accounts for 1% of primary HPT.

Four dimensional CT, PET scan, Technetium 99m sestamibi scintigraphy are the present methods of evaluation in these patients. On table methylene blue injection (5 mg/kg over an hour infusion) will make only the parathyroid gland blue to identify it.

Secondary HPT is an indication for removal of all four glands with autotransplantation of parathyroid only in severe cases or with renal osteodystrophy.

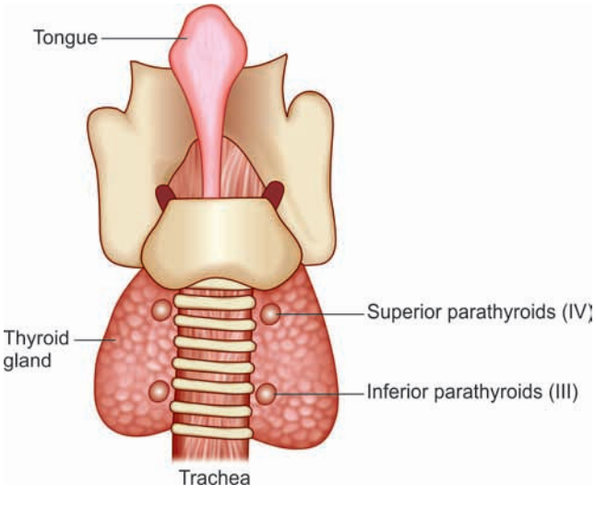


Fig. 15-45: Anatomy of parathyroid glands.

Indications for parathyroidectomy

- Severe symptoms
- Young age group
- Markedly reduced bone density
- Serum calcium more than 11 mg %
- Urinary calculi
- Neuromuscular presentations
- Urinary calcium more than 400 mg/24 hours

Preoperative Preparation

Vocal cords should be assessed by preoperative indirect laryngoscopy.

High calcium levels preoperatively may require treatment with hydration; diuresis; steroids (prednisolone 20 mg TID for 5 days before surgery); 100 mmol phosphate infusion in 6 hours; 200 units calcitonin subcutaneous injection for 5 days twice daily before surgery; diphosphanate – etiodronate disodium 7.5 mg/kg daily as slow IV infusion for 3 days; mithramycin 25 µg/kg as single dose.

Anaesthesia and Position

General anaesthesia is used with neck hyperextension by placing rolled sheet under the shoulder blades. Head is placed on the head – ring; head end of the table is raised to semi–erect position (*Semi-Fowler position).*

Incision and Dissection

It is same as for thyroidectomy. Flaps are raised in similar way. Strap muscles are separated after opening the deep fascia in the midline. Thyroid gland is mobilized to identify the parathyroid adenoma. Parathyroid having adenoma is mobilized which is close to recurrent laryngeal nerve. End artery of the parathyroid is identified and ligated. Adenoma is separated from adjacent thyroid tissue using gauze dissection. Either on table venous sampling for PTH assay is done or venous sample from cubital vein is done for PTH assay.

Parathyroid may be confirmed by frozen section biopsy or on table aspiration of parathyroid tissue which is analyzed for PTH assay which will be more than 1500 pg/ml (confirms removed tissue as parathyroid).

Total parathyroidectomy is done for parathyroid hyperplasia by removing all four glands and ⅓ of one gland is autotransplanted into the forearm muscle (brachioradialis) or sternocleidomastoid muscle with marker stitch. Transplanting gland is sliced into 1 mm pieces and around 18 pieces are embedded in decided muscle with a marker stitch or clip. If in postoperative period patient still presents with primary HPT features; transplanted area is re-explored and further reduction in parathyroid tissue is done.

Wound is closed with proper haemostasis.

Effects of Surgery

Among neuromuscular symptoms of primary HPT, proximal muscle weakness responds better than respiratory muscle weakness by parathyroidectomy.

Among psychiatric illnesses, depression and spatial learning and processing improve well by surgery.

Complications

Haemorrhage, recurrent laryngeal nerve palsy, hypocalcaemia and hungry bone syndrome are known to occur.

Persistent HPT (serum calcium is not normalized immediately after surgery leading total failure) or *Recurrent HPT* (serum calcium after surgery becomes normal but in 6-12 months, it again increases) may be a problem.

Hypoparathyroidism with severe hypocalcaemia is a problem when all glands are removed (3½) with bilateral neck exploration. 10 ampoules of calcium gluconate is diluted with one liter of normal saline and given as continuous infusion at a rate of 30 ml/hour – initial method of management. Hypomagnesemia should also be corrected.

Migration or inability to identify the transplanted parathyroid is often a problem in autotransplantation of parathyroid.

Bone mineral density in hip and lumbar spine becomes better.

Nephrocalcinosis is improved by surgery; but hypertension and renal excretion will not improve much.

Half life of PTH is 4 minutes. On table serial PTH assays are done at several intervals – before dissection of the gland, during dissection and after dissection. 50% reduction in PTH level from baseline in post removal sample is a 96% predictor of complete removal.

Operative failure rate is 1.5 to 6%. Intra-operative PTH assay improves the success rate very much (76% to 94%). Cure rate is defined as normocalcaemia in 6 months postoperative period.

Radio guided parathyroidectomy using intravenous injection of 20 mCi of 99mTc sestamibi 2 hours before surgery is not routinely practiced but may be useful for removal of adenoma appropriately. Hand held quantitative gamma counter is used intraoperatively on the neck over all parathyroid tissues.

- Primary HPT is commonly sporadic than familial
- Histological difference between adenoma and hyperplasia is difficult to assess
- Gross on table look is preferred method
- Adenoma is usually single. Multiple adenomas occur in elderly
- Hyperplasia involves all four parathyroids
- Parathyroid cyst may be developmental/secondary to degeneration of nodule or adenoma. Cyst aspiration shows clear fluid with high PTH level in the content fluid
- Preoperative IV methylene blue 5 mg/kg in 500 ml dextrose saline which stains parathyroids is often used to localize glands
- 50 mg of one gland is sufficient to maintain function
- Persistent HPT is one in which HPT persists immediately even after initial surgery,
- Recurrent HPT (initially after first surgery HPT is corrected but recurs 6 - 12 months after surgery) is due to parathyromatosis, development of new adenoma, and hyperplasia of transplanted parathyroid. *Parathyromatosis* is due to rupture and spillage of parathyroid tissue in neck, mediastinum and forming functioning nodules there
- Re-exploration and removal in persistent/recurrent HPT needs on table PTH assay. On table PTH level drop more than 50% of preoperative value indicates the success of surgical removal
- CT, MRI, PET scan and selective angiography are usually done only for recurrent diseases

Problems in parathyroidectomy

- Permanent hypoparathyroidism
- Recurrent hyperparathyroidism-hypercalcaemia 12 months after parathyroidectomy
- Recurrent laryngeal nerve injury
- Often needs additional thyroidectomy
- Variations in positions of the gland especially lower—may be in mediastinum
- Sudden drop in calcium level after surgery due to increased absorption of calcium by bones—***hungry bone syndrome***.

Approaches

Classic Approach (Traditional Approach)

It is under general anaesthesia exploring bilateral neck to remove parathyroid tissue which is confirmed by frozen section biopsy. It shows 95% cure rate with 2% complication rate.

Minimally Invasive Parathyroidectomy (MIP)

It is done in case of *single adenoma* of parathyroid under regional cervical block anaesthesia usually in ambulatory set up. It is actually unilateral parathyroidectomy with removal of adenoma and involved entire that particular one parathyroid gland using limited neck exploration (small incision of 2-4 cm). Procedure is not useful in multiple adenomas or hyperplasia. Preoperative localization with sestamibi combined with SPECT is a must. Intraoperative PTH assay is a must to confirm drop in PTH level to required level. Cervical block is given by infiltrating the xylocaine (1%) with adrenaline along posterior and deep to sternocleidomastoid muscle and also along the neck incision. Direct field block along the anterior border of the sternocleidomastoid and over the incision is also used. Postoperative serum calcium and PTH level should be assessed until 7th day.

Median Sternotomy (3%) Extension

Median sternotomy is often needed when parathyroid is in anterior mediastinum along with thymus. Often parathyroids may be 5, 6 or 7 in numbers instead of four.

Video-assisted Parathyroidectomy (Paolo Miccoli)

It is done in *localized single adenoma* using multiple ports on one side with intermittent CO_2 insufflation and suction irrigation. 1.5 cm incision 1 cm above the sternal notch helps in tactile assessment and dissection. Strap muscles are retracted laterally and thyroid is retracted medially. Conversion rate is 11%; RLN palsy is 2%.

Endoscopic Parathyroidectomy

Entire parathyroidectomy is done using laparoscopy. It is first used (1994) for a mediastinal parathyroid adenoma. In 1996, it was used for neck parathyroid hyperplasia by Gagner for removing 3½ glands. Now technique is *limited to single adenoma* to remove tumour and gland. Low pressure insufflations with 5 mm four trocars are used. Placement of trocars is dependent on the need of the operating surgeon. Many place trocars on one side only; but few prefer to place working trocars on opposite side.

Remedial Parathyroidectomy

It is done for persistent HPT (serum calcium is not normalized immediately after surgery leading total failure) or recurrent HPT (serum calcium after surgery becomes normal but in 6-12 months, it again increases). It is done through lateral approach (*Feind*) between anterior margin of sternocleidomastoid and strap muscles so that scar tissues are avoided from initial dissection. On table localisation methods, on table PTH assay are needed. Median sternotomy often may be needed to explore the mediastinum for complete removal of the gland. Parathyroids in such situations may be embedded in the tissue of thyroid or thymus. So removal of these glands also may be a need in such situations.

Subtotal Parathyroidectomy

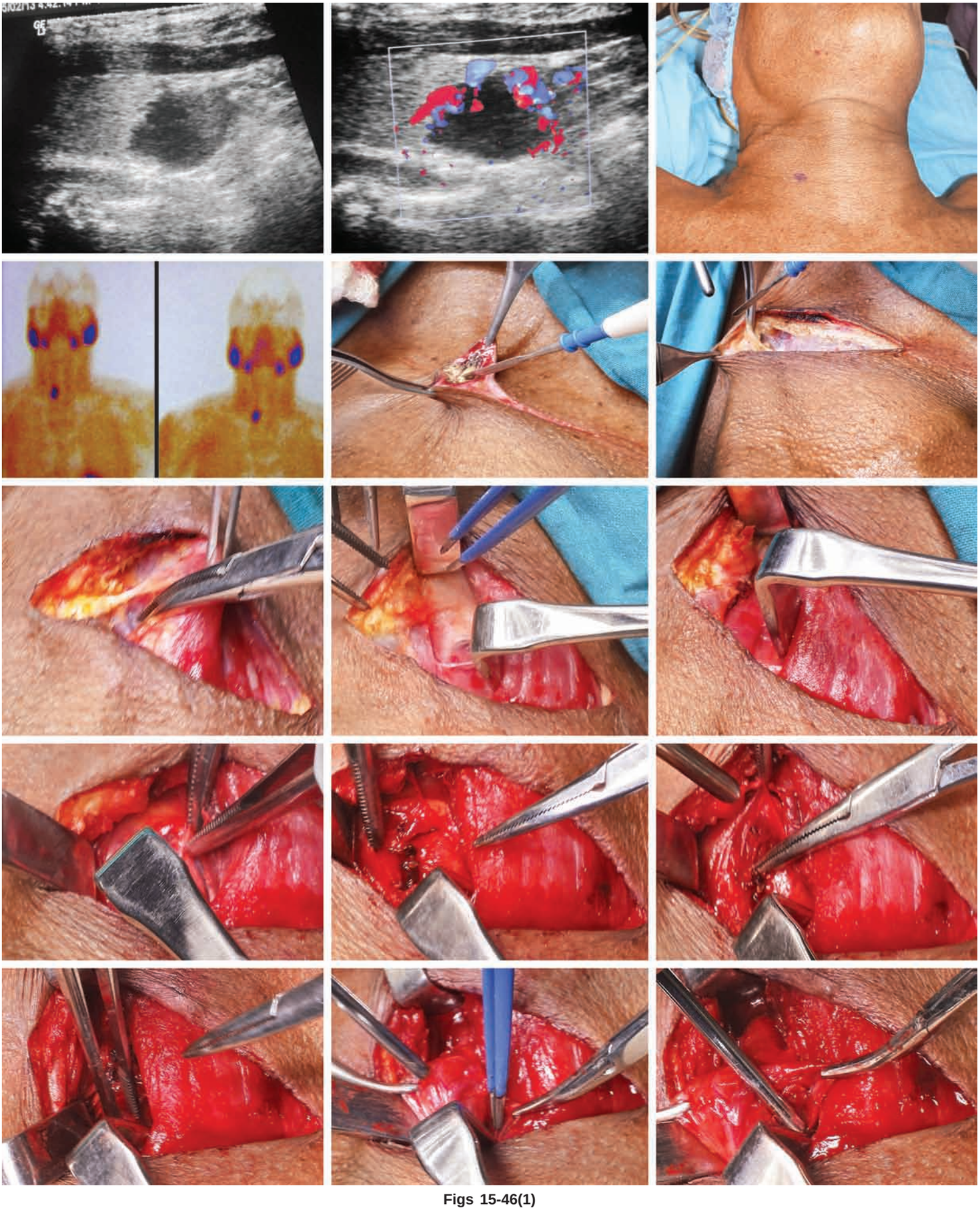
It is indicated in hyperplasia or secondary HPT wherein 3½ glands are removed, retaining ½ of one gland.

Total Parathyroidectomy with Parathyroid Autotransplantation

It is done alternatively in hyperplasia wherein all four glands are removed; ⅓ or ½ of one gland is transplanted into sternocleidomastoid or brachioradialis muscle with a marker. Disease control will not occur if more part of the gland is transplanted. It is removing all four glands and 1/2 or 1/3 of one gland is autotransplanted into the forearm muscle (brachioradialis) or sternocleidomastoid muscle with marker stitch. Transplanting gland is sliced into 1 mm pieces and around 18 pieces are embedded in decided muscle with a marker stitch or clip. If postoperatively still patient presents with primary HPT features; transplanted area is re-explored and further reduction in parathyroid tissue is done. Migration or inability to identify the transplanted parathyroid is often a problem in auto-transplantation of parathyroid.

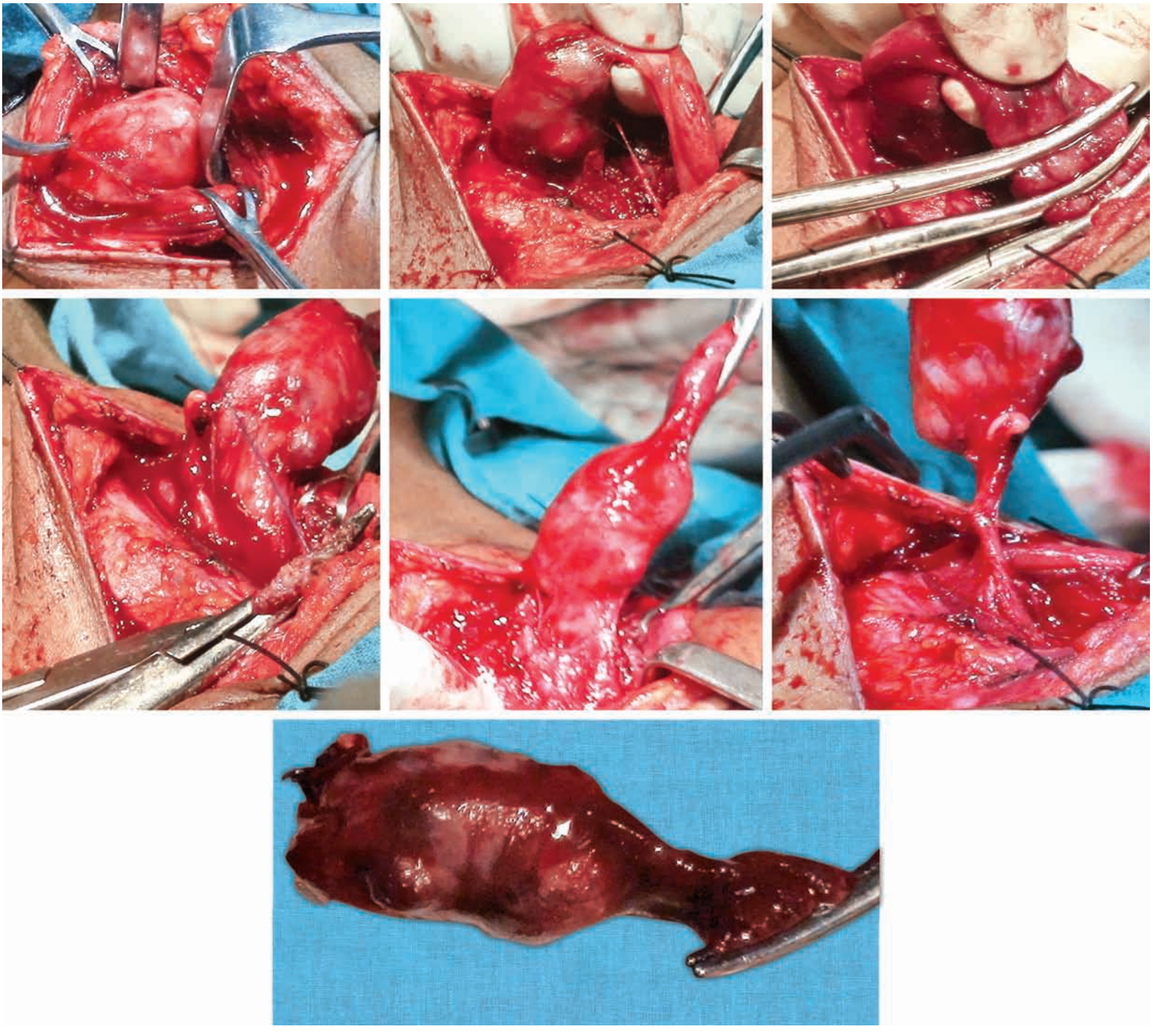
PARATHYROID CARCINOMA

It is rare but shows marked hypercalcaemia (more than 14 mg/dl). Renal and bone complications are more common. Palpable neck swelling, features of hypercalcaemia, high PTH level are typical. Lymph nodes in neck may be involved. Tumour is large grayish white, invasive to adjacent thyroid. Distant spread occurs to lung, liver and bone. *En bloc parathyroid resection, ipsilateral thyroid lobe removal, adjacent soft tissue resection* along with ipsilateral neck lymph node dissection if needed – is the treatment. Simple parathyroidectomy should not be done as it shows high recurrence rate (50%) and spread. Recurrence rate for en bloc removal is 8%. Nodal and distant spread carries poor prognosis. *Cinacalcet* (30-180 mg/day) is used for symptomatic control of hypercalcaemia. Removal of metastatic area may be needed to control severe hypercalcaemia. Chemotherapy is not useful. External radiotherapy may be used to neck and metastatic area; but results are not adequate.



Figs 15-46(1)

Figs 15-46(2)



Figs 15-46(3)

Figs 15-46: Technique of parathyroidectomy for adenoma in two different patients.

Chapter

16

Surgeries for Breast Diseases

SURGICAL ANATOMY OF BREAST

Breast, a *modified sweat gland* lies in superficial fascia in pectoral region with a small extension called as *axillary tail of Spence* into the axilla through *foramen of Langer* in deep fascia. It extends from 2nd to 6th rib; from lateral border of sternum to midaxillary line. Deep to breast, structures related are – retromammary space containing loose areolar tissue, pectoral deep fascia, muscles (pectoralis major, serratus anterior, external oblique), chest wall **(Fig. 16-1)**.

Retromammary bursa/space is located between deep layer of superficial fascia and pectoral (deep) fascia allowing free mobility of breast.

Nipple is located at the level of 4th intercostal space just below the centre/summit of the breast. It contains circular and longitudinal muscles to make nipple stiff or flat. It is pierced by 15 – 20 lactiferous ducts. Each duct independently opens into the nipple. It has rich sensory nerve endings. It also contains modified sweat and sebaceous glands. Nipple is supplied by 4th intercostal nerve.

Areola is circular pigmented area around the nipple. It is rich in modified sebaceous glands which enlarge during pregnancy and lactation as *Montgomery tubercles*. They secrete oily lubricant to nipple and areola. Areola and nipple do not contain hair and fat beneath.

Breast parenchyma contains 15-20 lobes. Each lobe contains alveoli, lactiferous sinus and lactiferous duct. Alveolus is lined by cuboidal (in rest) and columnar (in lactation); smaller duct is by single layer columnar; larger ducts by many layered columnar; lactiferous duct (2-4 mm in diameter) is by stratified squamous epithelium. *Myoepithelial cells* lie between epithelium and basement membrane from alveoli to duct. *Stroma* contains fibrous tissue and fat. Fibrous stromal septa, anchoring from skin to pectoral fascia, is called as *suspensory ligament of Cooper*. Fat is distributed all over the breast *except* under nipple and areola **(Fig. 16-2)**.

Arterial Supply

It is by - Internal thoracic mammary artery (60%), branch of subclavian artery through its perforators; lateral thoracic (30%), superior thoracic and acromiothoracic branches of axillary artery; lateral branches of posterior intercostal arteries. Thoracodorsal branch of subscapular artery is not supplying the breast but its location and pathway is

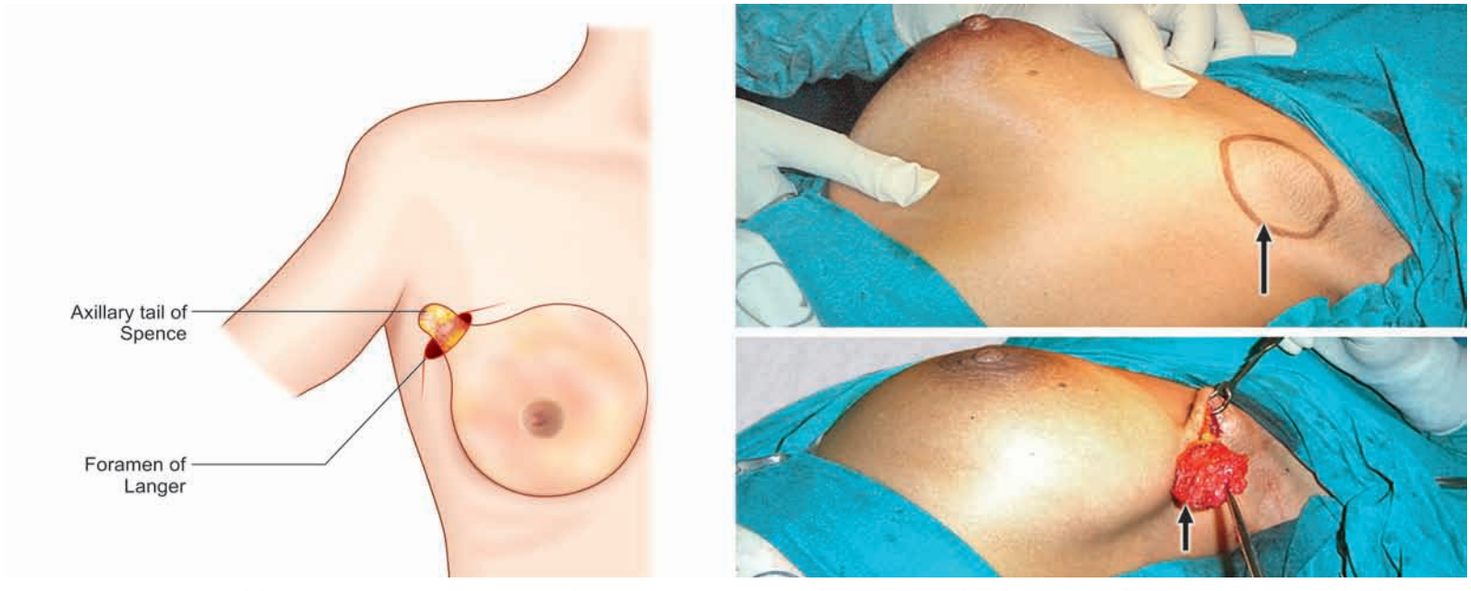


Fig. 16-1: Axillary tail of Spence, located deep to deep fascia, is an extension of main breast from superficial fascia through foramen of Langer.

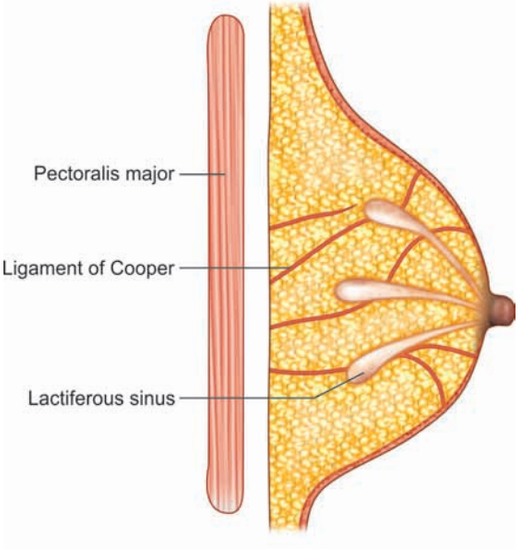


Fig. 16-2: Cooper's ligament.

important because it is very close to central and scapular (posterior) axillary lymph nodes. So during lymph node dissection injury of this vessel can cause significant damage; and it is essential to retain this branch. If LD flap is needed at a later period **(Fig. 16-3)**.

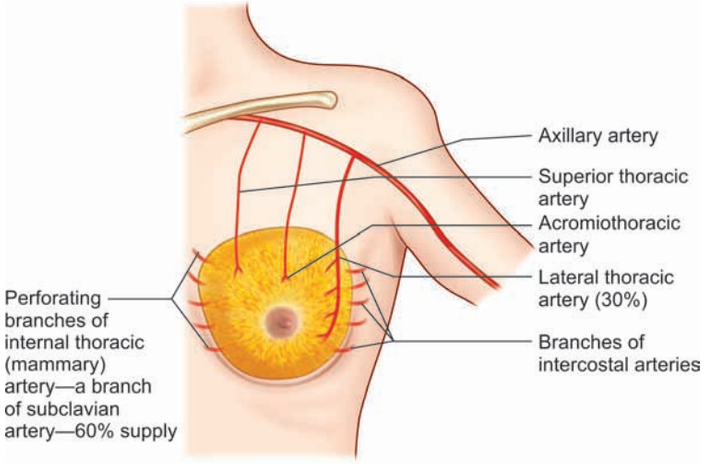

Axillary artery
Superior thoracic artery
Acromiothoracic artery
Lateral thoracic artery (30%)
Branches of intercostal arteries
Perforating branches of internal thoracic (mammary) artery—a branch of subclavian artery—60% supply

Fig. 16-3: Arterial supply of breast.

Venous return is by - Posterior intercostals with perforating branches which is also in continuity with Batson's vertebral plexus; axillary vein (primary); internal mammary vein. Venous network form an anastomotic venous circle near base of the nipple which eventually sets into superficial and deep veins. Superficial veins drain into internal thoracic vein; deep into internal thoracic, axillary and posterior intercostal veins.

Nerve supply of breast is from anterior and lateral cutaneous branches of the 4th to 6th intercostal nerves. They supply skin, smooth muscles, and blood vessels. They do not control milk secretion. Nipple is supplied by 4th intercostal nerve.

Milk secretion is controlled by prolactin.

Lymphatic drainage of breast – Superficial lymphatics drain skin over the breast except nipple and areola. Deep lymphatics drain parenchyma, nipple and areola. 75% drain into axillary nodes; 20% into internal mammary nodes (parasternal – along internal thoracic vessels deep to the costal cartilage); 5% to posterior intercostal nodes. In axilla, lymphatics mainly drain to pectoral nodes (anterior/external mammary along the lateral thoracic vessels); then to posterior (along subscapular vessels), lateral (along axillary vein), central (in the fat in centre of the axilla) and apical (subclavicular/*Halsted)* nodes (along pectoralis minor tendon). Supraclavicular, deltopectoral (cephalic), posterior intercostal nodes, subdiaphragmatic lymph plexus are other drainage areas. Sappey's subareolar lymphatic plexus drains into pectoral group of lymph nodes. Central group is the *most properly clinically palpable* axillary node. *Internal mammary nodes* are located in retrosternal intercostal spaces 1-2 cm lateral to the sternal margin; it is vertically placed parallel to internal mammary vessels in relation to endothoracic fascia; its efferent ends in subclavicular nodes.

Intercostal lymph nodes are located posteriorly in intercostal spaces near the origin of ribs. Its efferent drains into the right lymphatic duct or thoracic duct.

Diaphragmatic nodes are located on the thoracic surface of the diaphragm. Anterior prepericardial nodes are located under xiphoid process; lateral one is located on each side, right side near IVC, left side near oesophageal hiatus; posterior group is located near crura of diaphragm.

Axillary reverse mapping (ARM) – Here blue dye is injected on inner upper part of the arm to achieve a mapping of axillary lymphatic drainage **(Fig. 16-4)**.

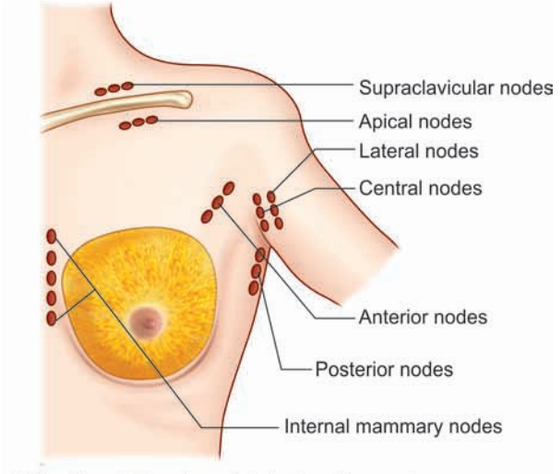

Supraclavicular nodes
Apical nodes
Lateral nodes
Central nodes
Anterior nodes
Posterior nodes
Internal mammary nodes
- 75% of lymph from breast drain to axillary nodes
- 20% into internal mammary nodes
- 5% to posterior intercostal nodes
- Internal mammary drains not only from inner but also from outer quadrant
- Lymphatics from deep part of breast pass through PM muscle and clavipectoral fascia to reach apical nodes and internal mammary nodes
- Lymphatics from lower inner quadrant of the breast communicate with subdiaphragmatic and peritoneal lymphatics across costal margin and linea alba.

Fig. 16-4: Lymphatic drainage of the breast.

Axilla

Axilla is pyramidal in shape with apex, base and four walls – anterior, posterior, medial and lateral. Apex (*cervicoaxillary canal*) is bound by clavicle, scapula and outer border of first rib. Anterior wall is formed by pectoralis major, clavipectoral fascia; posterior wall by subscapularis, teres major and latissimus dorsi; medial wall by upper four ribs with intercostal muscles, upper part of serratus anterior muscle; lateral

wall by shaft of humerus, coracobrachialis, short head of biceps. It contains axillary artery with its branches, axillary vein with its tributaries, axillary groups of lymph nodes, and long thoracic nerve of Bell to serratus anterior, intercostobrachial nerve, fat and fascia. Subscapular vessels run along the lower border of the subscapularis with its nerve and thoracodorsal nerve. Medial wall is related to long thoracic nerve and intercostobrachial nerve. Anterior/pectoral group of lymph nodes lie along the lower border of pectoralis minor on lateral thoracic vessels. Lateral group of nodes lie posteromedial to axillary vein. Central group lies in the fat of the axilla towards medial side. Apical nodes lie behind, above the pectoralis minor, medial to axillary vein. *Axillary sheath* covers axillary artery and brachial plexus *but not* axillary vein.

Note: A communicating vein between cephalic vein and external jugular vein (neck) is present which runs across the clavicle. It is important in draining the upper limb in axillary vein removal (in carcinoma breast, segment may be removed)/blockage **(Fig. 16-5)**.

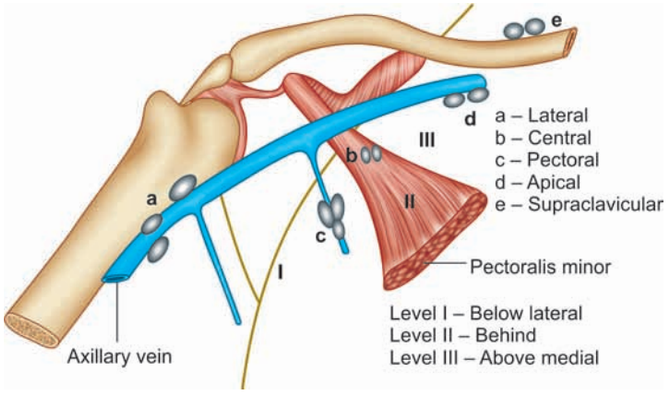


Fig. 16-5: Surgical levels of lymph nodes (Berg's) in the axilla draining from breast.

Levels of the axillary nodes (Berg's)

- Level I—Below and lateral to the pectoralis minor muscle—anterior, lateral, posterior
- Level II—Behind the pectoralis minor muscle—central
- Level III—Above and medial to pectoralis minor muscle—apical – Halsted's node

Note in carcinoma breast

- Spread restricted to Level I nodes carries better prognosis
- Spread to Level II has poor prognosis
- Spread to Level III indicates worst prognosis

Nerves Related to Axillary Dissection

Long thoracic nerve arises from C5, 6, 7 nerve roots of brachial plexus, enters the axilla running on the lateral surface of the serratus anterior muscle invested by serratus fascia and supplies serratus anterior which on division during axillary dissection causes *winged scapula* with inability to fix the shoulder.

Thoracodorsal nerve arises from posterior cord of brachial plexus runs posteriorly downwards to supply latissimus dorsi muscle. Its division may cause difficult in extending the shoulder but more importantly reconstruction with latissimus dorsi myocutaneous flap (LD flap) after mastectomy is not possible.

Intercostobrachial nerve is communicating nerve between lateral cutaneous branch of 2nd intercostal nerve and medial cutaneous nerve of arm, denervation of this nerve causes sensory loss of skin of upper medial and inner aspect of the arm, apex and lateral axilla. Second intercostobrachial nerve may be present occasionally arising from anterior branch of 3rd lateral cutaneous nerve.

Medial pectoral nerve arising from medial cord of the brachial plexus runs along the lateral margin of the pectoralis minor supplying pectoralis minor mainly and pectoralis major muscle partly. It often may pass through the fibres of the pectoralis minor muscle at its lateral aspect. It should be preserved during axillary dissection otherwise atrophy of pectoral muscles occur.

Lateral pectoral nerve arises from lateral cord of the brachial plexus after running on the medial aspect, supplies the medial part of the pectoralis major muscle (Lateral pectoral nerve is medial; medial pectoral nerve is lateral. They are not named on anatomical location but on their origin of cord).

Muscles Related to Breast/Breast Surgery

Pectoralis major muscle – It arises from medial half of clavicle (clavicular fibers), anterior part of manubrium and sternum up to 6th costal cartilages (sternal fibres), 2nd to 6th costal cartilages (costal fibres). It is inserted as bilaminar tendon into lateral lip of bicipital groove of the upper end of humerus. It is supplied by lateral and medial pectoral nerves. Fibres are mainly placed as *transverse* and oblique. It is adductor and medial rotator of the shoulder; clavicular fibres flex the arm also. Deeper relations are pectoralis minor, clavipectoral fascia which is pierced by cephalic vein, thoracoacromial artery and lateral pectoral nerve. Anterior axillary fold is formed by twisted fibres of the pectoralis major muscle **(Fig. 16-6)**.

Pectoralis minor muscle – It arises from 3rd, 4th and 5th costal cartilages near costochondral junctions. It is inserted to medial upper part of the coracoid process (along with coracobrachialis). It is supplied by medial and lateral pectoral nerves **(Fig. 16-7)**.

Serratus anterior muscle – It arises from 8 digitations from upper eight ribs and intervening intercostal fascia. It is inserted into the costal surface of the scapula; first to superior angle; 2-4 to medial margin of the scapula; last 4 into inferior angle of the scapula. It is supplied by long thoracic nerve to serratus anterior (*of Bell)* – C5, 6 and 7. Muscle pulls the scapula forward in pushing and punching movement; it rotates the scapula forward; it helps in raising the arm above the head; it steadies the scapula during weight carrying. Its paralysis causes inferior angle and medial border of the scapula to become more prominent during the pushing movement causing '*winging of the scapula*'.

Latissimus dorsi muscle – It arises from posterior third of outer lip of iliac crest; lumbar fascia; T7 to T12 spines; lower four ribs; inferior angle of scapula. It forms posterior fold of the axilla, with twisted tendon inserted into the floor of the intertubercular sulcus of the upper end of the humerus. It is supplied by thoracodorsal nerve (C6, 7 and 8). It causes adduction, extension and medial rotation of the shoulder. It is a muscle of climbing, swimming and rowing. Muscle is important in mastectomy while creating the L D myocutaneous flap.

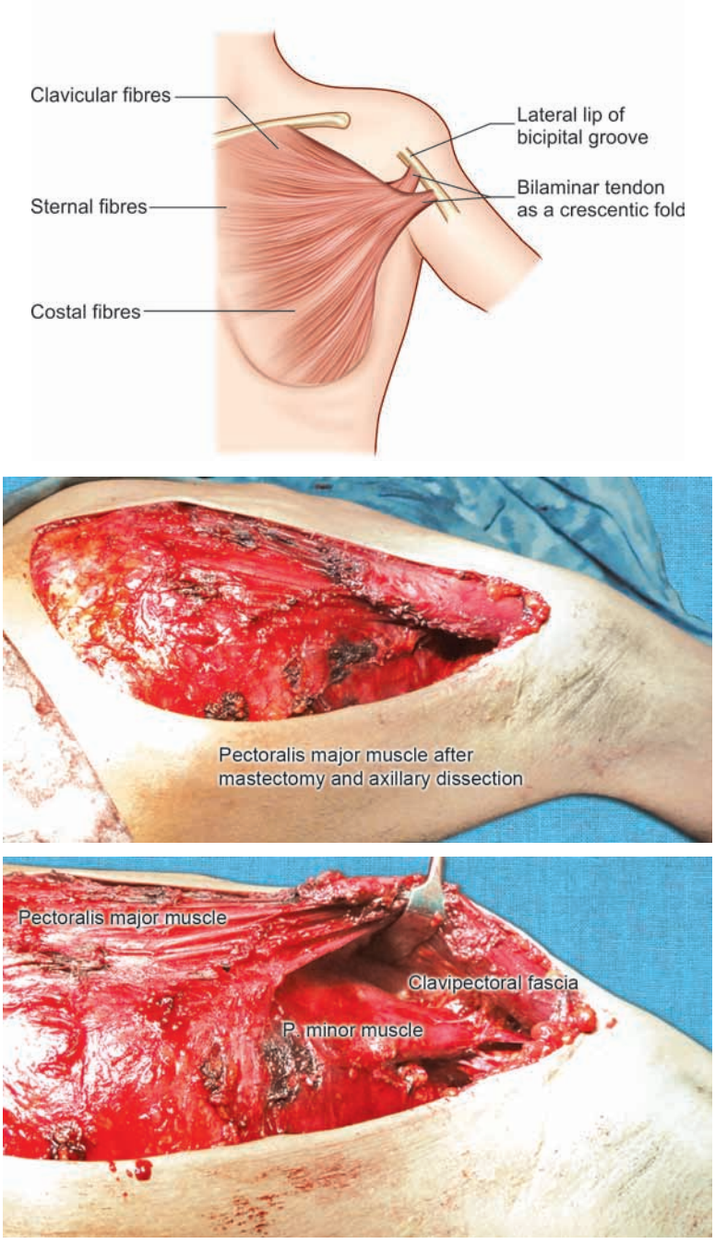


Fig. 16-6: Pectoralis major muscle.

Fig. 16-7: Pectoralis minor muscle.

FNAC (Fine Needle Aspiration Cytology)

Often, 22 gauge needle with 20 ml syringe with syringe holder (aspiration gun) is used. Two syringes are usually required. After cleaning the area, needle is passed into the required tissue/mass obliquely; - 40 cm of H_2O suction is created into the syringe. Needle is manoeuvred at different angles at same site to allow cells to enter the needle. Cells should fill the needle not the syringe. Before removal of the needle from the tissue suction is released. Needle is withdrawn; contents are carefully expressed into glass slides. 5 mm drop of contents are placed over the slides, smear is created by rubbing another slide over it. One slide is air dried; other slides are fixed with 95% ethanol. Remaining cells in the needle can be used for culture, cytocentrifugation. Complications of FNAC of breast are rare. Rarely pneumothorax, haemothorax, haematoma and acute mastitis can develop. Sensitivity is 98%. Specificity and positive predictive value is near 100%.

OPEN BIOPSY OF BREAST LESION

Indications – Lesions with atypia; LCIS; radial scar; atypical papillary lesions; high risk group with suspected lesions; radiologic-pathologic discordance; phylloides tumour; inadequate tissue harvesting; negative FNAC/core biopsy but doubtful lesion; failure of infection

to subside in spite of proper treatment plan; mammographically suspected lesion.

Anaesthesia – Xylocaine 1% local (plain) anaesthetic agent is used (with adrenaline may cause epidermolysis). Infiltration is done deep into retromammary space. General anaesthesia is used when mass is not palpable or deeply placed; apprehensive non-cooperative patient; if one stage procedure (biopsy – frozen section confirmation – definitive surgical procedure) is planned.

Procedure – Incision is placed as periareolar or circumferential along the Langer lines which is cosmetically acceptable and should able to include the specimen of the eventual anticipated mastectomy. Sharp dissection is preferred method in biopsy. Bipolar cautery can be used (unipolar cautery should be avoided). Surrounding 1 cm margin of normal breast parenchyma is included with the lump. A 'figure of eight' suture may be placed on the mass to facilitate the dissection around. Holding the mass with crushing/damaging instruments should be avoided. Skin edge is retracted using hook retractor. After excision, haemostasis is achieved by bipolar cautery. Wound is irrigated with saline and drain is placed if required. Skin is sutured with subcuticular or interrupted sutures. Specimen should be oriented with marker stitches **(Figs 16-8 and 16-9)**.

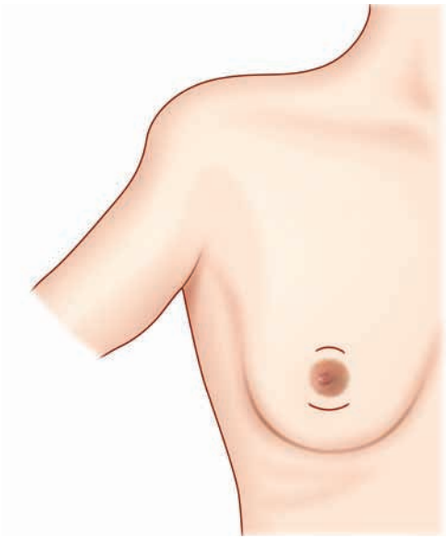


Fig. 16-8: Circumferential incision is preferred in breast biopsy.

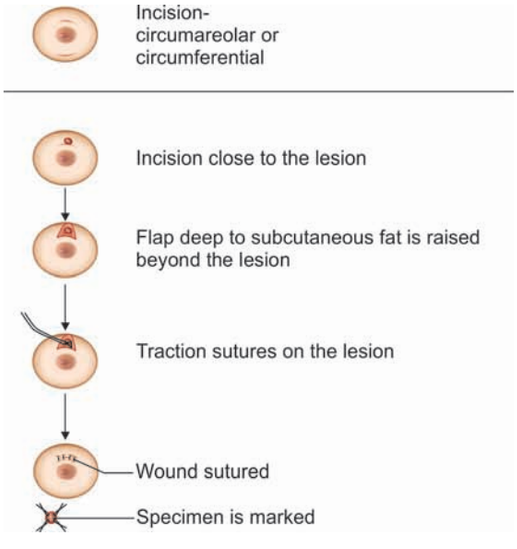


Fig. 16-9: Excision biopsy of the lump.

Incision biopsy instead of excision biopsy is done when tumour is more than 4 cm in size.

When there is nipple discharge suspicious of malignancy without any mass lesion, duct can be cannulated with a fine probe and circumferential excision of the duct with the lobe is done. Haematoma (10%), infection are the complications of breast biopsy.

Definitive surgery if done within 2 weeks of biopsy, it will not alter the recurrence rate or survival benefit.

EXCISION OF BENIGN BREAST LUMP

Palpable cyst can be aspirated. Recurrent cysts, solid benign masses need to be excised. Fibroadenoma, cysts, indicated fibrocystadenosis, traumatic fat necrosis are the common indications. Circumareolar, circumferential, lateral submammary incisions are commonly used. Smaller lesions are excised using circumareolar incision *(Webster's);* larger lesion is excised using submammary incision (*Gaillard Thomas incision)*. Type of incision is decided on individual patient basis. Superomedial incision is usually avoided as scar may become hypertrophic **(Figs 16-10 to 16-13)**.

Procedure

General anaesthesia is usually used. Patient is placed in supine position, cleaning and draping is done. Both monopolar and bipolar cautery can be used. Incision is made depending on the location and size of the lump. In *circumareolar incision*, dissection under the nipple should be done in deeper plane otherwise areolar necrosis may occur. Fine scissor and cautery dissection is done around the lump. Freely mobile and encapsulated fibroadenoma will easily come out of the wound with dissection around the capsule. *Figure of eight traction suture* on the swelling is beneficial to facilitate proper dissection around. It prevents destruction of the swelling/tissue to be removed by multiple applications of forceps. When cautery is used for excision, it should be wider to prevent coagulation artifacts in the specimen surface. Haemostasis achieved using cautery. Suction drain is placed. Deeper subcutaneous tissue is apposed using absorbable sutures (3 zero vicryl). Skin is closed using monofilament nonabsorbable (3 zero polypropylene) or 3 zero monocryl. Compression dressing applied. Drain is removed in 48 hours. Specimen should sent for histology after making proper markings. Special sports bra is used in postoperative period until recovery occurs. An icepack over the breast may be useful to relieve the pain in immediate postoperative period **(Fig. 16-14)**.

Complications

Seroma, haematoma, areolar necrosis, nipple deformity, asymmetry of breasts

Subcutaneous Mastectomy

It is removal of entire breast with retaining skin over the breast, areola and nipple. It is done through a submammary *Gaillard Thomas incision*. Adequate skin flap is raised with flap containing subcutaneous fat which maintains the blood supply of the flap and prevents flap necrosis. Entire breast is removed using fine scissor dissection or cautery dissection. It is done in gynaecomastia, as a prophylactic mastectomy in high risk patients. After haemostasis drain is placed. Breast implant can be placed in subcutaneous/submuscular plane either immediately or as delayed reconstruction.

Fig. 16-10: Circumareolar (Webster's) incision. Areolar flap is raised carefully in deeper plane otherwise areolar necrosis can occur.

Fig. 16-11: Areolar necrosis developed after circumareolar incision.

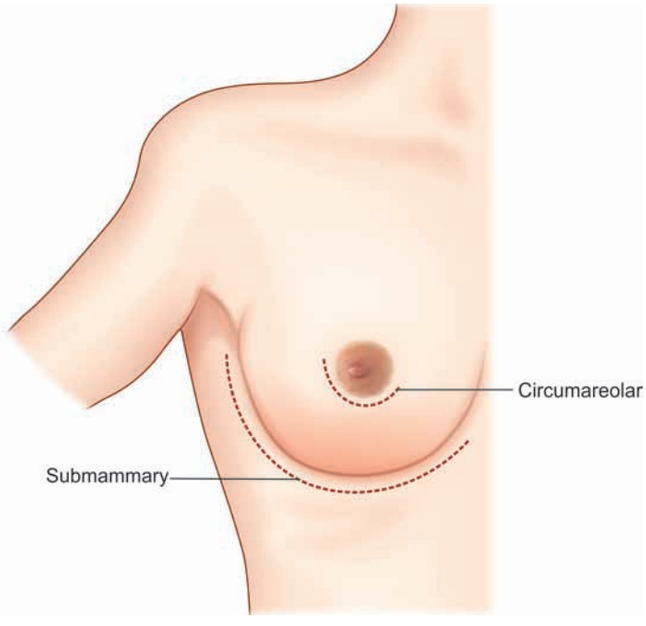


Fig. 16-12: Incisions used for breast lump excision. Circumareolar *(Webster's)* incision is cosmetically better and is used for small lumps. *Gaillard Thomas* submammary incision is used for excision of the large lump.

Indications for subcutaneous mastectomy are – fibrocystadenosis with epitheliosis, sclerosing adenosis, persistent nodules, gynaecomastia and DCIS. Breast implants (silastic) are placed in the subcutaneous/submuscular plane **(Fig. 16-15)**.

Complications

Nipple/areolar ischaemia, nipple distortion, saucer deformity of nipple, haematoma, seroma, wound infection, skin necrosis, asymmetry of breasts.

Fig. 16-13: Submammary incision is used to remove large benign swelling like fibroadenoma.

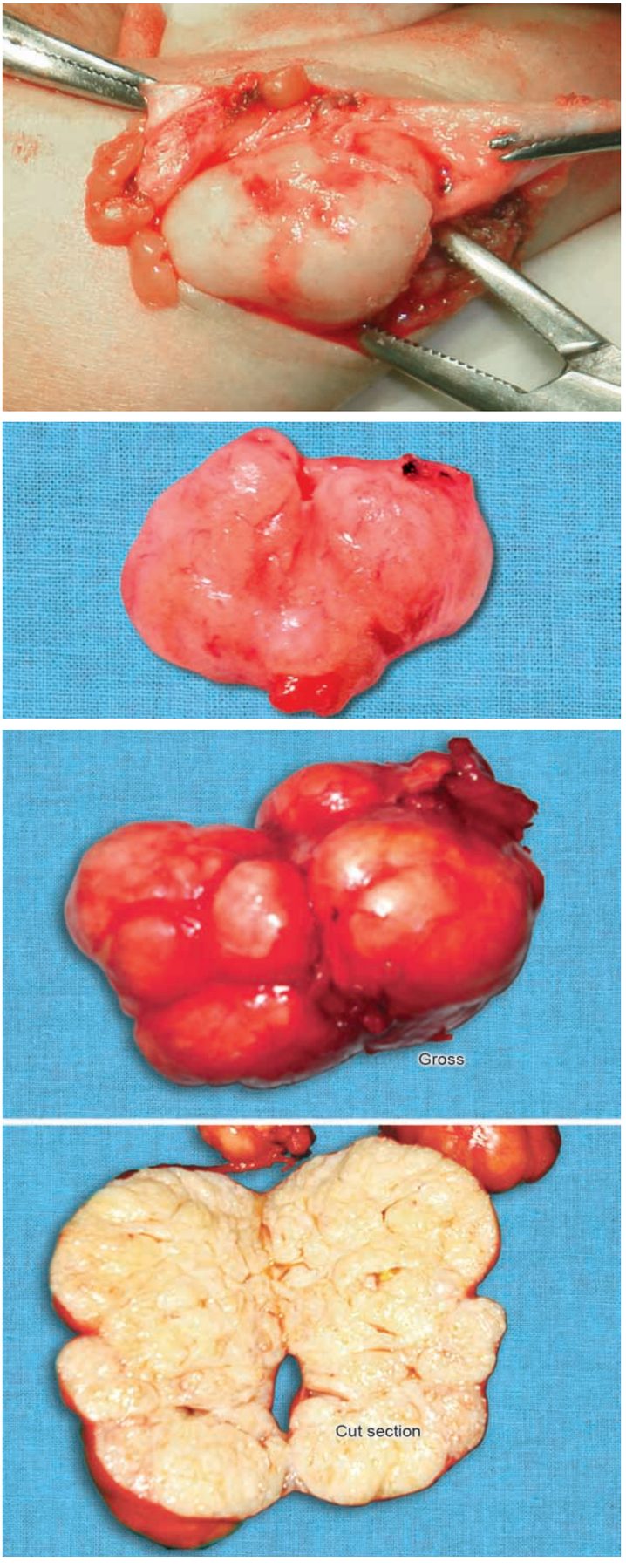


Fig. 16-14: Fibroadenoma is well capsulated and so easier to excise/enucleate. Circumareolar incision is used for small fibroadenomas. Submammary incision is used for large/multiple fibroadenomas.

Fig. 16-15: Excision of gynaecomastia – steps. Drain may be placed if needed.

DRAINAGE OF A BREAST ABSCESS

Both subareolar and intramammary breast abscess should be drained. Drainage is done under general anaesthesia. Subareolar abscess is drained with a subareolar incision. Intramammary abscess is drained with a deep incision. Once cavity is reached all loculi should be broken using a sinus forceps/finger/scoop. Pus should be sent for culture. *Counter incision i*s often needed to achieve complete drainage of the abscess cavity. Corrugated drain is placed for 72 hours or more or as required. Since intramammary abscess is common in lactating women, milk fistula may be a sequelae. It is often very difficult to manage such case. Milk from opposite breast should be expressed at regular intervals either manually or using breast pump. Only occasionally suppression of milk is needed using bromocryptine 2.5 mg for 5 days **(Figs 16-16 to 16-18)**.

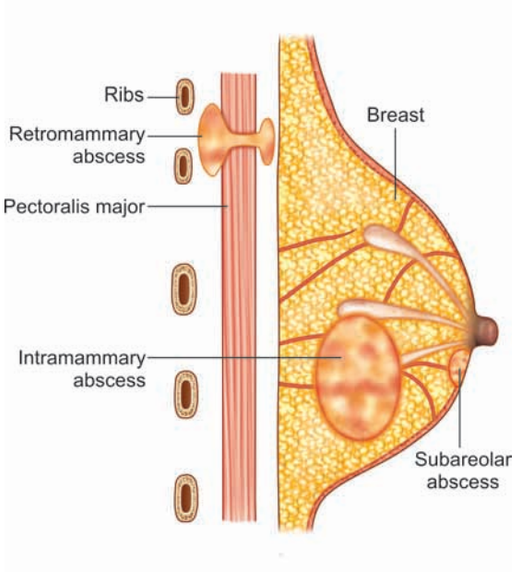


Fig. 16-16: Different types of breast abscesses – subareolar, intramammary and retromammary.

Fig. 16-17: Drainage of subareolar breast abscess.

Indications for drainage in mastitis/breast abscess

- Mastitis not resolving with antibiotics in 48 hours
- Persistent fever and progression of mastitis
- Brawny induration

Do not wait for abscess to form (fluctuation to develop)

Surgical Treatment of Mammary Fistula

Mammary fistula develops in a chronic abscess cavity at the drainage site or where abscess has pointed and opened. A probe is passed through the fistula towards the apex of the nipple. Track is laid open by cutting tissues along the probe. Opened wound is left to granulate. Often it requires major duct excision **(Fig. 16-19)**.

MICRODOCHECTOMY

It is excision of the entire lactiferous duct (single duct disease). It is done for duct papilloma. In a duct papilloma when there is no palpable mass, duct is expressed to see the discharge. A fine probe/stiff nylon suture (as a probe) is passed gently into the duct. Probe is fixed to nipple skin using silk sutures so that it will not displace during procedure. A triangular area is cut 1 mm away from the probe using fine scissor to raise the skin flaps. The duct with the probe is excised with the skin flap for 5 cm till the papilloma is identified. Papilloma will be always situated within 5 cm from the duct orifice. Wound is closed without a drain. Compression bandage is applied. It is ideal to rule out DCIS by frozen section biopsy.

MAJOR DUCT EXCISION (ADAIR–HADFIELD OPERATION)

It is done mainly for duct ectasia with involvement of many ducts or multiple papillomas. A circumareolar incision is made usually along lower half of the areola not exceeding more than 3/5th of circumference. After incising the subcutaneous tissue, with blunt dissection terminal lactiferous ducts are circumferentially dissected. All dissected ducts are divided at the junction of nipple. A cone of tissue of 4 cm depth and 2 cm width is removed with base deep in the breast parenchyma. Excised entire lactiferous ducts are sent for histology. Cavity in the breast is obliterated with vicryl sutures. Wound is closed with a suction drain. Bruising, infection, haematoma and recurrence of the disease – 15% (duct ectasia) are the complications **(Fig. 16-20)**.

Melhem Novel modified breast ductal system excision is also done for duct ectasia. Here only lactiferous ducts are excised after raising the areolar flap through circumareolar incision.

SENTINEL LYMPH NODE BIOPSY/DISSECTION (SLNB/SLND)

The first axillary (SLN) node draining the breast (by direct drainage) is designated as the *sentinel node.* SLN is first node involved by tumour cells and presence or absence of its histological involvement, when assessed will give a predictive idea about the further spread of tumour to other nodes. The incidence of involvement of other nodes without SLN is less than 3% and so if SLNB is negative nodal dissection can be avoided but regular follow up is needed. SLNB is done in all cases of

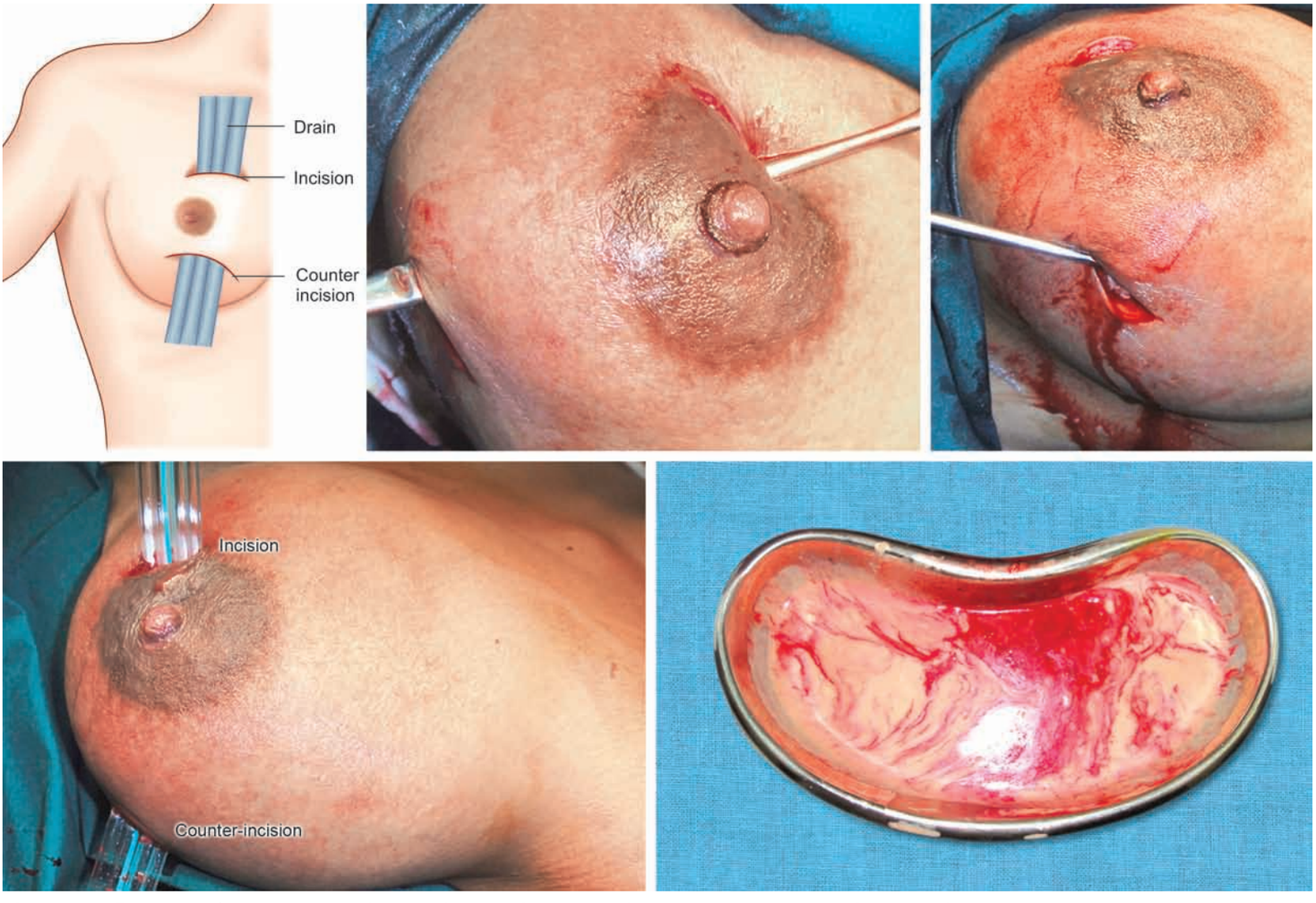


Fig. 16-18: Drainage of intramammary breast abscess. Incision and counter incision is used commonly to prevent cavity getting closed early which may cause recurrence.

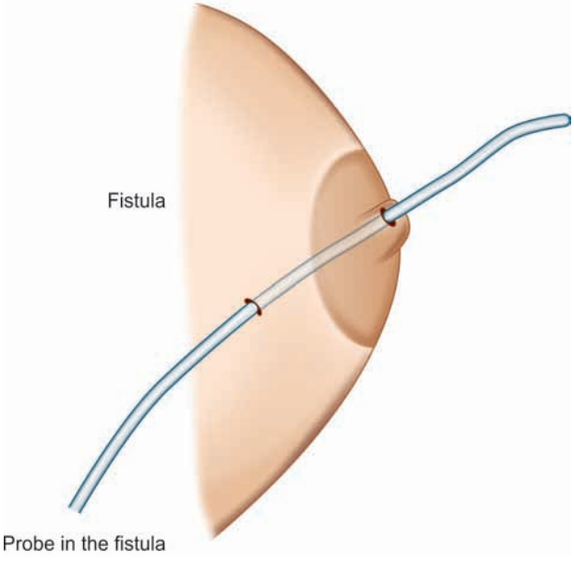


Fig. 16-19: Mammary fistula excision.

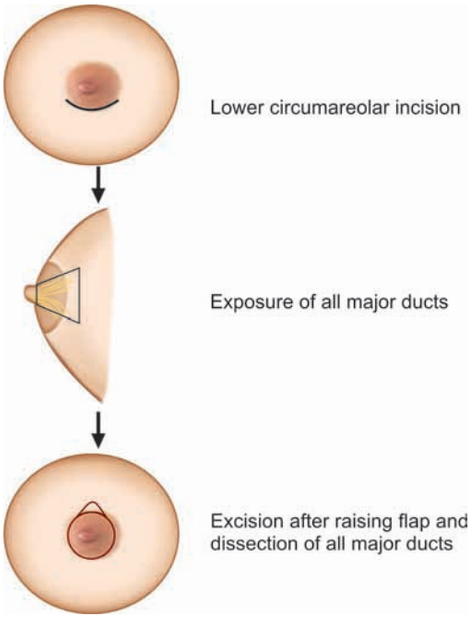

Lower circumareolar incision
Exposure of all major ducts
Excision after raising flap and dissection of all major ducts

Fig. 16-20: Adair–Hadfield major duct excision.

early breast cancers, T1 and T2 *without clinically palpable node*. It is not done in clinically palpable axillary node as there is already distortion of lymphatic flow due to tumour. It is also not done in multifocal and multicentric tumours, as there is involvement of many lymphatic trunks from different places of breast, and chances of false negative is high. Sentinel node is localised by preoperative (within 12 hours prior) or peroperative injection of patent blue (Isosulfan vital blue dye 2.5 – 7.5 ml) or 99m TC radio isotope labeled albumin (one mCi on previous day)/sulphur colloid (6 hours before) near the tumour (peritumour area) or over subdermal plexus around the nipple. Marker will pass through the sentinel node which can be detected visually as blue staining or with a hand held gamma camera; and is biopsied with a small incision directly over it. Frozen section biopsy or touch imprint cytology is done for presence of malignant cells. If there is no involvement of sentinel node by tumour then further axillary dissection is not required as *skip lesions* (skipping sentinel node) occur only in less than 3% cases. Detection rate of sentinel node for blue dye and radioisotope is 90% and 98% respectively. Subdermal/subareolar injection of radioisotope *has got better* sentinel node localisation than peritumour injection. But better imaging is obtained by peritumour injection and so *peritumour injection is usually* practiced. Radioisotope tracer injection done in the early morning of the day of surgery into peritumour area and perioperative injection of patent blue dye in subareolar region – as a *combined method* is often used in many centres. After injection of patent blue, breast is massaged continuously to enhance the uptake. *Incision* is made after 5-7 minutes between pectoralis major and latissimus dorsi to identify blue stained lymphatics which are traced to 2-3 blue lymph nodes. Hand held radio probe is used to identify the sentinel node which is later excised. Often 2-3 nodes are removed. *Paraffin section histology is better* than frozen section to identify positive sentinel lymph node. If report comes negative immunohistochemistry test is done to confirm that lymph node is negative for tumour. Sentinel lymph node biopsy *should be done before* wide local excision of the primary tumour.

Wide local excision of the primary tumour is done after SLNB in the same sitting.

SLNB is *less invasive* than axillary dissection. It is ideal in early invasive carcinoma. Positive SLNB is again classified as macrometastasis (> 2 mm) or micrometastasis (< 2 mm).

SLNB is *contraindicated* in patients who are allergic to vital blue dye or radio-colloid, in pregnancy and in inflammatory carcinoma of breast.

Complications

Complications of SLNB are rare they are - blue tattooing of skin which gradually fades; blue – green urine and stool for short periods; allergic reactions; anaphylaxis (0.1%); seroma formation. Blue dye binds to oxyhaemoglobin artificially registers in oximeter as hypoxaemia

Axillary Sampling

It is done before wide local excision of primary tumour. Incision is made between pectoralis major and latissimus dorsi muscles. Deep fascia is opened. 10 – 15 nodes of level I are dissected and removed. Often this procedure is done along with sentinel lymph node biopsy. Occasionally when level I nodes are not found, level II or III nodes are removed to identify 3-5% skip metastases.

BREAST CONSERVATIVE SURGERY (BCS)

In early breast cancer, breast conservative surgeries like quadrantectomy, axillary dissection (level I and II) and postoperative radiotherapy (to the breast) are used which prevents the disfigurement and psychological trauma of mastectomy to the patient. It is very well acceptable cosmetically. When disease outcome is considered, it is equivalent to mastectomy if patient is carefully selected. Tumour is removed with a rim of 1 cm normal tissue (macroscopic margin). Wide excision and QUART therapy are different procedures (Use of word lumpectomy is a debate and not well accepted).

Tumour size is *better* estimated by ultrasound or MRI breast than by clinical examination or mammography.

Breast conservative surgery

Indications	*Contraindications*
• Lump ≤ 4cm • Clinically negative axillary nodes • Mammographically detected lesion • Well differentiated tumour with low S phase • Adequate sized breast to allow proper RT to breast • Breast of adequate size and volume • Feasibility of axillary dissection and radiotherapy to intact breast • Absence of tumour multicentricity • Achieving tumour negative margin	• Tumour > 4 cm • Positive axillary nodes > N1 • Tumour margin is not free of tumour after breast conservative surgery • Poorly differentiated tumor • Multicentric tumour • Earlier breast irradiation • Tumour/breast size ratio is more • Tumour beneath the nipple/ central tumour • Extensive intraductal carcinoma • Existing collagen vascular disease as RT may be problematic • Strong family history of breast cancer

Principles and Technique of Conservative Breast Surgery

Curvilinear *non-radial incision* (radial incision should not be placed, if there is a need to convert into total mastectomy, and then incision plan may be difficult) is used to remove primary tumour. Separate incision is used for axillary dissection. Undermining of the skin flap must be avoided. Tumour clearance should be confirmed by frozen section. It may be often difficult and so tumour is cut and only margin which is close and doubtful is advocated for frozen section. Radiotherapy is a must to breast and chest wall region (locally). Consent for total mastectomy should be taken in case if need arises **(Fig. 16-21)**.

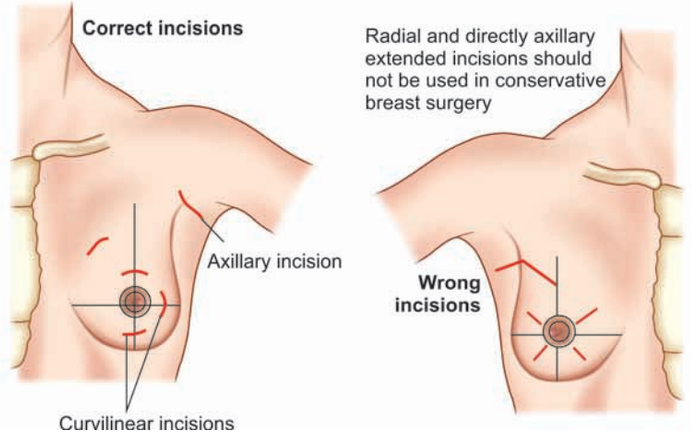

Correct incisions
Axillary incision
Curvilinear incisions
Radial and directly axillary extended incisions should not be used in conservative breast surgery
Wrong incisions

Fig. 16-21: Curvilinear incision should be placed in conservative breast surgeries. Never place wrong radial incisions. If conversion to total mastectomy is needed, it will be difficult in placing incision if radial incision is placed. In conservative breast surgery for axillary dissection separate incision in the axilla should be placed.

Ultrasound is good way of assessing the size of the tumour. If mammography shows calcification, this calcification should be localised using hook wires. Impalpable lesions are localised preoperatively by blue dye injection, hook wires, radioisotope markers. Intraoperative ultrasound also can be used. By mammography or ultrasound controlled injection of technetium labeled human serum albumin or sulphur colloid into the tumour and using hand held gamma probe intraoperatively lesion is located and excised.

Quadrantectomy and wide local excision are two types of BCS. Breast is distributed into segments with each segment draining into one major duct. Removal of *one entire segment with ductal system with 2 cm clearance* is *quadrantectomy* which is much wider and extensive removal than wide local excision. But presently quadrantectomy is not advocated as it is cosmetically poorer and there is no difference in outcome between quadrantectomy and ***wide local excision***.

Incision over the breast should be circumferential along the *Langer's line* or parallel to the lines of maximum resting skin tension in the breast (*dynamic lines of Kraisl*) **(Fig. 16-22)**.

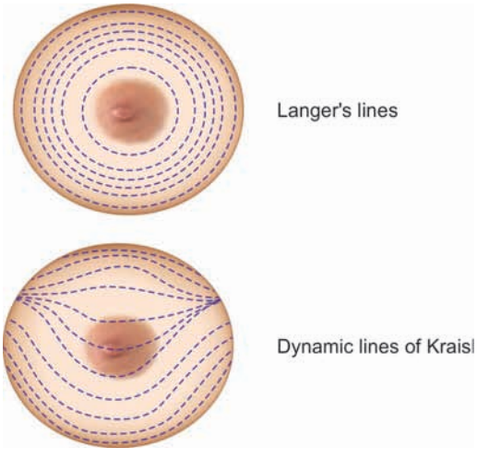


Fig. 16-22: Langer lines and dynamic lines of Kraisl.

If there is previous open biopsy scar, it should be included in the specimen as 'en bloc'. *Mexican hat incision* of the preexisting scar gives better scar. Otherwise routine skin excision is *not* done **(Fig. 16-23)**.

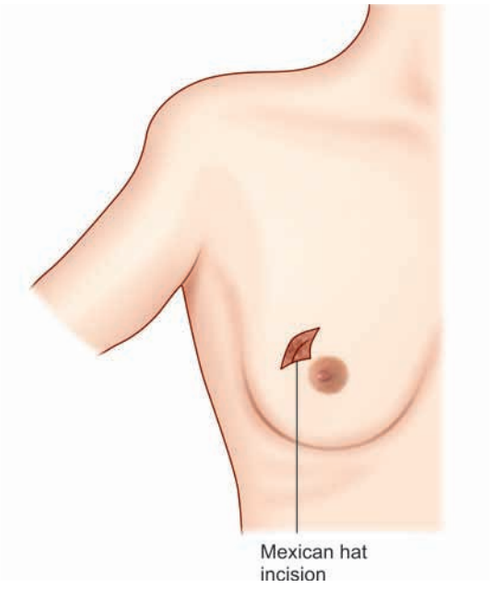


Fig. 16-23: Mexican hat incision is used to include previous scar area.

Skin flaps are deepened straight up to 1-2 cm beyond the lump margin. Only rising skin flaps is *not* advised. Skin with subcutaneous tissue can be raised judiciously.

Dissection is done around the tumour with a volume of normal breast tissue all around. Pectoral fascia *should not* be opened in deeper plane. Tumour with surrounding normal clearance tissue is lifted off the pectoralis fascia and breast tissue in deeper plane can be dissected off the fascia. Bipolar cautery is better than monopolar cautery. After removal of the specimen, it is properly marked using coloured markers or paints as superior, inferior, medial, lateral, anterior and posterior for identification of the clearance margins and *orientation*. Entire specimen is coated in India ink. Specimen should be inspected properly for tumour relation to margins. All marked surfaces and margin which is close to the tumour should undergo frozen section biopsy for confirmation of clearance. Doing *specimen mammography* is often better. Specimen may be kept in an *orientation – grid* and mammography of the specimen is taken. If few margins are close to the tumour, then re-resection at that particular margin is sufficient which again should be confirmed by frozen biopsy. Achieving margin clearance all around the tumour is essential but *width of cleared margin is not important*. Once confirmed, specimen is sent for receptor/molecular/cellular/biochemical study. Wound is closed without a drain. *Small defect* in the breast tissue (tumour area) less than 10% of volume can be left alone; *larger defect* in breast more than 10% of breast volume should be apposed by proper sutures. If many margins are invaded or very close to tumour, then total mastectomy should be planned **(Fig. 16-24)**.

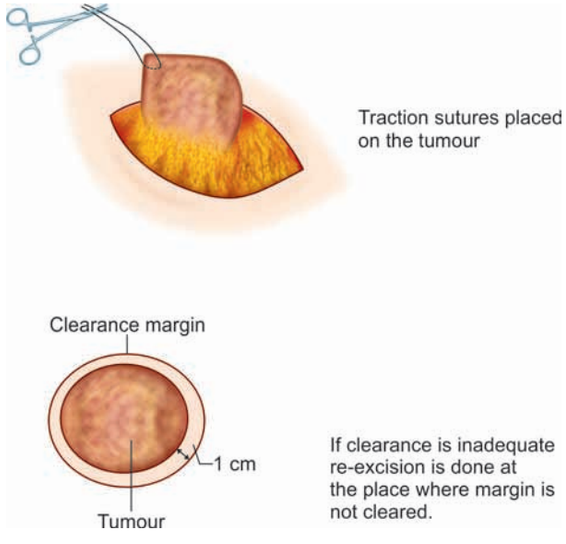

Traction sutures placed on the tumour
Clearance margin
1 cm
Tumour
If clearance is inadequate re-excision is done at the place where margin is not cleared.

Fig. 16-24: Technique of wide local excision.

Complications of wide local excision are – haematoma (2%); seroma; infection (5%); incomplete excision (15%); poor scar.

Recurrence after BCS is usually at primary site. Young age, family history, small volume breast are the patient related factors for recurrence. Grading of the tumour, lymphatic or vascular invasion (two times more), extensive in situ component (4 times more), multifocal tumours are the *tumour factors* for recurrence of the tumour. Delay in radiotherapy to breast area, further chemotherapy and hormone therapy also influence the local recurrence rate. Radiotherapy to breast is a *must* after BCS. Recurrence is treated by total mastectomy.

Microscopic disease free margin is defined as at least 1 mm rim of normal tissue around the tumour in all directions. Area lesser than 1 mm is considered as inadequate clearance and such area should

be re-excised and confirmed for clearance. It is done either through same scar or modified elliptical incision which includes the scar – `*Mexican hat incision*'.

QUART Therapy

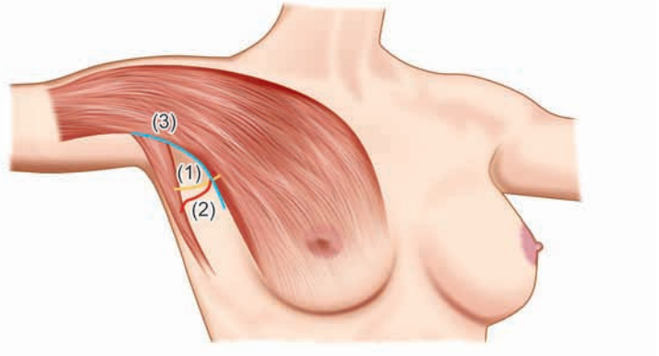
It is quadrantectomy, axillary dissection of level I and II nodes with separate axillary incision and postoperative radiotherapy to breast (5000 cGy) and axilla (1000 cGy). First it was started by Umberto Veronesi from Milan.

Axillary dissection is done to identify the nodal involvement of the disease which is an indicator of metastatic breast disease. It is also done for staging of malignancy. Number and level of nodes involved are independent predictors of the outcome of the disease. Therapeutic benefit of axillary dissection is a debate. It is done basically for infiltrating carcinoma of breast. In situ carcinomas do not require axillary dissection as incidence of nodal spread in situ carcinoma is less than 2%. Axillary flaps are elevated superiorly and inferiorly. Level I and II nodes are removed with fat and fascia. External mammary, lateral, subscapular and central nodes are removed. A minimum of 10 nodes should be removed. Wound is closed with a suction drain.

AXILLARY DISSECTION

It is done under general anaesthesia. Sandbag is placed under the shoulder to elevate the axilla. Arm, axilla, shoulder and same side chest wall is cleaned and draped. Forearm and hand are draped to facilitate holding and moving it as needed.

Incision is along the crease just below the hair bearing area of axilla. A lazy S incision between pectoralis major and latissimus dorsi muscle or an incision along the anterior axillary fold also can be used **(Fig. 16-25)**.



(1) Skin crease incision distal to hair bearing skin of the axilla.
(2) Lazy S incision between pectoralis major and latissimus dorsi.
(3) Anterior axillary fold incision.

Fig. 16-25: Different incisions for axillary dissection.

Skin flap is elevated behind up to the edge of latissimus dorsi muscle. Upper skin flap is raised. Medial part of the dissection is done by identifying the pectoral muscles. Medial pectoral nerve which winds the lateral margin of the pectoralis minor muscle is identified. One must remember that medial pectoral nerve arises from the medial cord of the brachial plexus and often passes through the fibres of the lateral part of the pectoralis minor muscle. Medial margin of the pectoralis minor is reached above to identify the part of clavipectoral fascia which contains few lymph nodes. It is upper medial limit of the dissection. Axillary vein meets the subclavius muscle here. When required pectoralis muscle should be divided from its insertion to coracoid process; index finger is passed around the insertion of the pectoralis minor tendon and muscle is traced towards coracoid process and is divided. Axillary vein is dissected to clear adipose tissue and lymph nodes on it. Now dissection should be done from lateral to medial using sharp and blunt dissection. Apex of the axilla should be cleared. Blood supply to pectoralis major muscle should be retained. Lower flap is dissected further to identify the serratus anterior muscle. Intercostobrachial nerve is identified and is preserved. Long thoracic nerve of Bell is 2 cm posterior to intercostobrachial nerve. It is in the serratus fascia. It should be identified and preserved. Further dissection exposes the thoracodorsal nerve (nerve to latissimus dorsi). Thoracodorsal vein is first identified; thoracodorsal nerve is most medial in thoracodorsal neurovascular bundle. This entire neurovascular bundle should be preserved if latissimus dorsi flap is needed at later period to patient. Dissection is continued laterally and behind to remove all the tissues up to the axillary tail. Specimen is removed. Its directions are marked. Single suction drain is placed. Skin flap is sutured from its deeper plane to chest wall as quilting to prevent seroma formation. Wound is closed in layers. Pressure dressing is placed.

Complications

Seroma formation, prolonged drainage through the drain for many days often weeks, frozen shoulder, lymphoedema of upper limb (10%), pectoral muscle atrophy due to injury to medial pectoral nerve, atrophy of latissimus dorsi muscle due to injury to thoracodorsal nerve, *winged scapula* is due to damage to long thoracic nerve.

Seroma formation is more common in obesity, when axillary nodes are positive, extensive mobilisation.

SKIN SPARING MASTECTOMY (SSM)

It is like a key-hole surgery of breast. Skin sparing/limited skin excision (5-10%) will not alter/affect the recurrence rate.

Indications are- central tumour/multicentric/extensive intraductal/T1/not feasible for breast conservation.

It includes excision of nipple-areola complex with very limited skin removal; marginal skin excision over the tumour/biopsy site; total glandular mastectomy; axillary dissection using either same (extension of SSM incision) or separate incision in the axilla.

Incision is either periareolar/tennis racquet/modified elliptical. Tennis racquet has got lateral extension to axilla. Reduction mammoplasty incision is also used with a periareolar incision extending vertically into an inframammary horizontal incision. Prior biopsy site should be included in the mastectomy incision or should be removed widely through a separate elliptical incision **(Fig. 16-26)**.

Skin flaps are elevated between breast parenchyma and subcutaneous adipose tissue allowing 5-10 mm thick skin flap. Circumferential flap is raised around using scissor/no. 15 scalpel blade/cautery (cutting is used; coagulation can cause cautery artifact). Skin hooks and retractors are used to facilitate the dissection. Headlight may be used to have a better visualisation during dissection. Parasternal and infraclavicular perforating vessels are preserved to maintain adequate blood supply of the retained skin. Superiorly dissection is done up to second rib; medially to sternum; below to inframammary crease; laterally to latissimus dorsi muscle. Entire breast tissue, nipple areolar complex

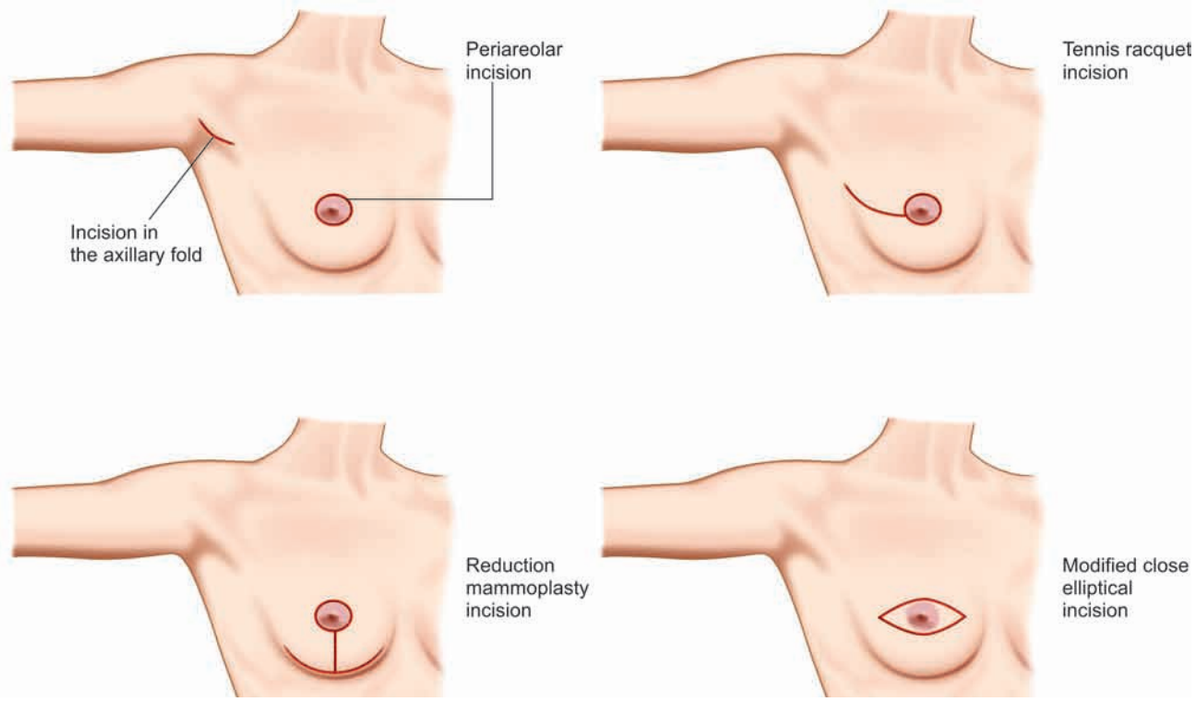


Fig. 16-26: Incisions used for skin sparing mastectomy (SSM).

are removed. Usually pectoral fascia is removed except in case of superficial tumours. Breast is raised off the pectoralis major muscle from the medial end towards lateral side. As it is raised it is delivered out of the wound to reach the dissection towards axillary tail. Axillary tail of Spence is separated from pectoralis major, minor and serratus anterior muscles. Junction of axillary tail and axillary tissue is clamped, ligated and cut. Axillary dissection may be added as decided. Wound is closed with a suction drain.

Immediate reconstruction with latissimus dorsi or TRAM flap is done with tissue expanders placed underneath the subcutaneous or submuscular plane.

Problems with SSM are – difficulty in raising flaps, haematoma/seroma formation, infection **(Figs 16-27 and 16-28)**.

INDICATIONS FOR TOTAL MASTECTOMY/ MODIFIED RADICAL MASTECTOMY IN BREAST CANCER

- When tumour is more than 4 cm.
- Multicentric tumour.
- Poorly differentiated tumour.
- Tumour margin is not clear of tumour after breast conservative surgery.
- Recurrence after BCS.
- Prior radiotherapy to breast.
- Scleroderma or association with other collagen disease.
- Stage I invasive/Stage II, III diseases.

MODIFIED RADICAL MASTECTOMY (MRM)

In MRM, breast tissue, nipple areolar complex, skin over the breast tissue are removed along with axillary clearance with or without removal of pectoralis minor.

Patey's operation – It is total mastectomy with clearance of all levels of axillary lymph nodes with removal of pectoralis minor muscle.

Scanlon operation – Here along with total mastectomy, pectoralis minor is not removed but incised to reach level III lymph nodes

*Auchincloss operatio*n – It is total mastectomy with axillary clearance (level I and II) keeping pectoralis minor intact. It is commonly advocated now.

Patey's operation: It is total mastectomy along with clearance of all levels of axillary nodes and removal of pectoralis minor muscle. It is *en bloc* dissection of breast and axilla.

General anaesthesia is used for the procedure. Patient lies in *supine position* with sandbag under the same side thorax and shoulder. Side of the chest wall, breast area, axilla, neck and sides are cleaned and draped. Same side entire arm and forearm is cleaned and is covered with drape and stockings. Shoulder should have free movement as needed during dissection of the axilla. Shoulder is kept in abducted and extended position. Surgeon stands on the side; first assistant near the shoulder on the same side; second assistant on opposite side; scrub nurse stands next to the surgeon near the leg side.

Different incisions are used as shown in **Figures 16-29 to 16-35**. *Classic elliptical Stewart incision* is commonly used. Incision is decided by the surgeon who is operating.

An elliptical incision is made from medial aspect of the second and third intercostals space enclosing the nipple, areola and tumour extending laterally into the axilla along the anterior axillary fold. Upper and lower skin flaps are raised. Flap is raised mainly using scissor/scalpel/cutting cautery along with blunt gauze dissection in between. It extends medially up to the midline on the sternum; laterally to anterior margin of the latissimus dorsi muscle; above up to second rib/subclavius muscle; below 3 cm down the inframammary fold. Skin with subcutaneous fat is dissected off while raising the flap.

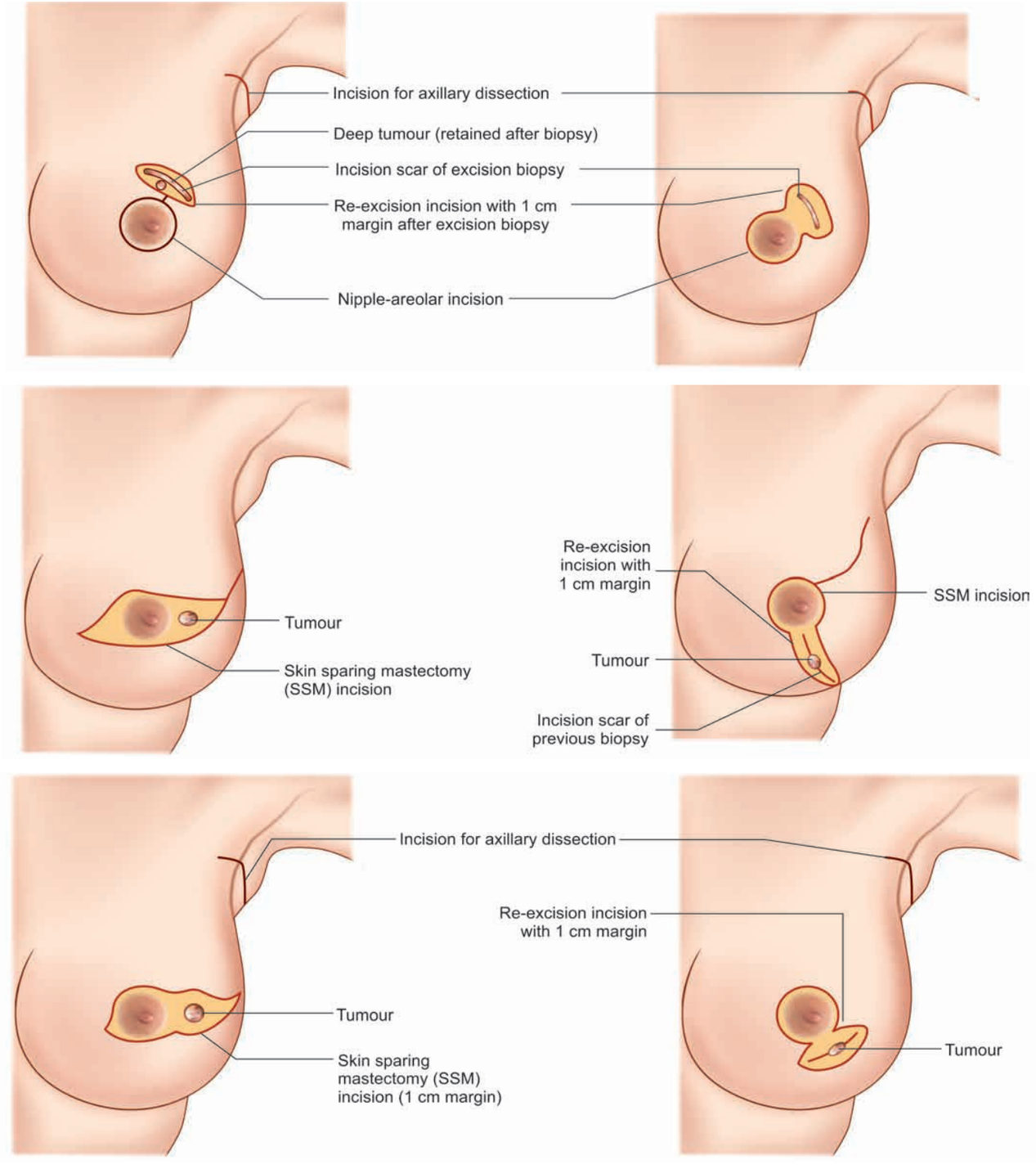

Incision for axillary dissection
Deep tumour (retained after biopsy)
Incision scar of excision biopsy
Re-excision incision with 1 cm margin after excision biopsy
Nipple-areolar incision
Tumour
Skin sparing mastectomy (SSM) incision
Re-excision incision with 1 cm margin
SSM incision
Tumour
Incision scar of previous biopsy
Incision for axillary dissection
Re-excision incision with 1 cm margin
Tumour
Skin sparing mastectomy (SSM) incision (1 cm margin)
Tumour

Fig. 16-27: Skin sparing mastectomy for carcinoma breast- different approaches. Skin sparing mastectomy (SSM) does not affect the recurrence rate.

Breast with tumour is raised from the medial aspect of the pectoral major muscle with pectoral fascia by making a deep incision close to midline, adjacent to sternum. Dissection is proceeded laterally ligating perforating vessels derived from lateral thoracic and anterior intercostal arteries. Once dissection reaches axilla, lateral border of pectoralis major muscle and pectoralis minor is exposed in deeper plane. Medial pectoral nerve (is lateral arises from medial cord of brachial plexus) which supplies lateral part of the pectoralis major muscle is identified here and preserved.

Axillary lymph node dissection is now started in continuity with mastectomy. Investing layer of deep fascia is divided. Fascia in front of the axillary vein is dissected to expose the vein in front. Small tributaries are ligated. Pectoralis major is retracted superomedially. Finger is swept between the two pectori to clear the Rotter's nodes. Lateral pectoral nerve is identified and preserved (it arises from lateral cord and is located medially supplies the medial part of pectoralis major). Attachment of pectoralis minor tendon is felt with index finger and with finger dissection it is hooked round the finger close to coracoid process

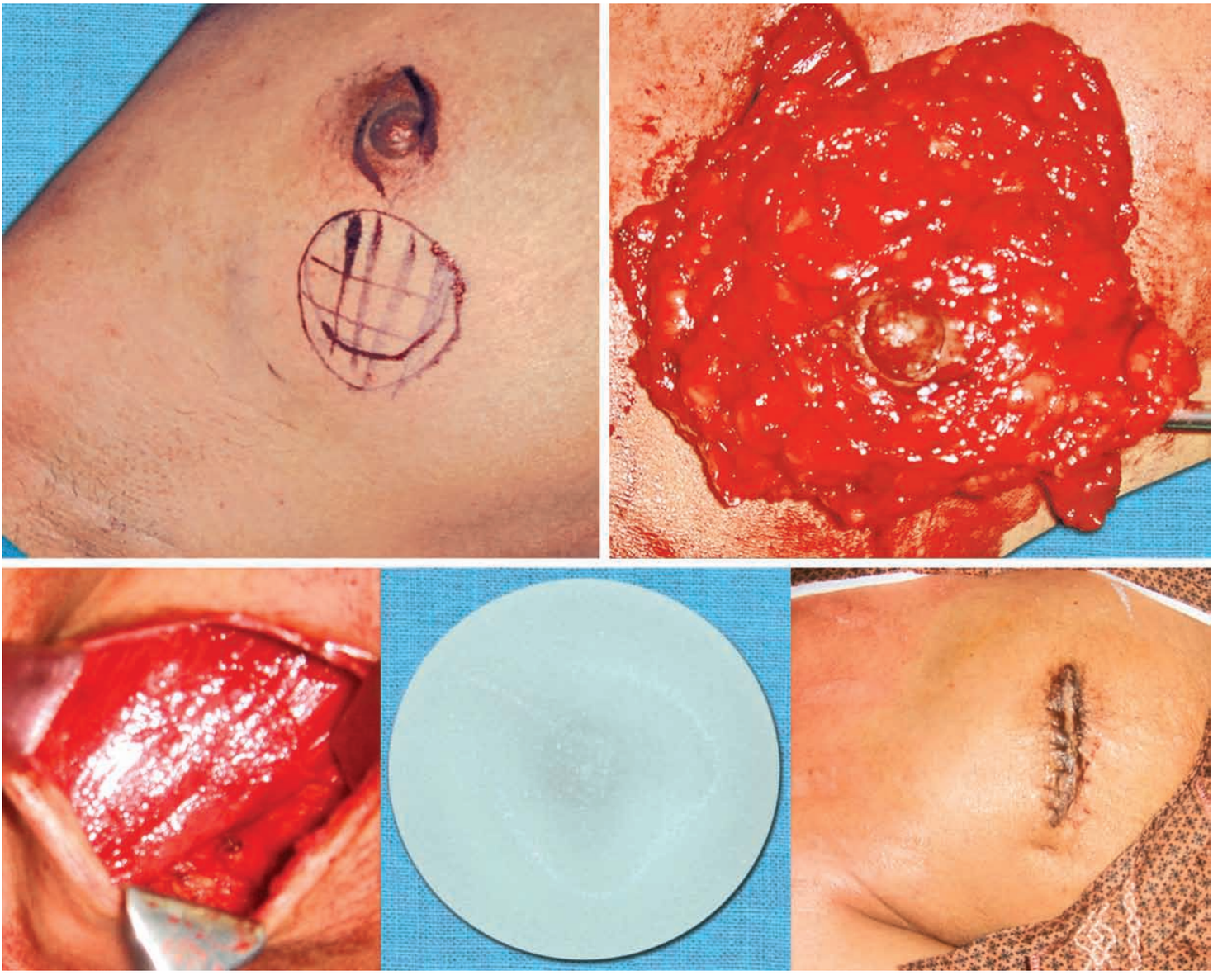


Fig. 16-28: Skin sparing mastectomy incision with prosthesis implant for placement.

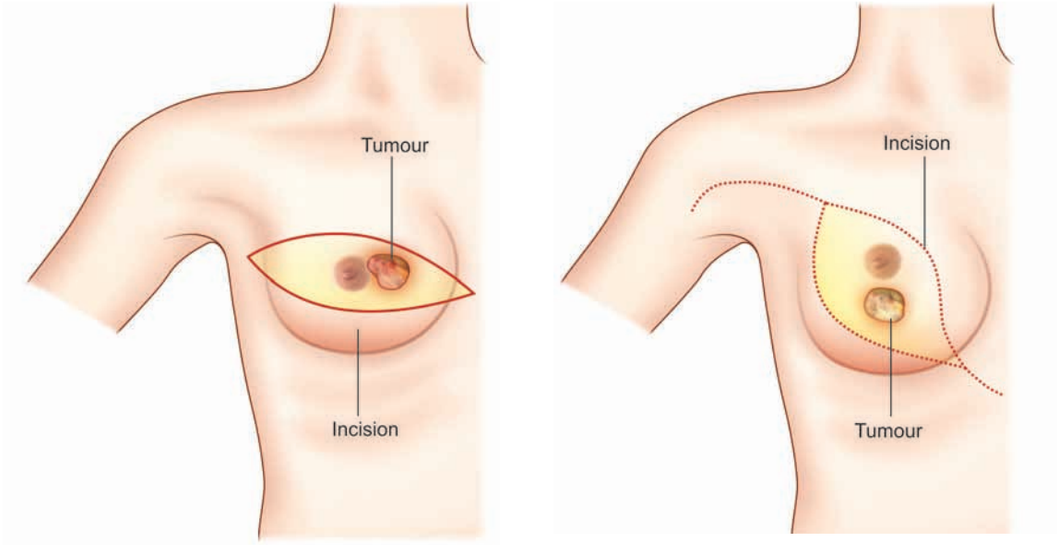


Fig. 16-29: A horizontal or oblique incision is commonly used for total mastectomy or modified radical mastectomy.

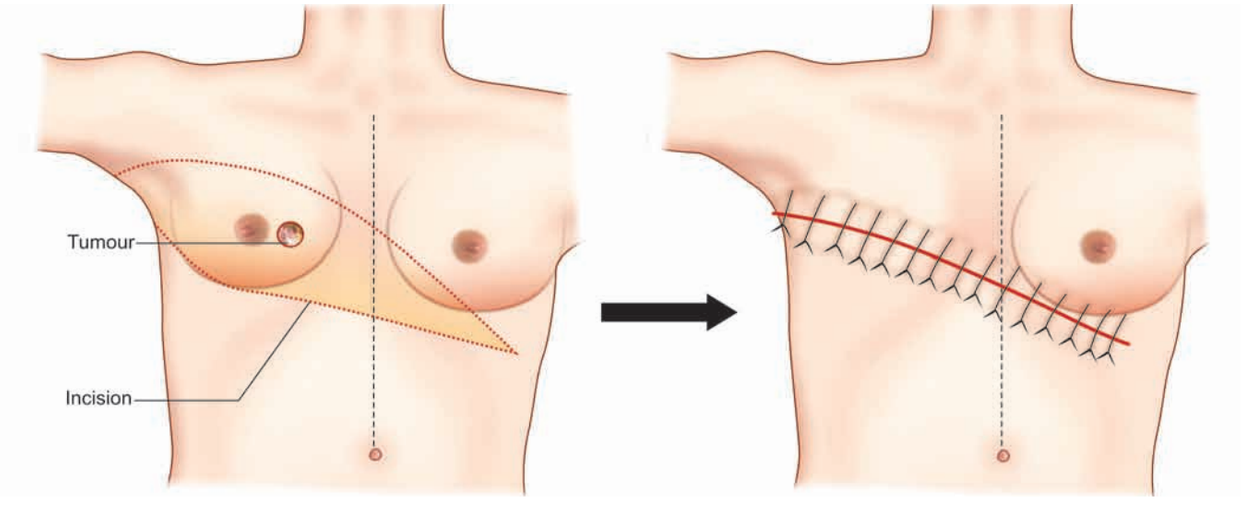


Fig. 16-30: Gray incision crosses the midline towards the opposite side.

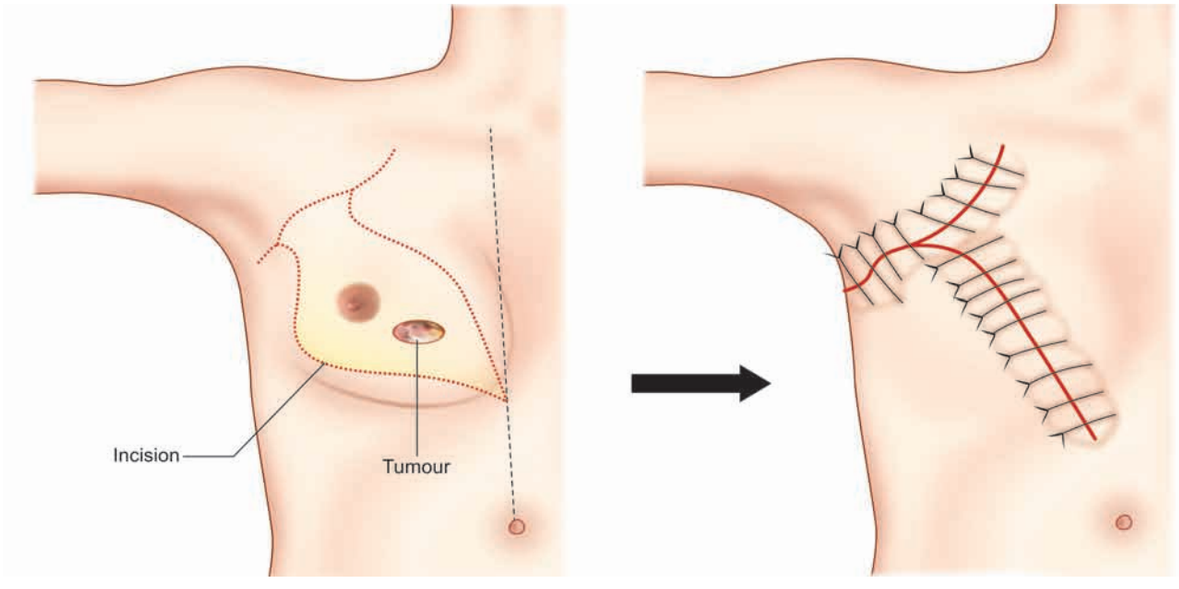


Fig. 16-31: Greenough incision.

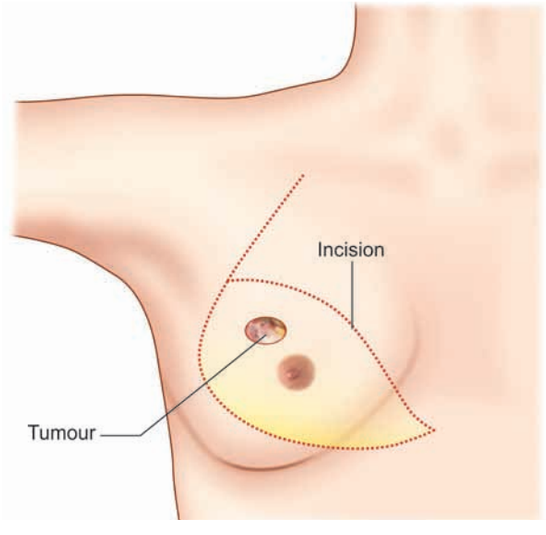


Fig. 16-32: Kocher's incision for mastectomy.

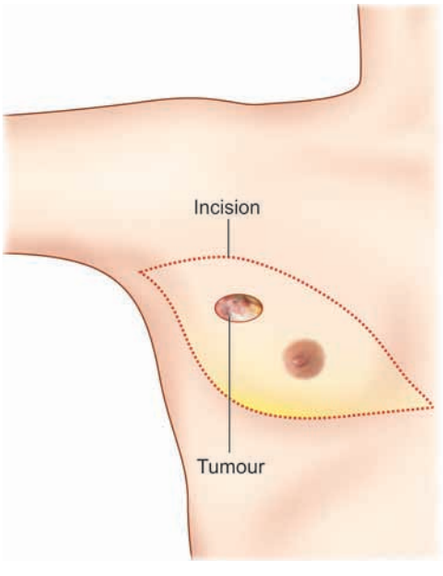


Fig. 16-33: Orr incision for mastectomy.

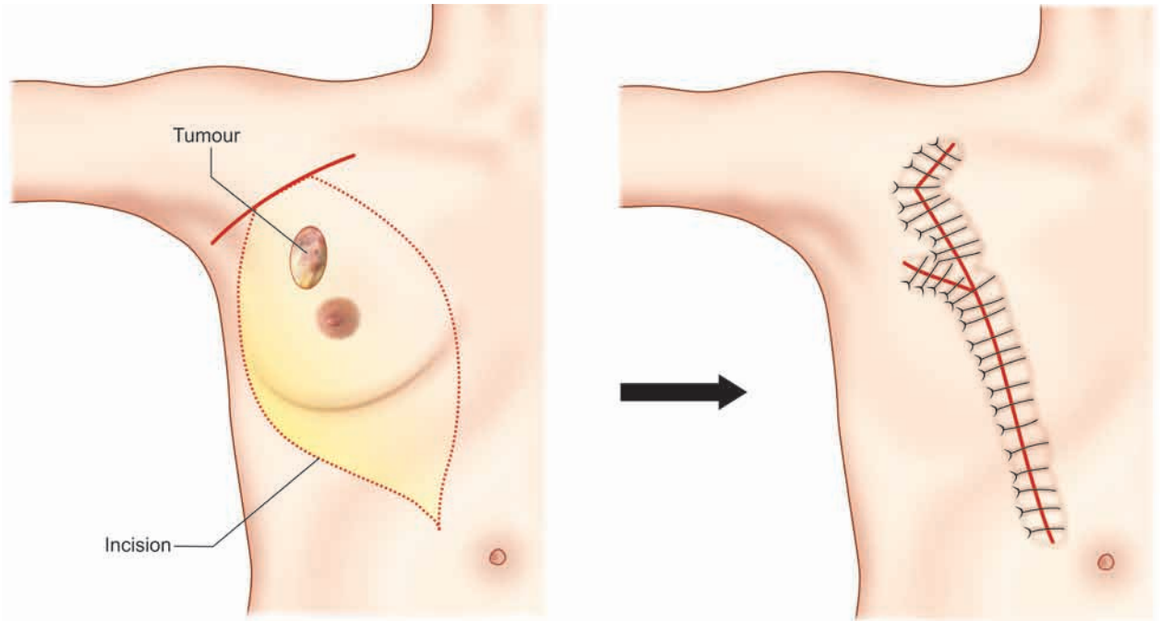


Fig. 16-34: Rodman incision for mastectomy with two branches in the final wound.

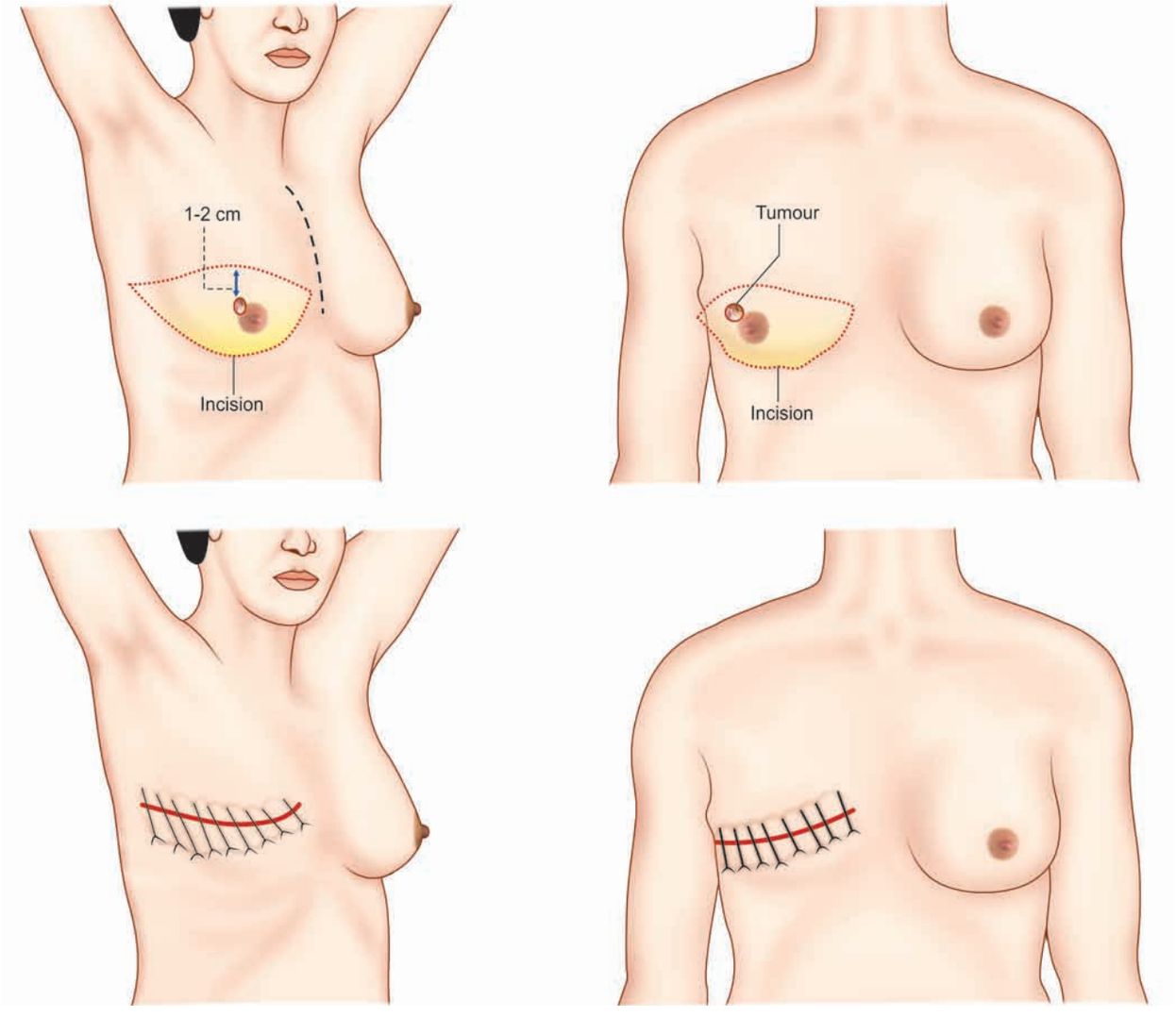


Fig. 16-35: Classical Stewart incision for mastectomy.

and is divided from coracoid process to clear level II nodes. Later from the apex of axilla level III nodes are cleared. Pectoralis minor muscle, after cutting from the coracoid process may or may not be removed. Axillary vein is cleared up to subclavius muscle medially. Posterior and lateral group of lymph nodes are cleared. Subscapularis medially and teres major laterally are exposed posteriorly. Nerve to serratus anterior (long thoracic nerve of Bell), nerve to latissimus dorsi with vessels (thoracodorsal neurovascular bundle), intercostobrachial nerve, axillary vein, cephalic vein and pectoralis major muscle are preserved. Long thoracic nerve is located in front of the subscapularis medially on the chest wall within the investing fascia. Once specimen is removed it is marked with orientation markers or clips **(Figs 16-36 to 16-38)**.

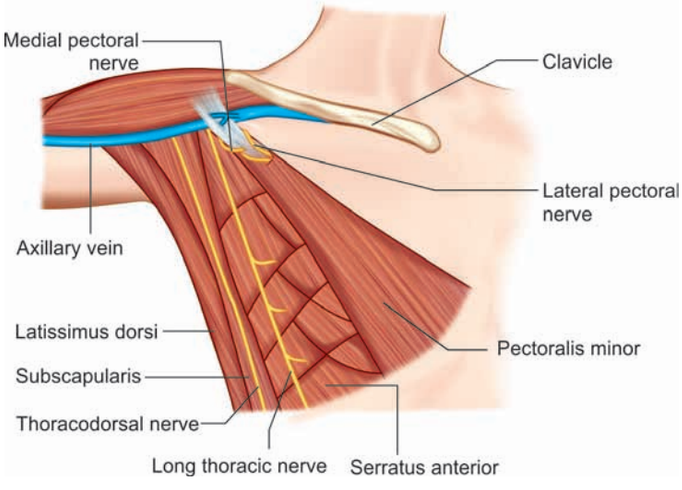


Fig. 16-36: Nerve to serratus anterior (long thoracic nerve of Bell), thoracodorsal nerve, medial pectoral and lateral pectoral nerves and intercostobrachial nerves usually come across during MRM. Medial pectoral nerve arising from medial cord of brachial plexus (hence the name) winds around the lateral margin of the pectoralis minor muscle (40%) or passes through its lateral part of fibres (60%), supplies part of the pectoralis major muscle. Lateral pectoral nerve arising from lateral cord of the brachial plexus runs close to the medial margin of pectoralis minor muscle to supply mainly pectoralis major muscle as its dominant nerve.

Wound is washed with saline. Haemostasis is maintained. *Two silastic suction drains* are placed, one laterally adjacent to latissimus dorsi muscle; another in front of the pectoralis major muscle. Wound is closed with a suction drain. Suction drain is kept for 5 – 7 days or until drainage becomes less than 30 ml per day **(Fig. 16-39)**.

Complications of MRM/mastectomy

- Injury/thrombosis of axillary vein
- *Seroma*- 50% - It should be aspirated repeatedly supported with compression dressing.
- Shoulder dysfunction 10%
- Pain (30%) and numbness (70%)
- *Flap necrosis*/infection
- Haematoma formation – If large needs drainage under general anaesthesia.
- Lymphoedema (15%) and its problems – Dissection above the axillary vein level increases the incidence of lymphoedema.
- Axillary hyperesthesia (0.5-1%)
- *Winged scapula* – Prominent medial border and inferior angle of scapula during punching action.

Contd...

Contd...

- *Stewart – Treves syndrome* is development of lymphangiosarcoma of upper limb in patient who develop lymphoedema (after 5 years) after mastectomy
- *Weakened shoulder adduction* due to injury to thoracodorsal nerve.
- Anaesthesia over the medial aspect of the upper arm (dysesthesia) due to injury to intercostobrachial nerve.
- Atrophy of pectoralis major muscle with loss of chest wall contour due to injury to medial pectoral nerve.

Mastectomy specimen should be carefully inspected and sent to pathology department

- Specimen is sent in formalin for histology.
- It is sent in saline in low temperature for ER/PR/Her 2 neu status study (histochemistry).
- Tumor grading, tumor clearance, nodal involvement - its number and capsular breach are assessed histopathologically.

Points to be remembered

Subcutaneous fat is included while elevating the flap of the breast skin; but it should be removed in axillary flaps.
Dissection in the axilla should be kept below the level of axillary vein.
All nerves in the axilla which will come across should be preserved as much as possible.
Subscapular/thoracodorsal vessels should be retained if LD flap is planned.
Proper haemostasis is essential.
Double tube silastic drain is a must. Drain is removed when only the discharge drained becomes less than 30 ml/day for 2 days.

DIFFERENT MASTECTOMIES

Total mastectomy also called as simple mastectomy – Here tumour, entire breast, nipple areola complex, axillary tail are removed. Axillary dissection is not done.

Extended total (simple) mastectomy is doing total mastectomy with clearance of level I axillary lymph nodes.

Modified radical mastectomy (MRM) is total mastectomy with axillary clearance. In *Patey's MRM* all levels of axillary nodes are cleared with division of tendon of pectoralis minor muscle close to coracoid process with or without removal of the pectoralis muscle. In *Scanlon's MRM* pectoralis minor is incised to reach the level III nodes. In *Auchincloss MRM* only level I and II are removed, pectoralis minor is left intact.

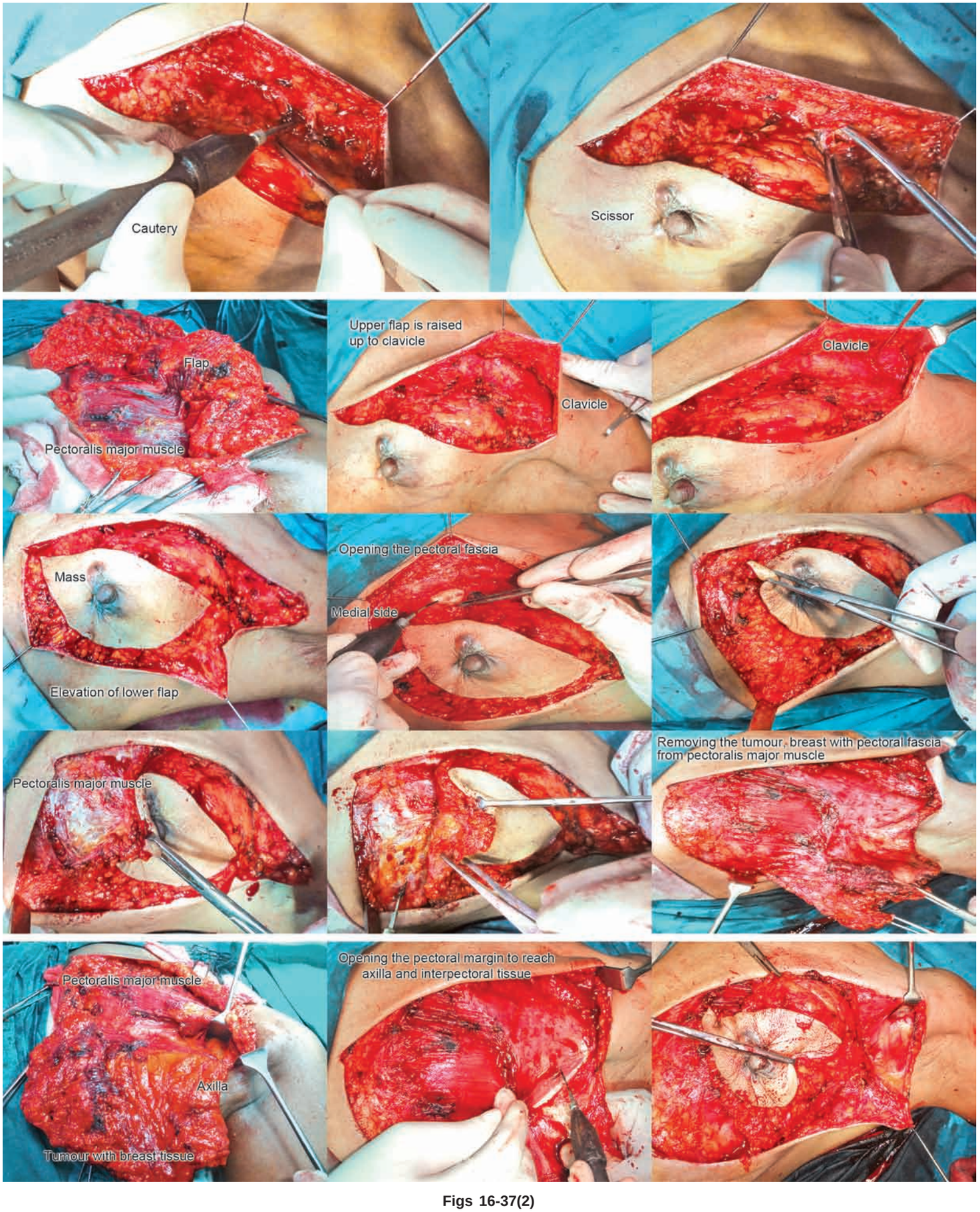
Breast conservative surgery (BCS) is done only when indications mentioned earlier is met with. It is often added with axillary dissection. Radiotherapy to breast is a must. Wide local excision is the commonly done procedure. Veronesi designed quadrantectomy, axillary dissection and radiotherapy (QUART) in BCS.

Skin sparing mastectomy (SSM) is keyhole surgery in which total mastectomy is done with removal of nipple areolar complex, earlier biopsy scar and entire breast and tumour. Skin over the breast is retained as the outcome of the disease will not be altered by removal or not removal of the skin widely over the breast.

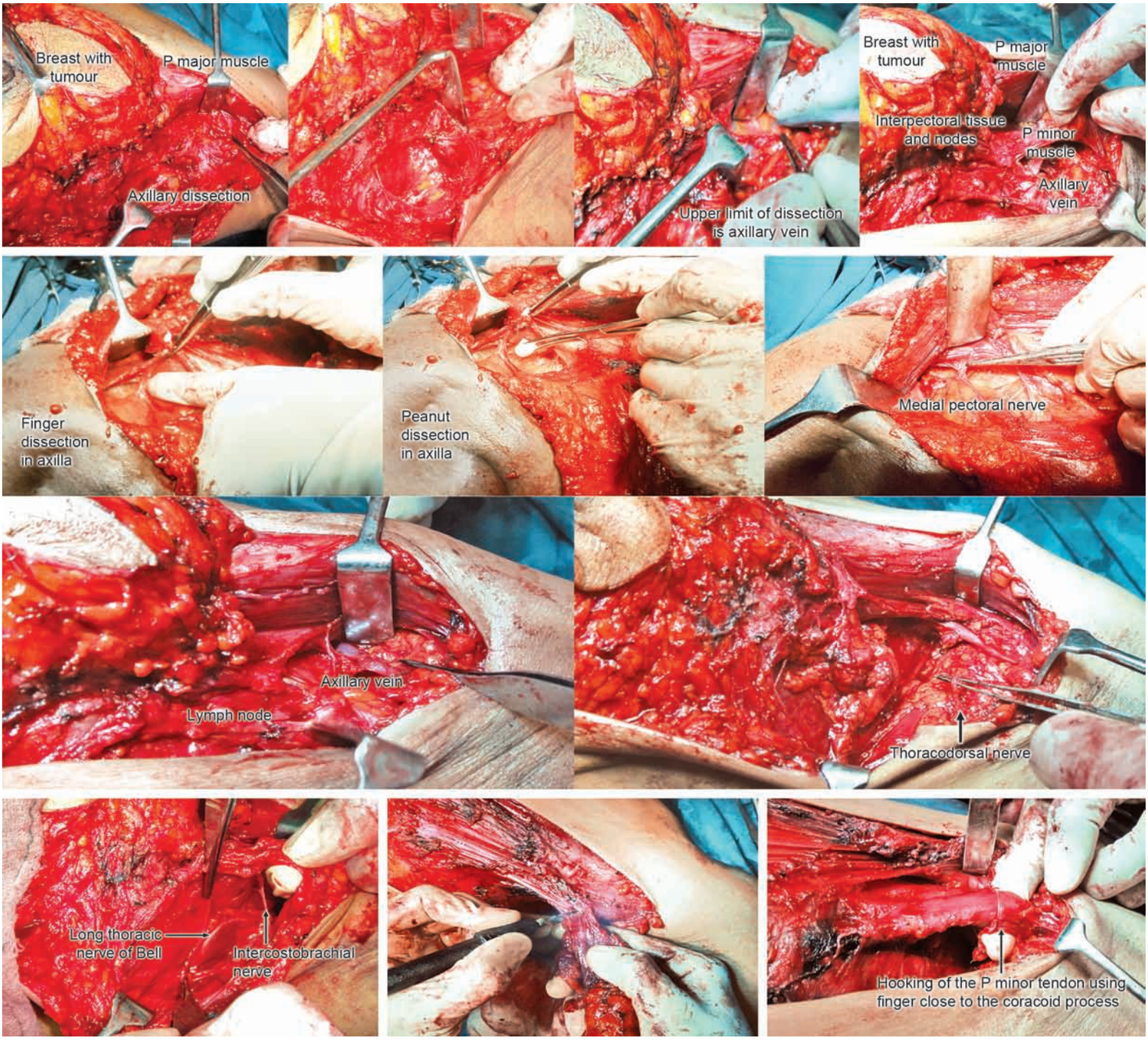
Radical mastectomy (Halsted) is removal of tumour, entire breast, nipple, areola, and skin over the breast and tumour, pectoralis major and minor muscles, fat, fascia, nodes in the axilla. Axillary vein, long thoracic nerve and cephalic vein are retained **(Fig. 16-40)**.

First assistant
Second assistant
Surgeon
Scrub nurse
Position of first assistant
Position of surgeon
Position of scrub nurse
Area to be cleaned for MRM
Draping for MRM
Incision for MRM
Incision
Mass
Skin hooks
Cautery
Scissor
Knife and blade

Figs 16-37(1)

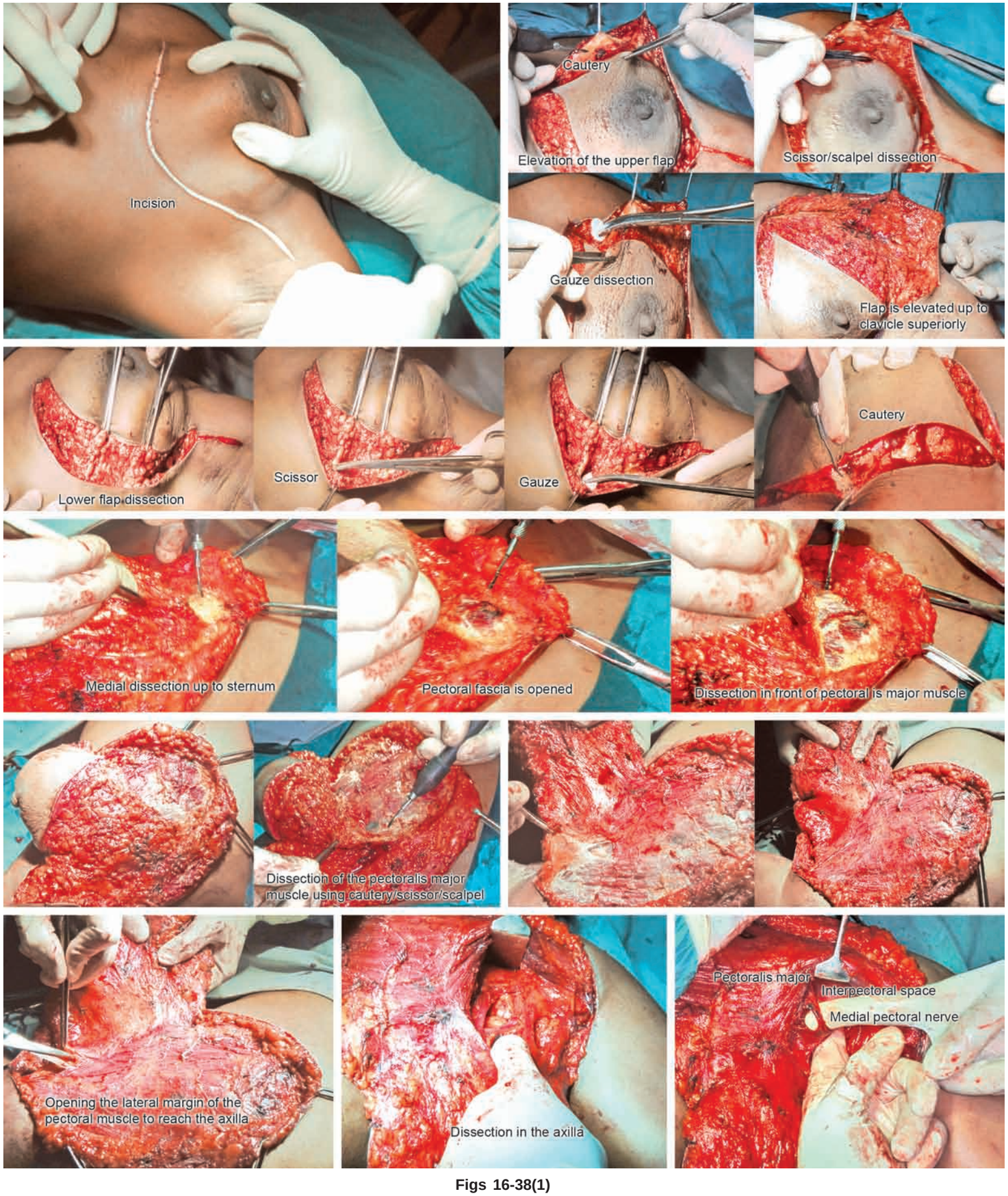

Cautery
Scissor
Flap
Pectoralis major muscle
Upper flap is raised up to clavicle
Clavicle
Clavicle
Mass
Elevation of lower flap
Opening the pectoral fascia
Medial side
Pectoralis major muscle
Removing the tumour, breast with pectoral fascia from pectoralis major muscle
Pectoralis major muscle
Axilla
Tumour with breast tissue
Opening the pectoral margin to reach axilla and interpectoral tissue

Figs 16-37(2)

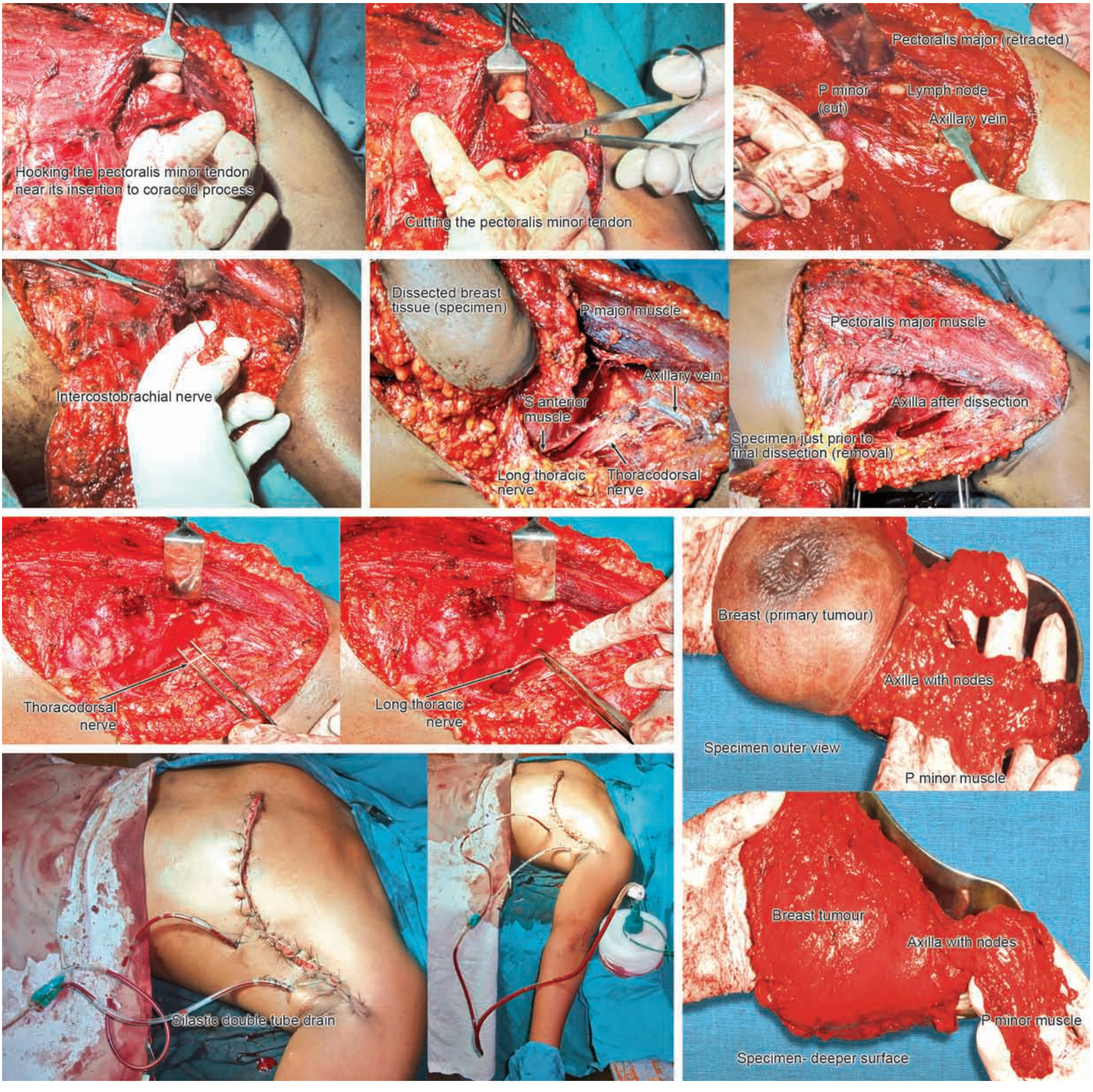


Figs 16-37(3)

Figs 16-37(1 to 3): *Technique of modified radical mastectomy (MRM)*. Skin over the breast, whole of ipsilateral chest wall, axilla, shoulder, supraclavicular region with neck, part of abdomen and part of opposite chest wall are prepared with antiseptic solution. Slight head up (Fowler's) position with same side tilting of the table upwards often with a sandbag under the shoulder region is used. Hand and forearm is often covered with a sterile towel so that to achieve a free movement of the arm and shoulder during axillary dissection. Incision placed depends on the need, either transverse or oblique which will be 5 cm beyond the tumour margin as an elliptical type. Upper flap is elevated first usually up to the level of clavicle above; up to sternum medially. Lower flap is elevated up to rectus sheath and costal margin below. Lateral flap is elevated up to the margin of latissimus dorsi muscle. Flaps are elevated using either cautery or scissor or scalpel or often with gauze dissection. In axillary region, subcutaneous tissue and fat is also cleared. Fascia on the lateral margin of pectoralis major is incised to expose the pectoralis minor. Deeper part of the pectoralis minor is dissected to expose the axillary vein beyond the subscapular vessels. Clavipectoral fascia is incised to clear the nodes, taking care not to injure the medial pectoral nerve which passes through the pectoralis minor (60%) or its lateral margin (40%) to supply pectoralis major muscle. Main supply of pectoralis major is lateral pectoral nerve which passes medial to the pectoralis minor close to acromiothoracic artery. Pectoralis minor is retracted to clear the apical nodes. Often pectoralis minor tendon is detached from its insertion to coracoid process (Patey's). The fascia over serratus anterior is cleared without injuring long thoracic nerve. Intercostobrachial nerve, if possible, is saved. Posteriorly dissection is continued over subscapular muscle preserving the subscapular vessels and thoracodorsal nerve. At the end specimen is freed from latissimus dorsi.


Incision
Cautery
Elevation of the upper flap
Scissor/scalpel dissection
Gauze dissection
Flap is elevated up to clavicle superiorly
Lower flap dissection
Scissor
Gauze
Cautery
Medial dissection up to sternum
Pectoral fascia is opened
Dissection in front of pectoral is major muscle
Dissection of the pectoralis major muscle using cautery/scissor/scalpel
Opening the lateral margin of the pectoral muscle to reach the axilla
Dissection in the axilla
Pectoralis major
Interpectoral space
Medial pectoral nerve

Figs 16-38(1)



Figs 16-38(2)

Figs 16-38(1 and 2): *Patey's modified radical mastectomy*. Here pectoralis minor tendon is detached from coracoid process. It achieves better approach and clearance of apical nodes.

Toilet mastectomy is done in locally advanced tumour with removal of tumour and possible breast tissue to prevent fungation.

Extended radical mastectomy is doing radical mastectomy with removal of internal mammary nodes of same side or opposite side. It is not practiced.

Nipple sparing mastectomy is done with preservation of nipple and areola.

Areola sparing mastectomy is done preserving areola with resection of the nipple.

RECONSTRUCTION OF THE BREAST

Breast reconstruction is done either as *immediate or delayed procedure*. Immediate reconstruction is done in early breast cancer or after prophylactic mastectomy. Reconstruction is delayed for 6 months in advanced cases.

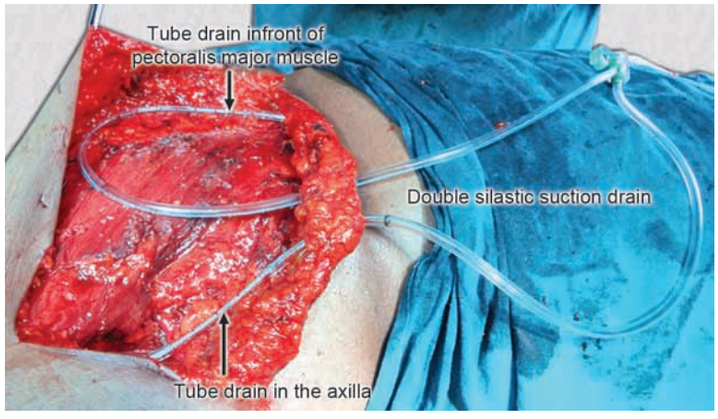


Fig. 16-39: Double tube silastic drain is kept. One tube is in front of the pectoralis major muscle; other in the axilla. Bulky dressings with elastic bandage support are usually used. Drain is removed once drainage is less than 30 ml per day for two consecutive days.

Skin is closed primarily as wound closure. If skin is removed widely and apposition is not possible then *skin graft* is ideal as it will tolerate radiotherapy very well **(Fig. 16-41)**.

Implant is placed under the pectoralis major, serratus anterior, external oblique and rectus abdominis myofascial plane **(Fig. 16-42)**.

Myocutaneous flap with or without breast implant in submuscular plane is good reconstructive approach. Latissimus dorsi myocutaneous flap (LD FLAP) or Transverse abdominis myocutaneous flaps (TRAM FLAP) are used with or without implants. LD flap usually needs implant. TRAM flap dose not require implant usually.

Silicone gel implant under pectoralis major muscle or expandable saline prosthesis may be used. Placement of implants is technically easier. One should take care to achieve symmetry. *Complications* of implants are pain, rupture, displacement, infection and capsular contracture.

TRAM flap can be standard lower TRAM or upper TRAM. Vertical RAM flap is also used as variation. Contralateral submammary flap is also used.

Factors deciding the reconstruction are – amount of skin retained; stage of carcinoma; need of radiotherapy or earlier radiotherapy; need for implant.

Standard lower abdominal TRAM flap is placed horizontally with upper incision at the level of umbilicus; lower incision below su-

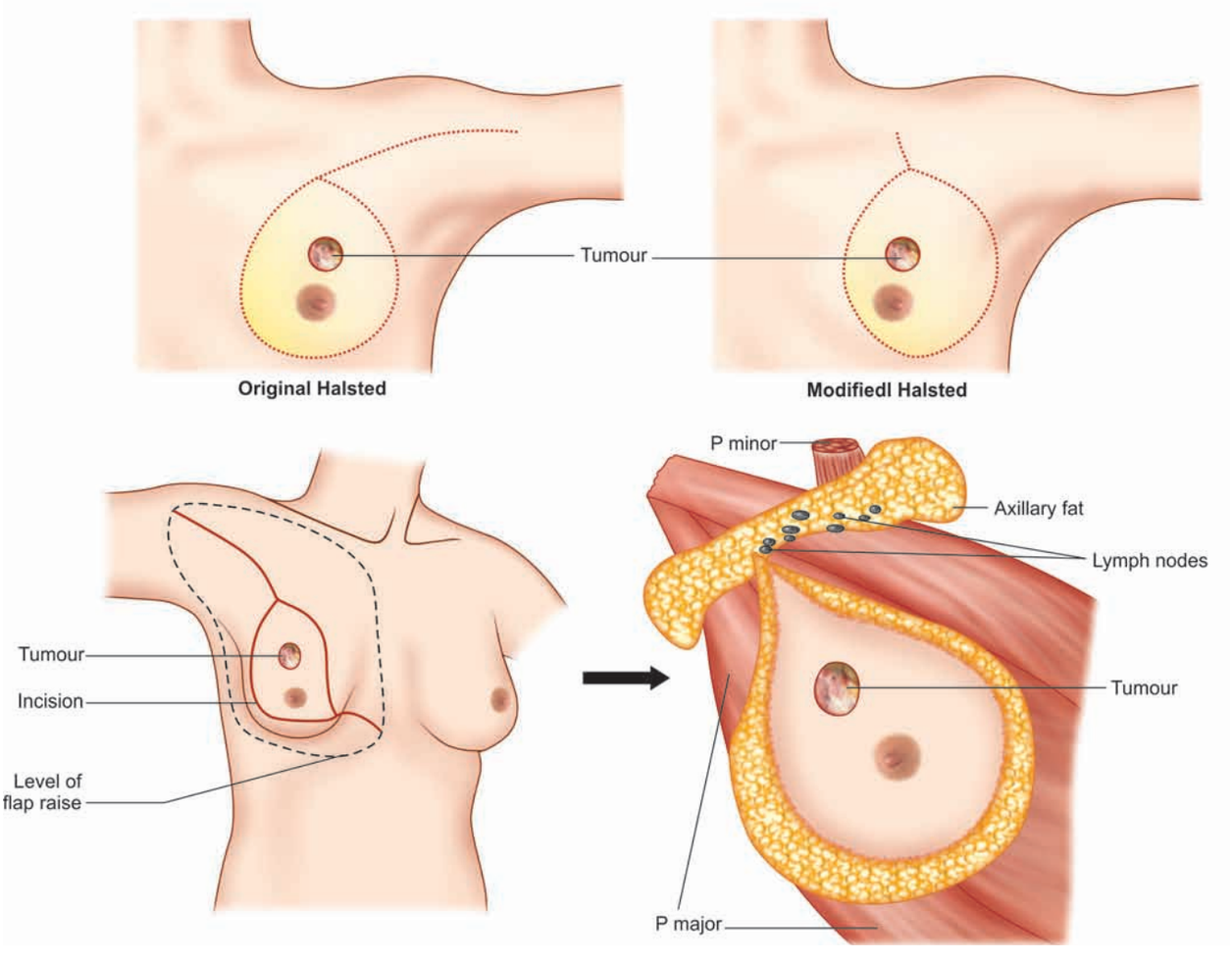


Fig. 16-40: *Halsted radical mastectomy*. It is not used now. Here entire breast with tumour, skin over the breast both pectoralis major and minor muscles, axillary fat, lymph nodes and fascia are removed. Axillary vein, nerve to serratus anterior (Bell's) and cephalic vein are retained.

Fig. 16-41: Split skin graft is done after mastectomy on one side. Other side primary closure was done. It was a bilateral carcinoma of breast.

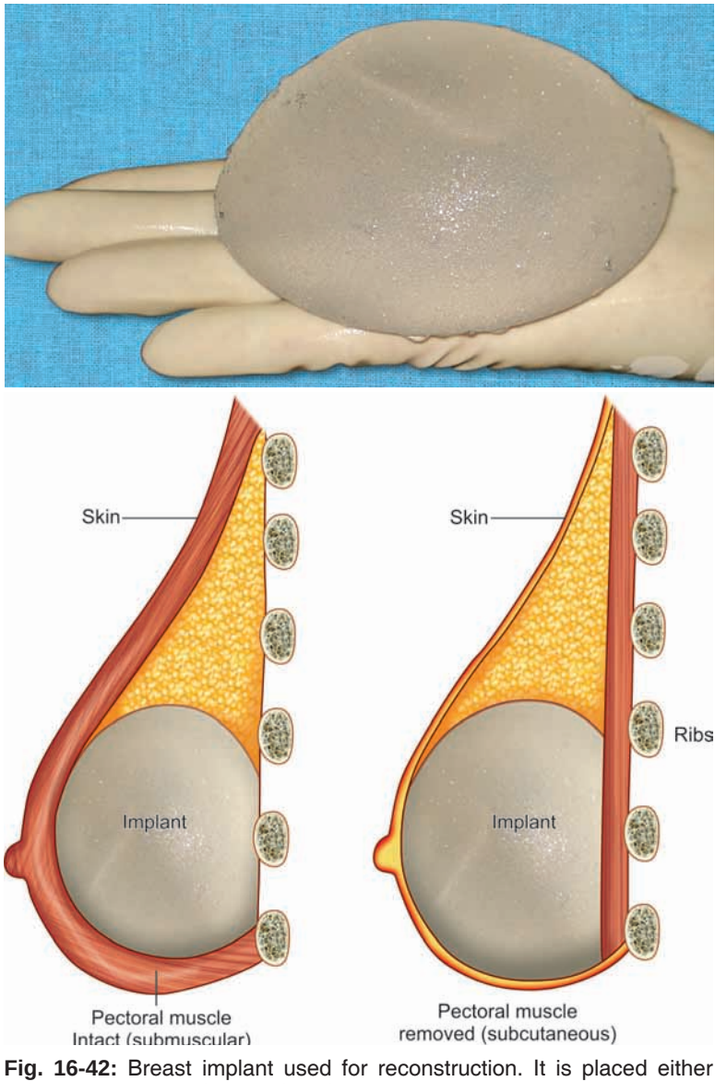


Fig. 16-42: Breast implant used for reconstruction. It is placed either subcutaneous or submuscular plane.

prapubic region with an ellipse. Even though theoretically opposite TRAM flap is better, it is technically not practicable and so ipsilateral TRAM is commonly used. Bilateral TRAM flaps are used to reconstruct both breast areas. Upper incision is deepened through subcutaneous and superficial fascia. Flap is raised often in front of the anterior rectus sheath up to the costal margin and xiphisternum. Anterior rectus sheath protects the muscle. Many advocate the cutting of the anterior rectus sheath and flap is raised in front of the muscle carefully. Small branches of intercostal vessels are ligated. Lower flap is deepened through the rectus muscle which is cut just below the semicircular line. Inferior epigastric vessels are identified which are securely ligated. Muscle with skin is raised from deeper plane above towards xiphisternum as myocutaneous flap. Tunnel for the passage of mobilised flap is done along the midline above. Muscle need not be cut above but can be done so if needed. Skin part of the flap on same side moves towards the axilla and skin part of the flap on opposite side moves towards lower medial part of the defect. Defect is sutured to flap. Suction drains are placed under the flap. Abdominal defect is closed meticulously in layers often placing a synthetic mesh underneath **(Figs 16-43 and 16-44)**.

Vertical RAM/upper TRAM/Contralateral submammary flap are variations of the same, depending on the need. Free TRAM flap can be used to revascularise through internal mammary artery. *Deep inferior epigastric perforator flap (DIEP)* is used as a free flap in breast reconstruction. Revascularisation is done using internal mammary or thoracodorsal vessels **(Figs 16-45 and 16-46)**.

Latissimus dorsi muscle/myocutaneous flap- It is based on thoracodorsal artery, a branch of subscapular artery. Skin over the upper and anterior border of the muscle is used for transfer. It is commonly used to cover the defect after mastectomy. But it does not give the bulk. It is technically easier. It can be used as muscle flap also. It helps as skin cover. Prosthesis (submuscular silicone) is needed to place underneath to provide bulk in postmastectomy defect. Muscle arises from iliac crest upwards to midthoracic spine. Muscle is like a fan below forming tendinous fibres above to insert into humeral shaft. Subscapular artery a largest branch is derived from 3 part of axillary artery runs along posterior wall of the axilla giving circumflex scapular vessels at 4 cm distance and later continues as thoracodorsal artery for about 6 cm, enters the muscle giving many branches. Flap is usually taken as myocutaneous flap with elliptical skin on the surface. Skin part is either horizontal ellipse when taken from upper margin of the muscle or vertical when taken from the anterior margin of the muscle. Point of origin of the subscapular artery is the pivot point of the flap. Artery is accompanied by the vein. While raising the flap after islanding it with skin, only pedicle can be retained cutting muscle above to attain extra length (but commonly anterior attachment is retained) and flap is rotated to the needed area. Donor area can be sutured primarily or covered with a split skin graft. *Often* in LD flap nerve is not retained (if retained it causes *unpleasant muscle contractions* and so it will not maintain the bulk but gives good coverage of the defect). Flap harvesting is done in lateral position. Subscapular vessels maintain the adequate length and caliber and so it is often used as *free flap* based on subscapular vessels **(Fig. 16-47)**.

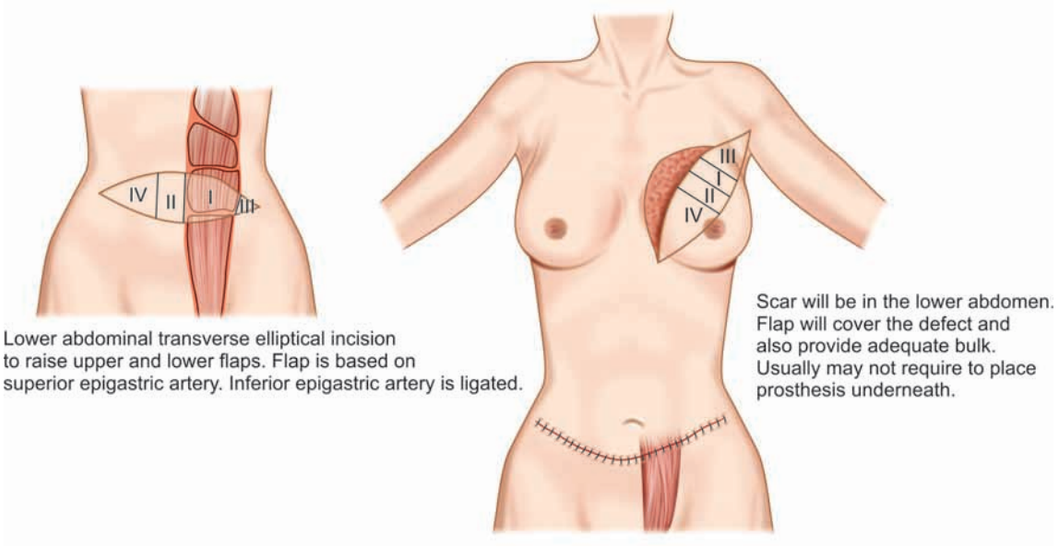

IV
II
I
III
III
I
II
IV
Lower abdominal transverse elliptical incision to raise upper and lower flaps. Flap is based on superior epigastric artery. Inferior epigastric artery is ligated.
Scar will be in the lower abdomen. Flap will cover the defect and also provide adequate bulk. Usually may not require to place prosthesis underneath.

Fig. 16-43: Standard TRAM flap is used from ipsilateral side. It is infraumbilical and is based on superior epigastric artery.

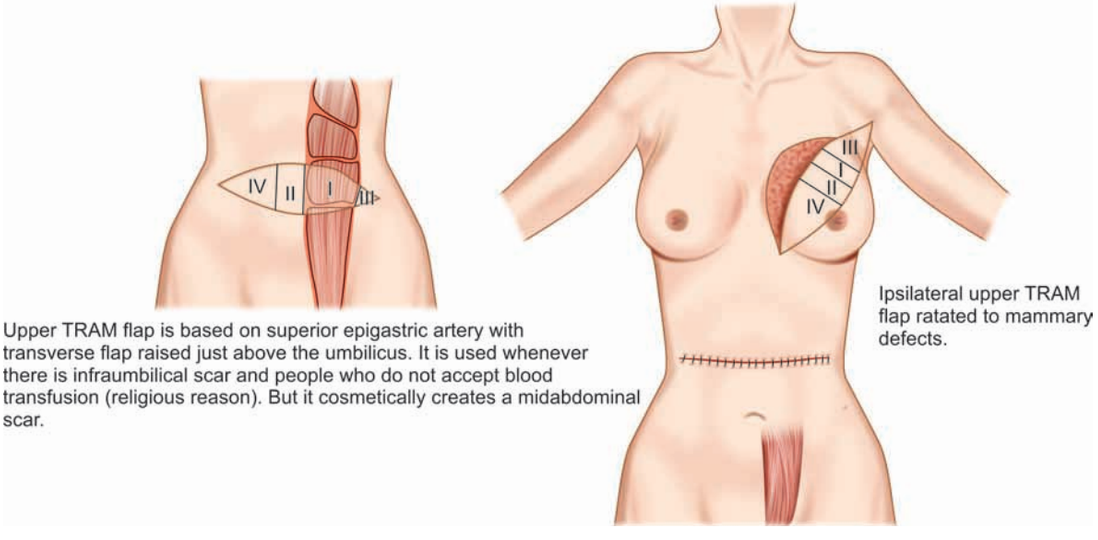

IV
II
I
III
III
I
II
IV
Upper TRAM flap is based on superior epigastric artery with transverse flap raised just above the umbilicus. It is used whenever there is infraumbilical scar and people who do not accept blood transfusion (religious reason). But it cosmetically creates a midabdominal scar.
Ipsilateral upper TRAM flap ratated to mammary defects.

Fig. 16-44: Upper TRAM flap is often used with flap incision in upper abdomen – horizontal.

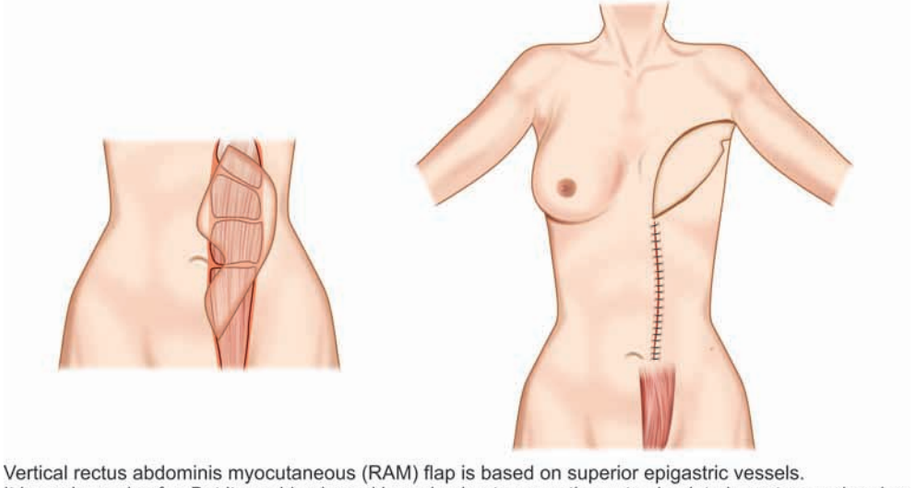
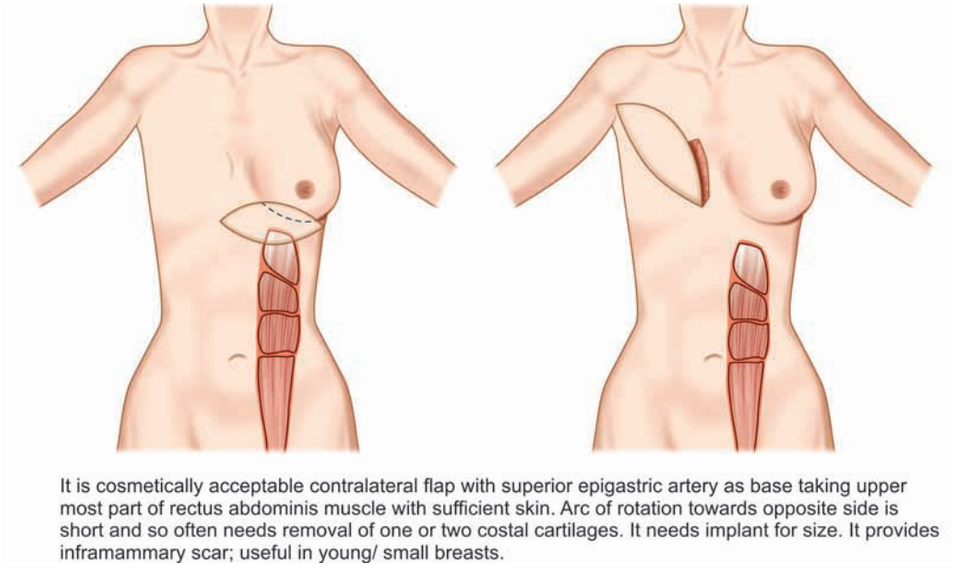

Vertical rectus abdominis myocutaneous (RAM) flap is based on superior epigastric vessels.
It is easier and safer. But it provides less skin and subcutaneous tissue to simulate breast mound and so needs an implant. Abdominal contour is not improved with this flap.

Fig. 16-45: Vertical rectus abdominis myocutaneous flap.



It is cosmetically acceptable contralateral flap with superior epigastric artery as base taking upper most part of rectus abdominis muscle with sufficient skin. Arc of rotation towards opposite side is short and so often needs removal of one or two costal cartilages. It needs implant for size. It provides inframammary scar; useful in young/ small breasts.

Fig. 16-46: Submammary TRAM flap is used from opposite side with least scar.

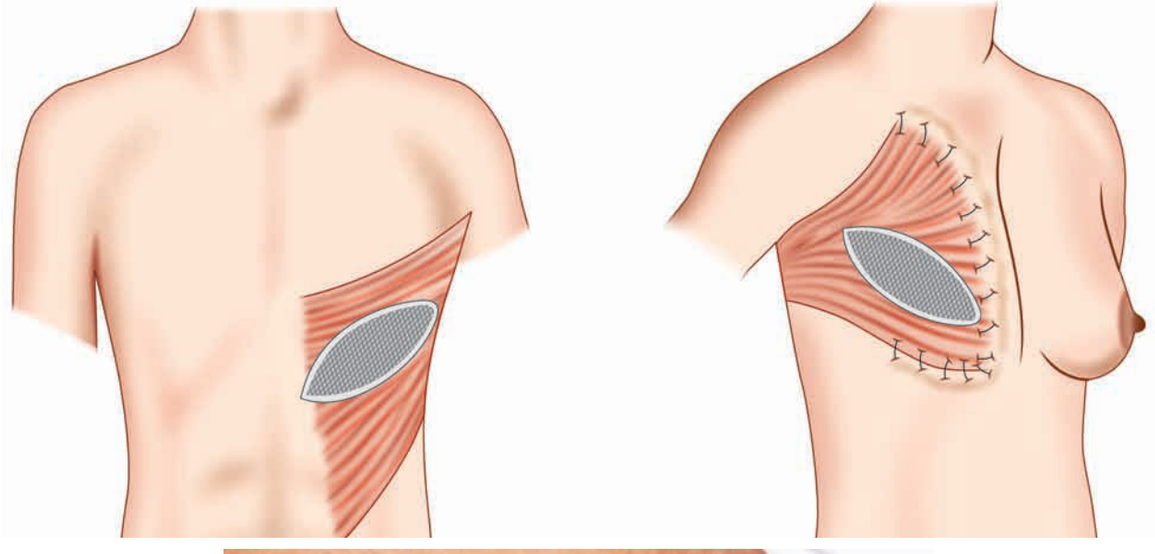


Fig. 16-47: Latissimus dorsi myocutaneous flap.

LD flap	*TRAM flap*
Myocutaneous flap based on subscapular artery Easy to perform Reliable flap, well vascularised Can be placed over prosthesis Low complication rate, but causes unsightly donor area on the back	Transverse rectus abdominis myocutaneous flap based on superior epigastric artery. Ipsilateral or contralateral TRAM flap is used It gives the bulk needed for reconstruction and so implant is not needed Donor site morbidity and fat necrosis can occur. Free TRAM flap into internal mammary/ thoracodorsal axis can be done Limitations to position, shape and rotate; needs mesh placement in the abdomen wound to prevent the formation of incisional hernia

Nipple is created using— Local breast flaps, 3 months after breast reconstruction; nipple sharing from contralateral nipple using composite graft; s*kate flap*: local flap with de-epithelialised donor site around the periphery over which a full thickness graft is applied; nipple prosthesis.

Areola pigmentation is created using (*it is done 3 weeks after nipple creation*) – Full thickness skin graft from non-hairy skin lateral to *labia majora,* as the pigmentation of this graft matches that of the areola; from contralateral areola if reduction mammoplasty is done on that side; *tattooing* – colour tends to fade with time and may need to be repeated; split skin graft from retroauricular area or from thigh.

Chapter

17

Surgeries of Salivary Glands

SURGICAL ANATOMY OF PAROTID (PARA – AROUND; OTIC – EAR) GLAND

Parotid, *pyramid* shaped largest of salivary glands (15 gram) is located below the external acoustic meatus, between ramus of the mandible and the sternomastoid. Gland overlaps these structures and masseter muscle. Gland is of ectodermal origin.

Surface marking of the gland: Line joining from a point at upper margin of mandibular head; along a point at the center of the masseter muscle; to a point at posteroinferior angle of the mandible and at a point at upper part of anterior margin of the mastoid process. *Parotid duct* is marked in the middle third of a line joining the lower border of tragus to a point which is at the middle of the line joining the nasal ala to margin of upper lip. *Facial nerve* is marked from a point at middle of the anterior border of mastoid process (stylomastoid foramen lies 2 cm deep to this point) to a point behind the neck of the mandible **(Fig. 17-1)**.

Investing layer of deep fascia of neck splits at the lower posterior margin of the gland into two layers, as a thick adherent superficial lamina, and a thin deep lamina. Superficial part is attached to zygomatic arch above. *Parotid capsule* otherwise is superficial lamina is thick, inelastic and unstretchable. Deep lamina is attached to styloid process, mandible, and forms thick *stylomandibular ligament* to separate it from submandibular salivary gland **(Fig. 17-2)**.

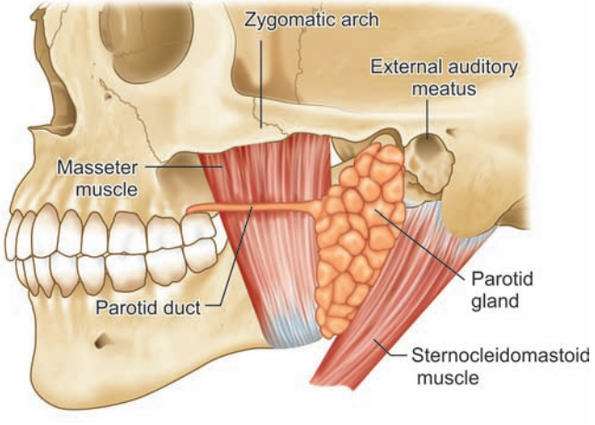


Fig. 17-1: Location of the parotid in relation to masseter muscle.

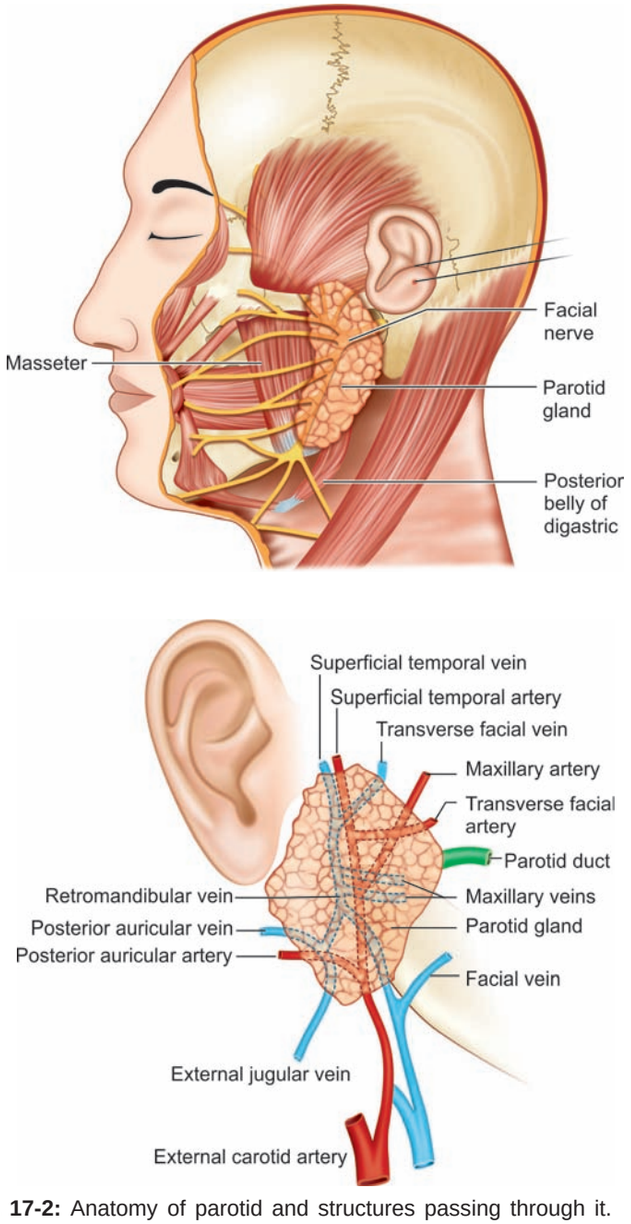


Fig. 17-2: Anatomy of parotid and structures passing through it.

Parotid gland has *4 surfaces* – superior/base; superficial; anteromedial; posteromedial. *Apex* is directed downwards; *3 borders* are – anterior, posterior and medial. Apex lies on the posterior belly of digastric and partly extends into the carotid triangle. Cervical branch of facial nerve and divisions of retromandibular vein emerges at the apex. Upper small concave superior surface is related to auriculotemporal nerve, superficial temporal vessels, temporomandibular joint (posterior part), and cartilaginous part of external acoustic meatus. Largest superficial surface is related to skin, superficial fascia, preauricular/superficial parotid lymph nodes, platysma, risorius, and parotid fascia. Anteromedial surface is related to masseter, lateral part of temporomandibular joint, posterior margin of the mandibular ramus, medial pterygoid, branches of facial nerve. Posteromedial surface is related to mastoid process, sternomastoid, posterior belly of digastric musle, styloid process. External carotid artery enters the gland through this surface. Internal carotid artery is deep to styloid process.

Parotid gland is divided conventionally into two lobes – *superficial lobe* (80%) is also called as *exofacial lobe* which is outer to facial (7th cranial) nerve plane; *deep lobe* (20%) is also called as *endofacial* which is deeper to facial nerve plane. Deep lobe is located adjacent to masseter muscle along the ascending ramus of the mandible. *Isthmus* of the parotid is that portion which is between temporofacial and cervicofacial branches. Tail of the parotid is the portion which extends posteroinferiorly over mastoid tip and sternocleidomastoid muscle **(Figs 17-3 and 17-4)**.

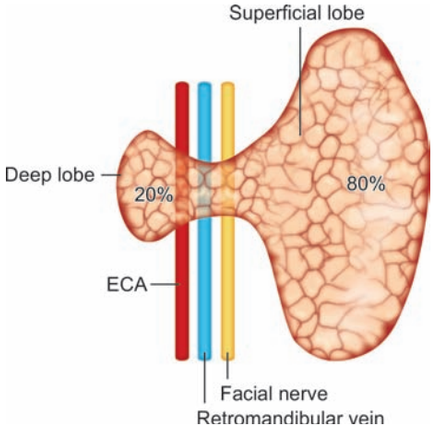


Fig. 17-3: Lobes of parotid.

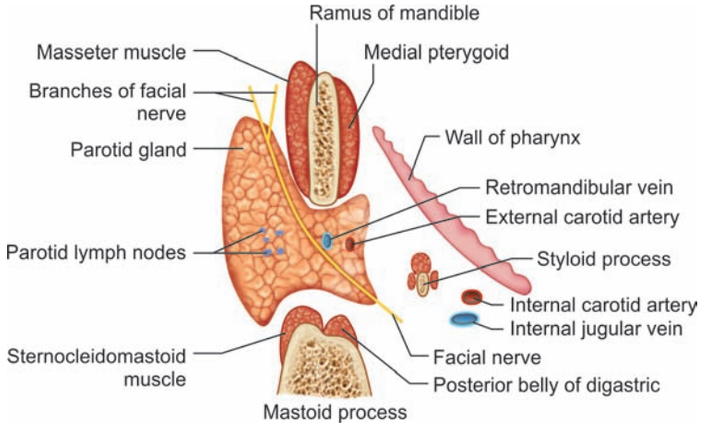


Fig. 17-4: Relations of the parotid gland.

Parotid gland is *bounded* above by zygoma, below by styloid process, styloid muscles, internal carotid artery and internal jugular vein, behind by external auditory canal. Fascia deep to deep lobe is extension of the fascia from deeper part of the digastric muscle and is called as *stylomandibular membrane* which occupies between mandible in front, styloid process behind and stylomandibular ligament below. This membrane separates parotid from submandibular salivary gland. Deep lobe tumour extends to parapharyngeal space through this membrane.

Structures passing through the anterior margin are – parotid duct, facial nerve branches and transverse facial vessels.

Structures within the parotid gland are –**Arteries** (deepest) – ECA enters the gland through posteromedial surface of the gland; maxillary artery (begins at neck of the condylar process of mandible) leaves the gland through anteromedial surface of the gland medial to gland to reach infratemporal fossa; superficial temporal artery comes out through superior surface passing between external acoustic meatus and TM joint to reach temporal fossa where it is accompanied by auriculotemporal nerve. Transverse facial artery arises from superficial temporal artery runs horizontally above the parotid duct. Posterior auricular artery arises from ECA passing posteriorly deeper and at upper margin of the posterior belly of digastric to reach posterior auricular region. Posterior auricular artery gives stylomastoid branch which runs in front and along the facial nerve to enter the stylomastoid foramen to supply tympanic cavity, mastoid air cells and semicircular canals. **Veins** (outer to arteries) – superficial temporal vein and maxillary vein (formed by pterygoid venous plexus at lateral pterygoid muscle) joins to form retromandibular vein (posterior facial vein/temporomaxillary vein) within the gland which descend and divides into anterior and posterior divisions which emerge at apex of the gland; anterior division after emerging joins facial vein to form common facial vein which runs superficial to digastric to reach IJV; posterior division joins the posterior auricular vein to form external jugular vein which runs downwards in front of posterior belly of digastric muscle, sternocleidomastoid, great auricular nerve to reach subclavian vein. *Patey's faciovenous plane* is important during surgical dissection. **Facial nerve** (outer to venous plane) – comes out of stylomastoid foramen where it is accompanied with stylomastoid branch (in front of facial nerve) of posterior auricular artery (artery enters, nerve comes out). Here it gives posterior auricular branch to supply posterior auricular and intrinsic muscles of the ear and branches to posterior belly of digastric and stylohyoid. Nerve after traveling for 1 cm enters the gland through its posteromedial surface and again runs for 1 cm in the gland dividing within gland into two terminal branches – zygomaticotemporal (larger) and cervicofacial (smaller). Terminal temporal (auricularis anterior and superior part of frontalis) and zygomatic (frontalis and orbicularis oculi) branches arise from larger zygomaticotemporal division. Upper buccal, lower buccal (buccinator, orbicularis oris and elevators of lip), marginal mandibular (lower lip muscles), cervical (platysma) arise from smaller cervicofacial branch/division which emerge through the anteromedial surface. Multiple communications are common between branches especially in zygomatic and temporal branches (*pes anserinus/goose foot*). They supply muscles of facial expression and platysma. **Deep parotid lymph glands** – They are embedded in the superficial lobe of the gland. *Faciovenous plane of Patey* is a plane where vein and facial nerve branches lie within the parotid with nerve lying superficial to vein in this plane **(Figs 17-5 and 17-6)**.

Parotid duct (Niels *Stenson's—Anatomist Copenhagen; father of geology)* is 5 cm in length (2-3 mm diameter) with thick wall which after

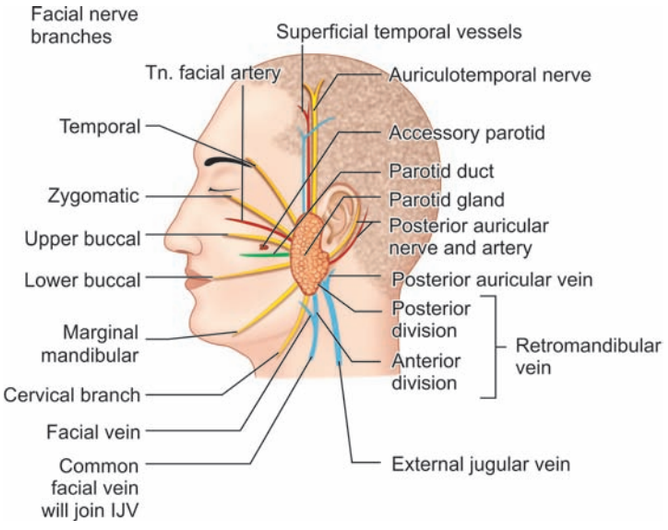


Fig. 17-5: Structures passing out of the parotid gland.

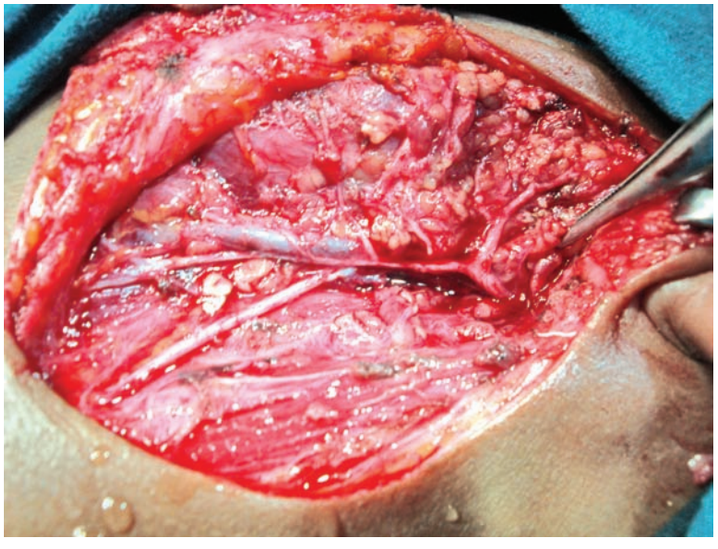


Fig. 17-6: Patey's faciovenous plane.

beginning at deep and behind the angle of mandible 1.5 cm below the zygoma runs forwards and emerges from the anterior border running forward and downward on the masseter muscle up to its anterior margin where it pierces obliquely the buccal pad of fat, buccopharyngeal fascia, buccinator muscle and opens into the vestibule of the mouth opposite the crown of 2nd upper molar tooth. During its course it receives interlobular from above and one duct from accessory parotid gland. Above it is related to *accessory parotid gland*, upper buccal branch of facial nerve, transverse facial vessels; below to lower buccal branch of the facial nerve **(Fig. 17-7)**.

Blood Supply

Parotid is supplied by ECA through its direct branches and also branches of ECA in the parotid region; venous drainage is into the external jugular vein **(Figs 17-8 and 17-9)**.

Lymphatic Drainage

Superficial parotid lymph glands lie outer to parotid (deep fascia); *deep parotid lymph glands* are located deep to parotid sheath in *superficial*

Fig. 17-7: Accessory parotid gland is above the parotid duct.

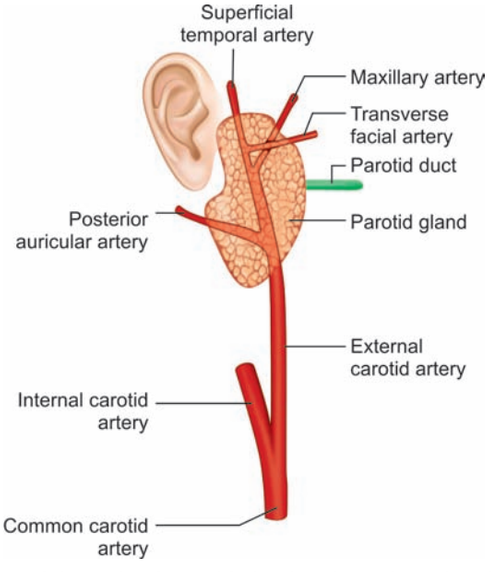


Fig. 17-8: Arterial supply of parotid gland and arteries related to parotid.

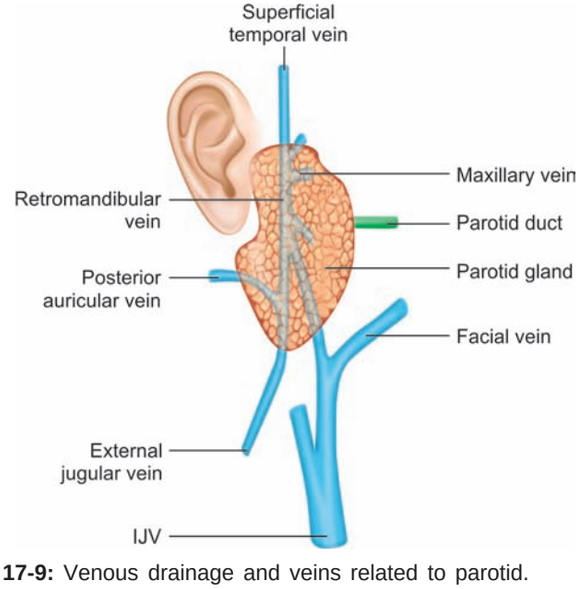


Fig. 17-9: Venous drainage and veins related to parotid.

lobe. Drainage area are – temple, side of the scalp, lateral part of ear, external acoustic meatus, middle ear, parotid gland, upper part of cheek, eyelids partly, orbit. Efferent from these nodes drain into upper deep neck nodes.

Nerve Supply

Parotid fascia sheath is supplied by great auricular nerve (C2); *sensory supply* to gland is through auriculotemporal nerve; *sympathetic* vasomotor fibres are from plexus around ECA; *parasympathetic supply* is through otic ganglion with complex pathway. Inferior salivatory nucleus → Preganglionic fibres → glossopharyngeal nerve → tympanic branch → tympanic plexus → lesser petrosal nerve → otic ganglion → post-ganglionic fibres → through auriculotemporal branch of mandibular division of trigeminal nerve → parotid gland **(Fig. 17-10)**.

FACIAL NERVE

It is 7th cranial nerve (2nd branchial arch). It is the '*queen of the face*'. It arises from 4 nuclei at lower pons. Sensory (nervus intermedius) and motor roots run along with 8th cranial vestibulocochlear nerve to enter the internal acoustic meatus with labyrinthine vessels. In the meatus two roots join to lie in the petrous temporal bone. In the canal it has got 2 bends. First bend is called as *genu* which is related to geniculate ganglion. Nerve leaves the skull through stylomastoid foramen. *Stylomastoid foramen* is located medial to mastoid tip and lateral to styloid process. Stylomastoid branch of posterior auricular artery (branch of ECA) is just in front of the facial nerve trunk which also enters the stylomastoid foramen. Here facial nerve runs lateral to styloid process to enter the parotid gland; divides into branches behind the neck of the mandible. ***Branches*** *–in the canal* are greater petrosal, nerve to stapedius, chorda tympani; branches immediately *after coming out of stylomastoid foramen* - are posterior auricular (to post auricular muscles), digastric (to posterior belly) and stylohyoid; *terminal* branches are - temporal, zygomatic, buccal, marginal mandibular and cervical. Buccal branch is in relation to the parotid duct; marginal mandibular branch crosses over the anterior facial vein. *Chorda tympani* originates from facial nerve 6 mm above the stylomastoid foramen; enters middle ear close to tympanic membrane, then petrotympanic fissure to reach infratemporal fossa where it joins lingual nerve to distribute secretomotor fibres to submandibular ganglion (parasympathetic secretomotor) and submandibular and sublingual glands. It also gives taste fibres to anterior 2/3rd of the tongue **(Figs 17-11 to 17-14)**.

Greater petrosal nerve pathway is - superior salivatory nucleus → facial nerve → greater petrosal nerve → opening in the petrous temporal bone for greater petrosal nerve → joins sympathetic deep petrosal nerve to

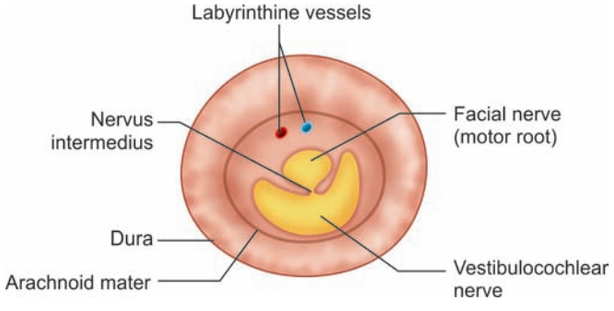


Fig. 17-11: Structures in the internal meatus (Left).

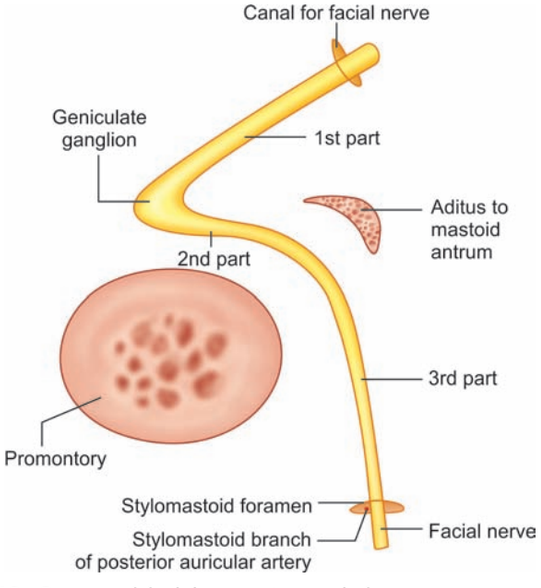


Fig. 17-12: Course of facial nerve to reach face.

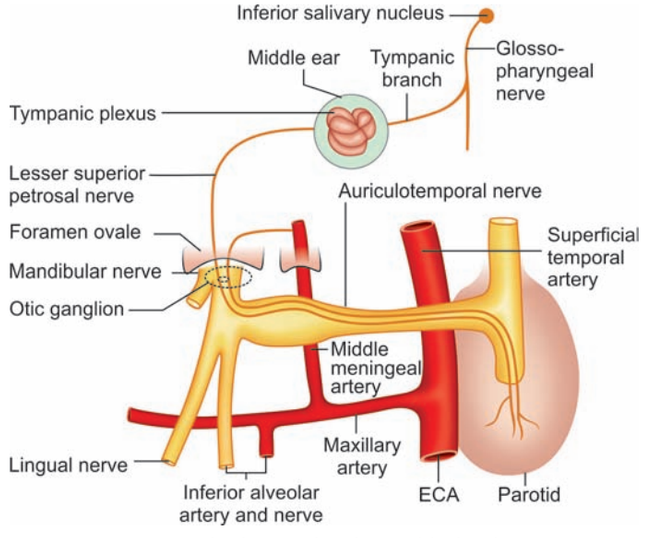


Fig. 17-10: Parasympathetic supply of parotid gland.

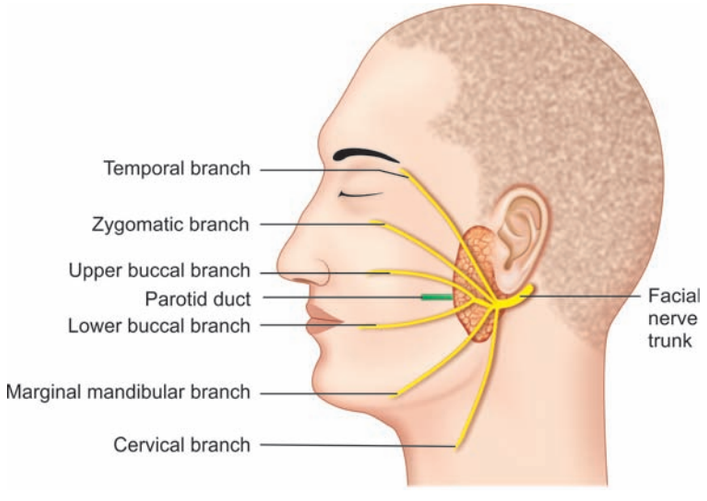


Fig. 17-13: Facial nerve and its branches.

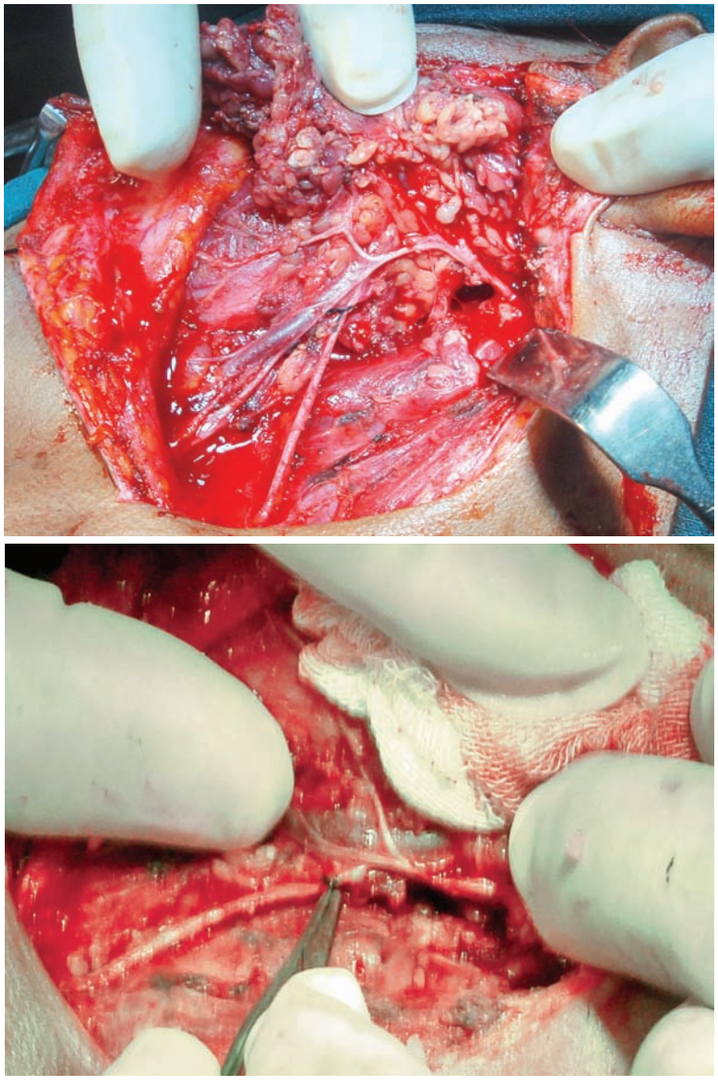


Fig. 17-14: Facial nerve – on table look.

form nerve of the pterygoid canal → through canal reaches pterygopalatine ganglion (largest peripheral parasympathetic ganglion) → postganglionic fibres supply lacrimal gland and mucous glands of nose, sinuses, palate and pharynx.

PAROTIDECTOMY

Indications

Parotidectomy is done in benign/malignant tumours of parotid including adenolymphoma of parotid. Superficial parotidectomy is done only in benign tumours of superficial lobe. In tumours (benign) involving both superficial or deep lobe and only deep lobe total conservative parotidectomy is done. In malignant tumour invading facial nerve radical parotidectomy is done. Presently even in malignant parotid tumours, sacrificing only the involved/infiltrated branches of facial nerve and retaining uninvolved branches, with wide clearance and neck dissection is contemplated; as evidence suggests that there is no survival benefit between removing all branches and removing only the involved branches. In aggressive tumour radical parotidectomy is done sacrificing the trunk of facial nerve with nerve graft.

Occasionally superficial parotidectomy is added as part of radical neck dissection in case if primary tumour is in head and neck region and in skin malignancies of face and scalp. First branchial cleft cyst excision involves removal of the parotid. Type I first branchial cyst is located in the external auditory canal in relation to angle of the mandible and parotid.

Some surgeons even though not well accepted advocate total parotidectomy for chronic parotitis, sialorrhoea, fistula, refractory parotid stones.

Types of Parotidectomy

Superficial/lateral parotidectomy (Patey) – It is removal of superficial lobe of the parotid in front of the faciovenous plane of Patey.

Total conservative parotidectomy – Here both superficial and deep lobes of the parotid are removed preserving the facial nerve. Dissection along the faciovenous plane is carried out to identify the branches of the facial nerve retaining the isthmus/tumour bearing area. Nerve branches are retracted aside to reach the deep lobe which is removed entirely by dissecting off the branches of facial nerve carefully without injuring them. This is the right technique even though many advocate removing superficial lobe initially then deep lobe separately. Retromandibular vein is ligated here.

Radical parotidectomy – Involves removal of both lobes of parotid with facial nerve, fat, fascia, masseter, pterygoid, buccinator along with neck lymph node dissection. Facial nerve is sacrificed. Its branches whenever possible can be saved as additional advantage of survival not thereby removing uninvolved branches. On table frozen section biopsy of cut ends of nerve are needed. Ends of the cut nerve branches are tagged by fine sutures for eventual nerve grafting using great auricular nerve or sural nerve. Often radical parotidectomy is combined with removal of temporomandibular joint, mastoid process and external auditory meatus with less additional benefit. Mastoidectomy is done to visualize the clear proximal part of the facial nerve. Reconstruction of the main trunk, marginal mandibular, temporal and buccal branches are done to maintain eye closure and good oral competence.

Suprafacial parotidectomy is done for benign tumour at lower pole wherein all branches of facial nerve need not be dissected.

TECHNIQUE OF PAROTIDECTOMY

Position and Anaesthesia

Procedure is done under general anaesthesia. Paralytic agents used for intubation purpose are of short acting only as during surgery facial nerve branches are identified and confirmed by stimulation to achieve contraction of facial muscles. Neck is extended by placing a sandbag under the shoulder with a head support using a ring. After cleaning, draping is done to expose the face and eyelids to see the contractions of muscles whenever needed. Head is extended with face turning opposite side. Head end of the table is elevated 15° to reduce venous congestion. In many centres of China procedure is done under local anaesthesia also. Nerve monitor device is used. Its electrode tips are placed into orbicularis oculi and orbicularis oris muscles. Nerve either the main trunk or branches are stimulated using nerve stimulator whenever needed.

Incision

Standard incision is '*Lazy S*' incision (*modified Blair/Sistrunk* incision). It begins in front of tragus closely running vertically to the ear lobule;

curving on the margin of the ear lobule towards middle of the mastoid (mastoid tip) along postauricular part; again curving back downwards along the margin of the sternocleidomastoid muscle in the superior cervical crease 2 cm below the angle of the mandible. *Inverted T and modified Y incisions* are also used. '*Face lift' incision*' can be used in benign tumours of the tail or middle part of the parotid. It begins at tragus running vertically downwards curving the ear lobule and extending in the postauricular region along the hair line **(Figs 17-15 to 17-18)**.

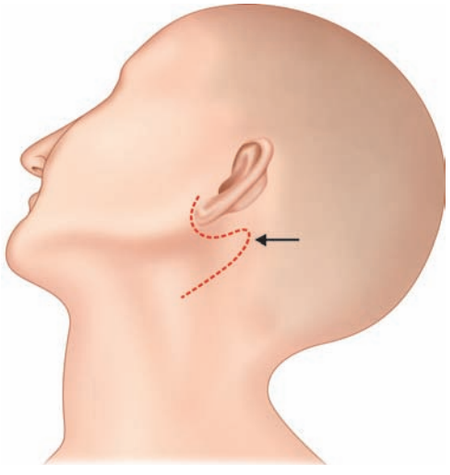


Fig. 17-15: Modified Blair incision for parotidectomy.

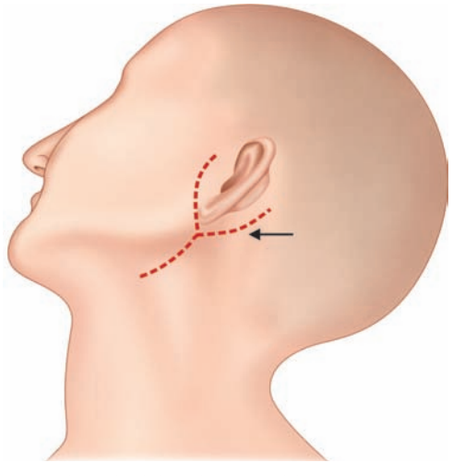


Fig. 17-16: Inverted 'T' incision for parotidectomy.

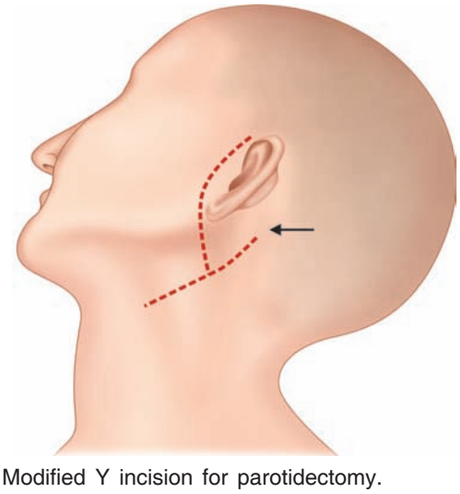


Fig. 17-17: Modified Y incision for parotidectomy.

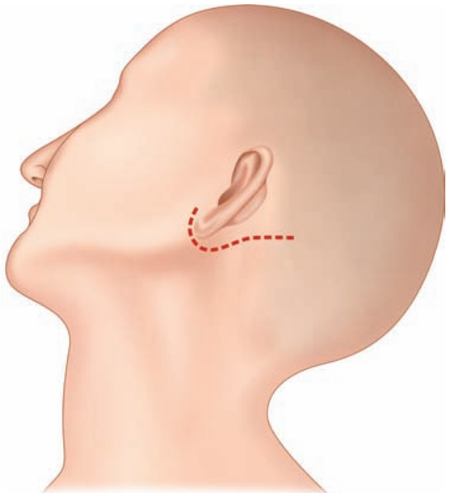


Fig. 17-18: Face lift incision for parotidectomy.

Usual plane used is *subplatysmal* in the *neck* area. Incidence of Frey's syndrome and flap necrosis are higher if flap is raised in front of the platysma. Ear lobule is held under traction with suture. Skin flap is raised anteriorly superficial to parotid fascia in *face* by holding with skin hooks up to the anterior margin of the parotid with visualisation of the masseter muscle. While elevating the flap anteriorly close to the masseter, branches of facial nerve will be close to skin flap and care should be taken not to injure them. Posterior skin flap is raised to expose the anterior border of the sternocleidomastoid muscle and mastoid process **(Fig. 17-19)**.

Even though *great/greater auricular nerve* has to be cut, it is cut close to the parotid gland or after it gives the posterior branch (it is the largest branch of cervical plexus). Adequate length of the great auricular nerve is dissected for the possible need of nerve graft in case of facial nerve injury. *External jugular vein* with its tributaries is visible which can be retained or transected. Fascia along the anterior border of the sternocleidomastoid muscle is incised to expose the upper part of the muscle. After retracting sternocleidomastoid, once posterior belly of digastric muscle is identified; both muscles are retracted; dissection is done in front of the mastoid along the tragal cartilage. Dissection begins from the posterior part of the gland near tail of the parotid. Gland is freed of the fibrous attachments and with blunt dissection bony cartilaginous junction of the auditory canal, tympanomastoid suture/fissure (groove between mastoid tip and tympanic portion of the temporal bone) and tragal pointer is felt and identified. Parotid tissue between superior border of posterior belly of digastric muscle and tympanomastoid fissure is dissected and separated carefully layer by layer by blunt and sharp dissection. Temporoparotid fascia from tympanomastoid fissure to parotid is cut to visualize facial nerve. Facial nerve is 1 cm below and medial (or *anterior and inferior*) to tip of the tragal cartilage **(Fig. 17-20)**.

Identification of Facial Nerve

Facial nerve trunk is identified by different techniques – (1) Facial nerve is 5 – 10 mm deep and below from the tip of the cartilaginous canal – *Conley's point*. (2) Sternocleidomastoid muscle is retracted behind, gland is retracted front; posterior belly of digastric is identified where nerve is anterior to this. (3) Nerve is lateral to styloid process. (4) Tracing branch from distal to proximal – *Hamilton–Bailey* technique through buccal branch or marginal

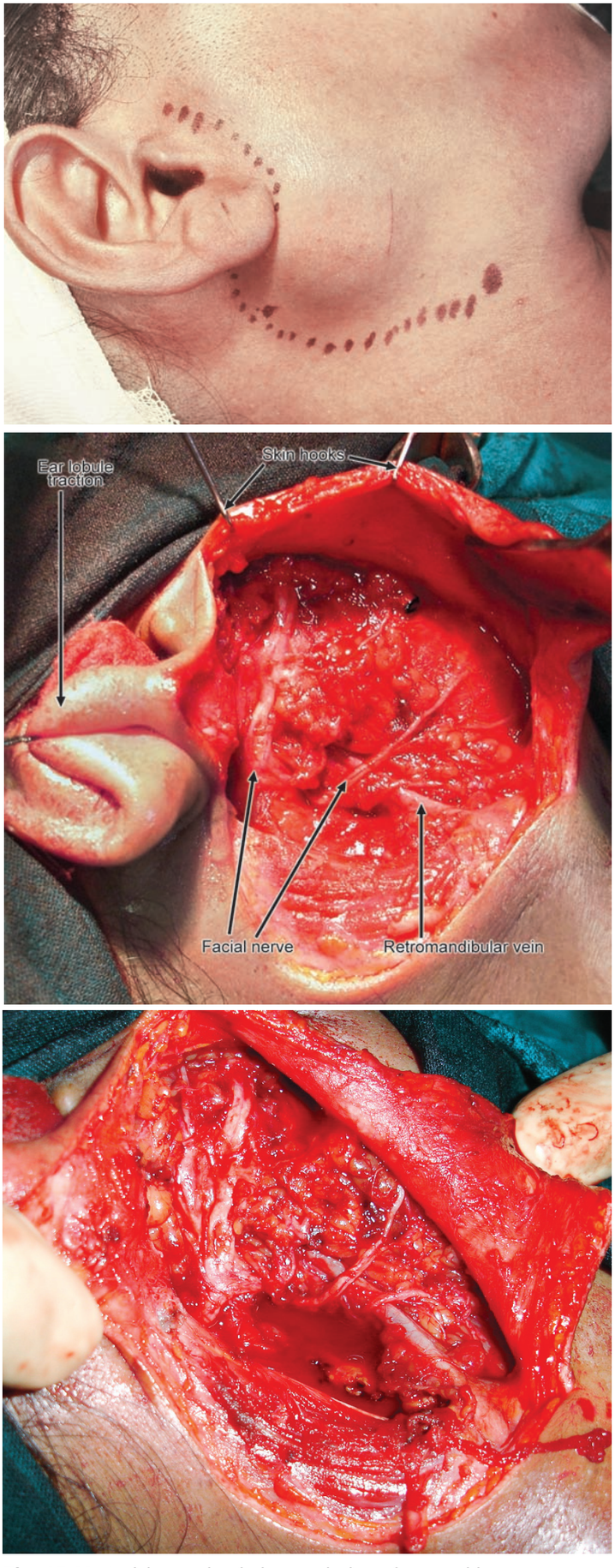


Fig. 17-19: Incision and subplatysmal plane for parotidectomy.

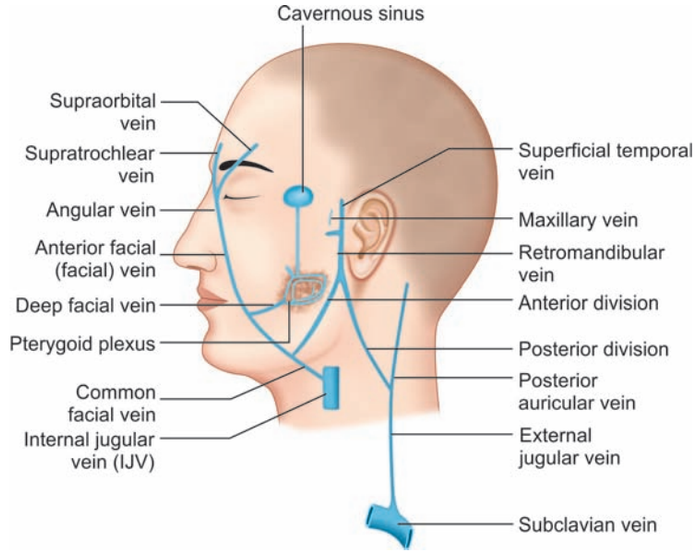


Fig. 17-20: Venous anatomy of face is important in parotidectomy.

mandibular branch. (5) Using Faradic or mechanical stimulation (pinching tissues) muscle movements/twitching can be observed. (6) Stylomastoid branch of posterior auricular artery is just in front of the facial nerve trunk which also enters the stylomastoid foramen. Facial nerve after coming out of stylomastoid foramen travels for 1 cm forward and below between mastoid process and membranous portion of external auditory canal and divides into temporofacial/temporozygomatic and cervicofacial branches behind the neck of the mandible. This bifurcation may be often distal or often proximal before coming out of the stylomastoid foramen. Cervicofacial branch divides into cervical (for platysma) and marginal mandibular branch which runs below the horizontal ramus of the mandible within the platysma muscle to supply lower lip. This branch *does not have any communicating* branch unlike other branches of facial nerve. This branch is more often superficial to posterior facial vein. Buccal and zygomatic branches have numerous communications which supply periorbital and upper lip muscles. Temporal branch supplies frontalis muscle but does not have cross communications and has got weak regenerative power and so often paralysis of frontalis stands permanent in facial nerve palsy. Buccal branch is situated close to parotid duct and so if duct is identified it is easier to look for buccal branch. Dissection from distal to proximal is more difficult than dissection from proximal to distal.

Separation of Gland off the Facial Nerve Branches

It requires patience and fine dissection. There are two methods to dissect the facial nerve. (1) Forward/*antegrade* technique – Dissection from main trunk of facial nerve; (2) *Retrograde* technique – Dissection from branches towards main trunk (it is followed in many centres in China).

Dissection using fine haemostat and fine scissor is ideal with tip of the instrument facing forward. Tiny oozing points need ligation using fine vicryl. Bipolar cautery can be used carefully away from the nerve branches. All parotid tissue is cut only with visualisation of nerve branches. One of the division and its branches are separated and dissected completely first; later other division and branches. Monopolar cautery *should not* be used. Dissection is first started

along the upper divisions of the facial nerve. Dissection is carried out up to the anterior margin along the faciovenous plane of Patey to remove the entire superficial lobe. Deep lobe (20% of total gland) is nicely visualised. Haemostasis is achieved. If deep lobe needs to be removed after partial dissection of superficial gland from facial nerve branches, branches are gently retracted to dissect beside the isthmus of the parotid gland to reach deep lobe which can be removed. Often this is technically difficult and so many advocate removal of superficial lobe first followed by identification of deep lobe; facial nerve branches are retracted and deep lobe is dissected and removed. Parotid duct is located in relation to deep lobe. Upper buccal branch is above the duct which is larger than lower buccal branch. Ideally all the branches should be identified and dissected. In malignant parotid, branches which are invaded are sacrificed. Main trunk if divided then nerve graft is done using great auricular nerve or sural nerve. Operating microscope is needed for nerve suturing. Even though nerve is not injured post operative neuropraxia is common which recovers completely at a later period. Many use short term steroid therapy to prevent this. In removal of deep lobe retromandibular vein should be ligated. The parotidectomy should be done with the tumour 'en bloc' **(Fig. 17-21)**

Removal of the Deep Lobe in Total Conservative Parotidectomy

Branches of facial nerve which are dissected are gently retracted away using nerve hook or smooth loops to visualize the deep lobe. Parotid duct is transected at its anterior part and ligated. One should not injure upper buccal branch of facial nerve. Duct may be dissected up to the mucosa through buccinator if needed before ligation. Deep lobe is separated from nerve branches from its deeper plane. Often it is required to ligate the retromandibular vein to facilitate easy dissection and reduce bleeding. Deeper part of the deep lobe is dissected of the stylopharyngeus and stylohyoid muscles by blunt dissection while retracting the deep lobe. Superficial temporal vessels, maxillary artery deep to ramus of mandible, the occipital artery, posterior auricular artery and pterygoid venous plexus are deep to deep lobe. Deep lobe can be extirpated superior/inferior/in between nerve branches. Haemostasis should be achieved using bipolar cautery.

Main trunk of the facial nerve is stimulated with 0.5 mA to confirm the anatomical and physiological integrity of the branches of the facial nerve.

Points to be remembered are -

Dissection of the facial nerve should be done just superficial to the nerve to expose it clearly. Dissection deep to the nerve is inadvisable. The sheath of the facial nerve should not be opened to avoid damage to the nerve fibers.

Using *wet gauze* is better than dry gauze for haemostasis. Clearing of blood from the operative field should be done by mild pressure absorption of the blood rather than scrubbing. The dissected nerve should be covered by wet gauze to avoid dryness following exposure to air.

Bleeding from capillary vessels should be stopped by the pressure of wet gauze, as some blood vessels are distributed along with the nerve. The facial nerve is readily damaged if artery forceps are used for haemostasis. The dissection is continued in the other areas of the gland while attaining this haemostasis.

The bifurcation of the nerve is close to the retromandibular vein, and its fine branches should be ligated. Suction is used to achieve a clear surgical field. Any bleeding vessel should be carefully clipped or ligated.

The branching ducts of the gland must be distinguished from the facial nerve. The nerve is *white and shiny,* while the duct is *grey and dull*.

The parotid duct if ligated like done by many, in traditional superficial parotidectomy, then remaining deep lobe of parotid atrophies spontaneously. But it is possible to preserve the duct so that the saliva secreted from the parotid remnant will be made to extrude into mouth. So that partial function of the retained gland is achieved. It is important to ligate the interlobular ducts identified during the dissection carefully to prevent the formation of salivary fistula.

After parotidectomy, even though not practiced widely, parotid remnant is often sutured by absorbable sutures to achieve proper haemostasis and to prevent formation of salivary fistula. If the duct and function of the parotid remnant are to be preserved, deep sutures should be avoided in order to prevent ductal ligation.

The wound is irrigated with hypertonic saline/distilled water probably to destroy spilled tumour cells. The integrity of the facial nerve is checked by finger pinch or nerve stimulator. If the nerve has been disrupted, an end to end anastomosis of the nerve is carried out or with suitable graft immediately.

Closed suction drainage is used with suction tube placed away from the dissected facial nerve to prevent damage to the nerve. Compression bandage is kept often for 3 days.

Deep lobe mass may appear as lateral oropharyngeal masses. Tail of the parotid mass mimics cervical lymph node. Common site of the parotid tumour is tail of the parotid.

Only FNAC and imaging (CT scan) are the investigations done for parotid tumour. Open biopsy is not done in parotid tumour.

Enucleation of the parotid tumour should not be done. This increases the risk of facial nerve injury, risk of tumour recurrence.

Loupe or microscope is useful in dissecting the branches especially in reoperation.

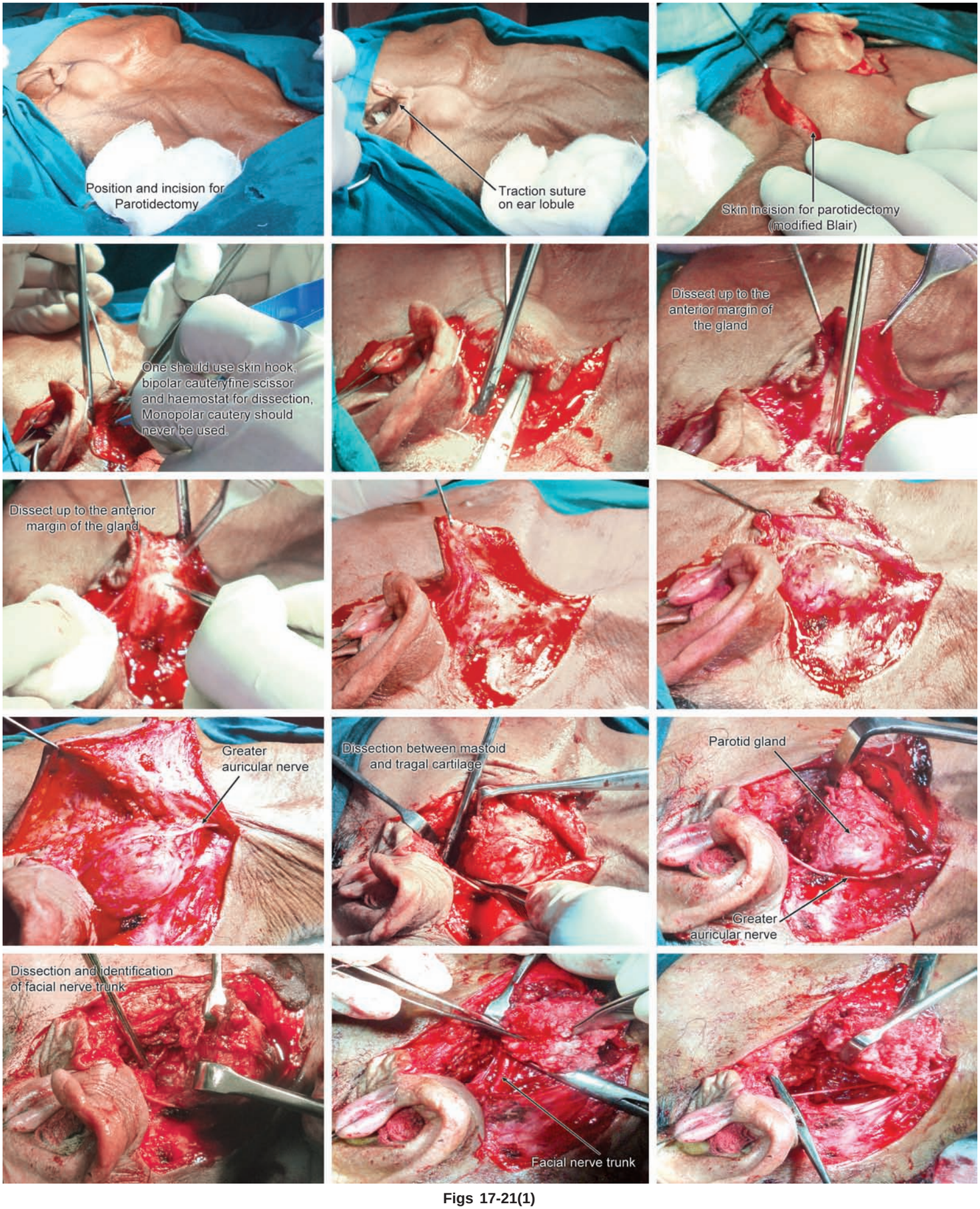
Nerve stimulator should be used judiciously otherwise it itself can cause neuropraxia.

Closure

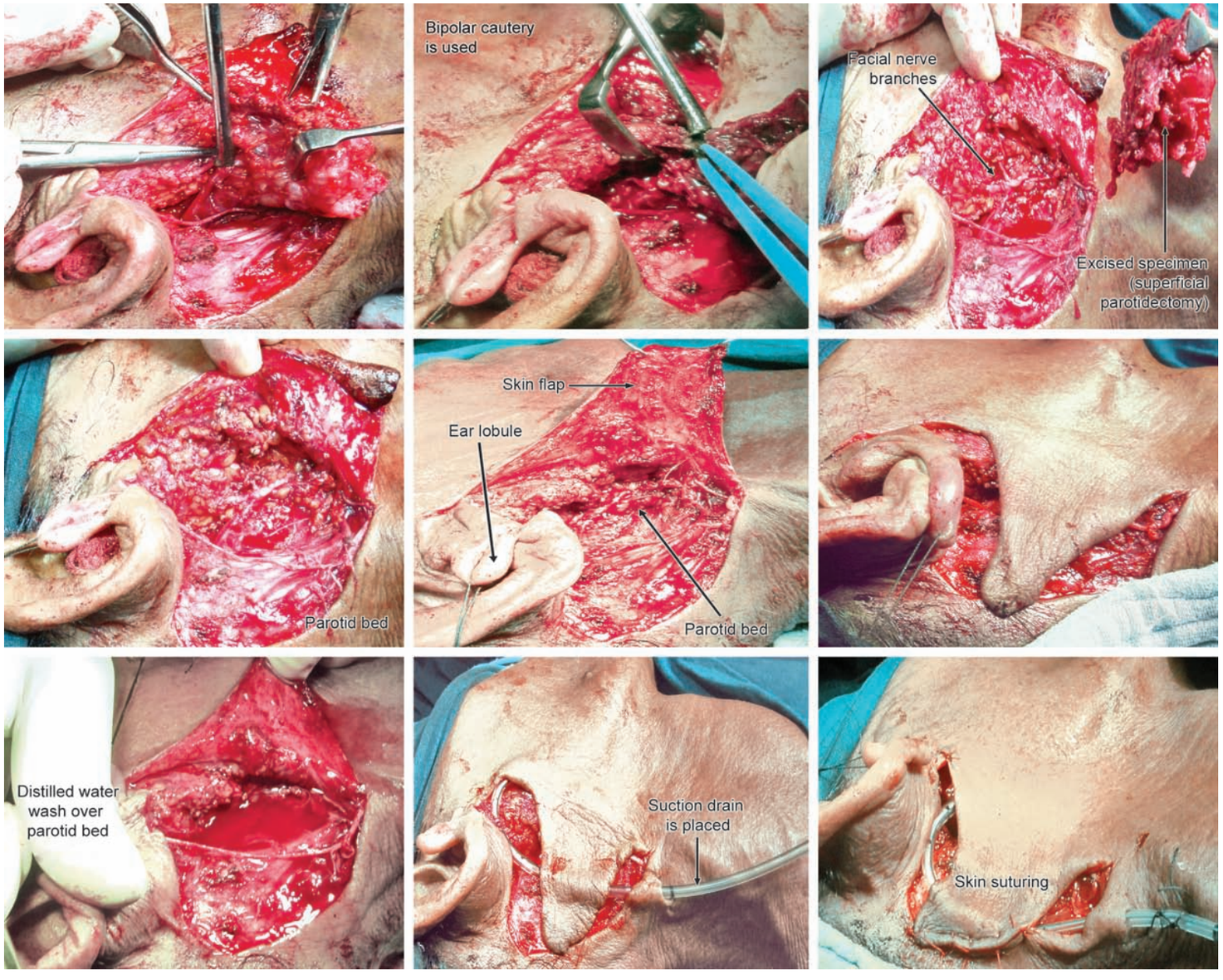
Proper haemostasis is achieved using fine vicryl ligatures or bipolar cautery. Often it is of practice to pour distilled water in the parotid bed and keep it for few minutes to kill spilled tumour cells from the capsule. *Digastric flap* is often used to cover the area of facial nerve. Posterior belly of digastric is detached from its hyoid/pulley attachment and rotated upwards over the facial nerve and attached to zygoma. An *acellular dermal matrix graft* can be placed into the wound prior to skin closure to cover the facial nerve trunk and auriculotemporal nerve area to prevent scar adhesion into the facial nerve trunk and formation of Frey's gustatory sweating. Suction drain is placed before closure which is removed in 3 days. Drain should not come into contact with the facial nerve main trunk. Skin is closed with interrupted polypropylene or polyethylene 4 zero or 3 zero sutures. Slight pressure dressing is often used **(Fig. 17-22)**.

Postoperative Care

Drain is removed in 48 hours. Facial expressions are observed for features of facial palsy. Temporary facial nerve paralysis is common in the postoperative period for which the surgeon should not worry. If closure of eyes is inadequate due to neuropraxia, repeated saline drops to eye and eye cover is needed to prevent exposure keratitis. Neuropraxia recovers in 4 weeks.


Position and incision for Parotidectomy
Traction suture on ear lobule
Skin incision for parotidectomy (modified Blair)
One should use skin hook, bipolar cauteryfine scissor and haemostat for dissection, Monopolar cautery should never be used.
Dissect up to the anterior margin of the gland
Dissect up to the anterior margin of the gland
Greater auricular nerve
Dissection between mastoid and tragal cartilage
Parotid gland
Greater auricular nerve
Dissection and identification of facial nerve trunk
Facial nerve trunk

Figs 17-21(1)



Figs 17-21(2)

Figs 17-21(1 and 2): Technique of parotidectomy.

COMPLICATIONS OF PAROTIDECTOMY

Haemorrhage

It is rare, usually of venous origin and ooze from the bed. Major arterial injury is rare. When haematoma once develops, patient presents with swelling, pain, distress with blood in the drain. It is usually due to bleed from retromandibular vein or its tributaries. If haematoma is progressive then wound is reopened under general anaesthesia. Retromandibular vein is ligated both proximally and distally. Ligation of this vein causes ipsilateral facial oedema which gradually subsides in few weeks.

Facial Nerve Injury

It is the most important, common and worried complication. It may be due to simple neuropraxia due to handling during dissection or nerve injury at various levels either of the main trunk in case of neoplastic conditions or few of branches. *Incidence* of temporary facial nerve palsy due to neuropraxia is 40%; whereas permanent palsy is 4%. *Features* are – inability to close the eyelid, difficulty in blowing and clenching; drooping of angle of the mouth; obliteration of nasolabial fold; loss of forehead wrinkles; wide palpebral fissure and epiphora. Effects of temporary facial nerve injury/neuropraxia will recover in few days to few weeks (12 weeks). Oral or intravenous steroids with vitamin B_1 and B_{12} injection are often tried. Permanent facial nerve injury needs specialised methods to correct the deformity. Nerve grafting is done using greater auricular, sural, lateral cutaneous or hypoglossal nerves. It needs operating microscope and is done using 6 zero polypropylene sutures. Angle of mouth can be suspended to zygomatic bone using temporal facial sling. Corneal ulceration is prevented using lateral tarsorrhaphy. Epiphora is controlled by reconstruction of medial canthus. Dynamic surgery like neurovascular muscle graft can also be used **(Fig. 17-23)**.

Fig. 17-22: Suction drain is placed after parotidectomy.

Fig. 17-23: Facial nerve palsy after parotidectomy.

The House–Brackmann Score

It is a score to grade the degree of nerve damage in facial nerve palsy. The measurement is done by measuring the upward movement of the middle portion of the top of the eyebrow, and the outward movement of the angle of the mouth. Each reference point scores 1 point for each 0.25 cm movement, up to a maximum of 1 cm. The scores are then added together, to give a number out of 8. It is a measure of the range of intentional movement of the patient's facial muscles. It is based largely on the observations of the physician as a subjective scale. So there may be discrepancies between assessments by different clinicians. But overall reliability is good and is the most commonly used scale. Electroneuronography is the other method used **(Fig. 17-24)**.

Grade	*Description*	*Measurement*	*Function %*	*Estimated function %*
I	Normal	8/8	100	100
II	Slight	7/8	76–99	80
III	Moderate	5/8–6/8	51–75	60
IV	Moderately severe	3/8–4/8	26–50	40
V	Severe	1/8–2/8	1–25	20
VI	Total	0/8	0	0

Surgeries for facial nerve palsy

- Static
  - Suspension surgeries using temporal fascia
  - Correction of medial canthus
  - Lateral tarsorrhaphy to prevent exposure keratitis
  - Upper lid gold weights to protect cornea.
- Dynamic
  - Muscle transfer-temporal to masseter
  - Free muscle graft like gracilis muscle neurovascular transfer
  - Cross facial nerve transplant from opposite facial nerve to injured facial nerve using sural nerve
  - Nerve grafts.

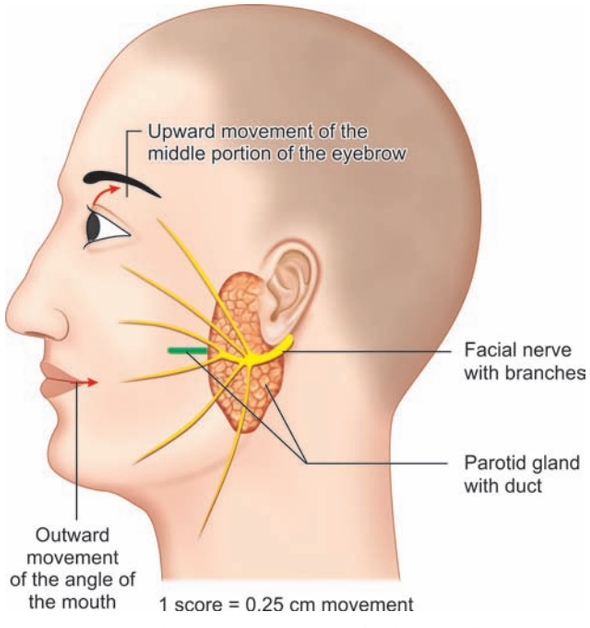


Fig. 17-24: Diagram showing how to look for House–Brackmann score.

Local Accumulation of Saliva under the Wound and Salivary Fistula Formation

It can occur in superficial parotidectomy as deep lobe is retained. This often subsides on itself. Aspiration of collected saliva and compression dressing is usually sufficient. Atropine is useful. Avoidance of spicy and acidic food; injection atropine 0.3 mg 30 minutes prior to food intake is helpful. Repair or reinsertion of duct into the oral mucosa can be done. *Newman–Seabrock's operation*- A probe is passed into the parotid duct through the opening in the mouth. Another probe is passed through the fistula. Duct and fistula are dissected over the probe. After removal of the fistula track severed duct ends are identified; and ends are trimmed. Probes are removed. A tantalum wire is passed into the duct across the severed ends and duct is sutured over it using 4 zero vicryl. Tantalum stent is removed after 3 weeks. If still persists, auriculotemporal nerve which supplies secretomotor component of parotid is cut. If there is stenosis at the orifice of the Stenson's duct, papillotomy at the orifice may help. Total conservative parotidectomy is done in failed cases.

Loss of Sensation of Ear Lobule

It is due to cutting of the great auricular nerve. Numbness of ear lobule causes difficulty in wearing ear ring. It slowly subsides and ear lobule gains its sensation in 1½ to 2 years. It can be prevented by preserving greater auricular nerve or its posterior branch.

Flap Necrosis

It is not uncommon. It usually heals on its own.

Frey's Syndrome

It is also called as *auriculotemporal syndrome or gustatory sweating* (*Lucie Frey – Polish surgeon 1032)*. It is probably due to injury to auriculotemporal nerve wherein postganglionic parasympathetic fibres from the otic ganglion become united to sympathetic nerves from the superior cervical ganglion creating pseudosynapsis. Auriculotemporal nerve has got two branches. Auricular branch supplies external acoustic meatus, tympanic membrane surface, skin of auricle above external acoustic meatus. Temporal branch supplies hairy skin of the temple. Sweating and hyperaesthesia occurs in this area of skin. Whenever salivation is stimulated or during mastication, flushing, sweating, pain and hyperaesthesia occur in this area of skin. Involved skin is painted with iodine and dried. Dry starch applied over this area will turn blue in Frey's syndrome due to more sweat (*Minor's Starch iodine test*). It is usually treated with conservative treatment with reassurance, drugs like antiperspirants like aluminium chloride, injection of botulinum toxin to skin, topical scopolamine. 10% of such patients later need surgical intervention. Tympanic branch of glossopharyngeal nerve below the round window of middle ear is cut – *intratympanic parasympathetic neurectomy (Jacobsen)*. Condition can be prevented by raising skin flap deep to platysma or deep to parotid fascia or by placing sternocleidomastoid/posterior belly of digastric or temporal fascia or artificial membranes over parotid bed.

DRAINAGE OF PAROTID ABSCESS

Parotid abscess being within the tense parotid fascia will not show fluctuation and fluctuations should not be awaited. Brawny induration with tenderness over the parotid is diagnostic; often with trismus.

It is drained under *general anaesthesia* (intubation may be difficult if there is trismus) with a small *vertical* skin incision in front of the tragus with a *transverse* incision/*split* on the parotid fascia to allow pus to drain. Sinus forceps is used to break the loculi; pus should be sent for culture. Facial nerve should not be injured. Irrigation of the cavity with normal saline and packing is needed. Facial nerve palsy and salivary fistula are the *complications* **(Fig. 17-25)**.

SUBMANDIBULAR SALIVARY GLAND

It is J shaped salivary gland situated in the anterior part of the digastric triangle which is indented by posterior border of the mylohyoid with larger part is located superficial to it and smaller part is deep to it.

Submandibular region extends 1.5 cm above the base of the mandible and below to the greater cornu of the hyoid bone. Gland is marked outside as an oval area posterior half of the base of the mandible and posterior border of the ramus.

Superficial lobe fills the digastric triangle extending above to mylohyoid line deep to mandible. Superficial lobe is covered by superficial and deep lamina of deep fascia of neck; deep lamina is

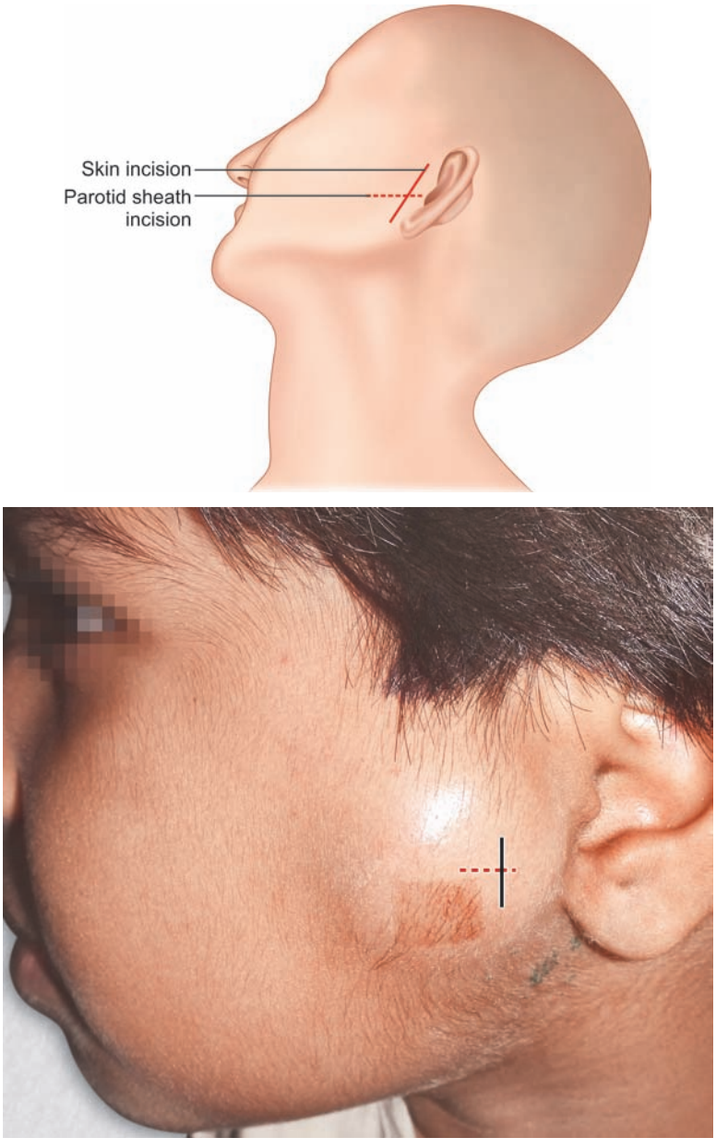


Fig. 17-25: Incision for parotid abscess. Vertical skin incision and horizontal parotid sheath incision.

attached to mylohyoid line; superficial lamina is attached to base of the mandible. Inferior surface is covered with skin, platysma, cervical branch of facial nerve, deep fascia, facial vein and submandibular lymph glands. Medial surface is related to mylohyoid muscle, vessels and nerve anteriorly; hyoglossus, styloglossus, lingual nerve, submandibular ganglion and hypoglossal nerve in the middle; styloglossus, stylohyoid ligament, 9th (glossopharyngeal) nerve and wall of pharynx.

Smaller deep lobe lies deep to mylohyoid and superficial to hyoglossus and styloglossus, continuing posteriorly with superficial part after winding round the posterior border of mylohyoid muscle. Anterior end of deep lobe is close to sublingual gland.

Wharton's submandibular salivary gland duct is 5 cm long with thin wall begins at the anterior end of deep part of the gland running over hyoglossus muscle between lingual and hypoglossal nerves. Duct is crossed by lingual nerve at the anterior border of the hyoglossus muscle; duct later opens on the floor of the mouth on the side of tongue frenum on the summit of the sublingual papilla.

Secretomotor fibres of submandibular salivary gland: Preganglionic fibres from *superior salivary nucleus* → facial nerve → chorda tympani nerve → lingual nerve → *Langley's* submandibular ganglion → post ganglionic fibres → submandibular and sublingual salivary glands **(Figs 17-26 to 17-28)**.

Suprahyoid muscles are –

Digastric muscle has got anterior belly which arises from the digastric fossa of the mandible running downwards and backwards towards intermediated tendon on the fibrous pulley of the hyoid bone; posterior belly arises from mastoid notch of temporal bone runs forward and downwards towards intermediate tendon. Anterior belly is supplied by nerve to mylohyoid; posterior belly is supplied by facial nerve.

Stylohyoid muscle arises from posterior surface of the styloid process to insert into the greater cornu of hyoid bone at its junction to the body. Its tendon is perforated by the tendon of the posterior belly of digastric muscle. It is supplied by facial nerve.

Mylohyoid is triangular muscle arising from mylohyoid line of mandible runs medially downwards to get inserted to body of hyoid bone and median raphe in the midline connecting to opposite mylohyoid muscle forming floor of the moth. It is supplied by nerve to mylohyoid.

Geniohyoid muscle arises from genial tubercles/inferior mental spine runs backwards and downwards to insert on the anterior surface of the body of the hyoid bone. It is supplied by C1 nerve through hypoglossal nerve.

Hyoglossus arises from entire length of greater cornua and lateral part of the hyoid bone running upwards and forwards to attach to side of tongue between styloglossus and inferior longitudinal muscle of the tongue. It is supplied by hypoglossal nerve.

Facial Artery

It was earlier called as *external maxillary artery* arises from external carotid artery just above the tip of greater cornu of hyoid bone (just above the origin of the lingual artery) in the carotid triangle. It shows tortuous course running beneath the digastric and stylohyoid muscles, grooving posterior surface of the groove of the submandibular salivary gland in front of hypoglossal nerve. It curves over the body of the mandible at anteroinferior angle of the masseter muscle, running across the cheek to the angle of the mouth, side of the nose, medial

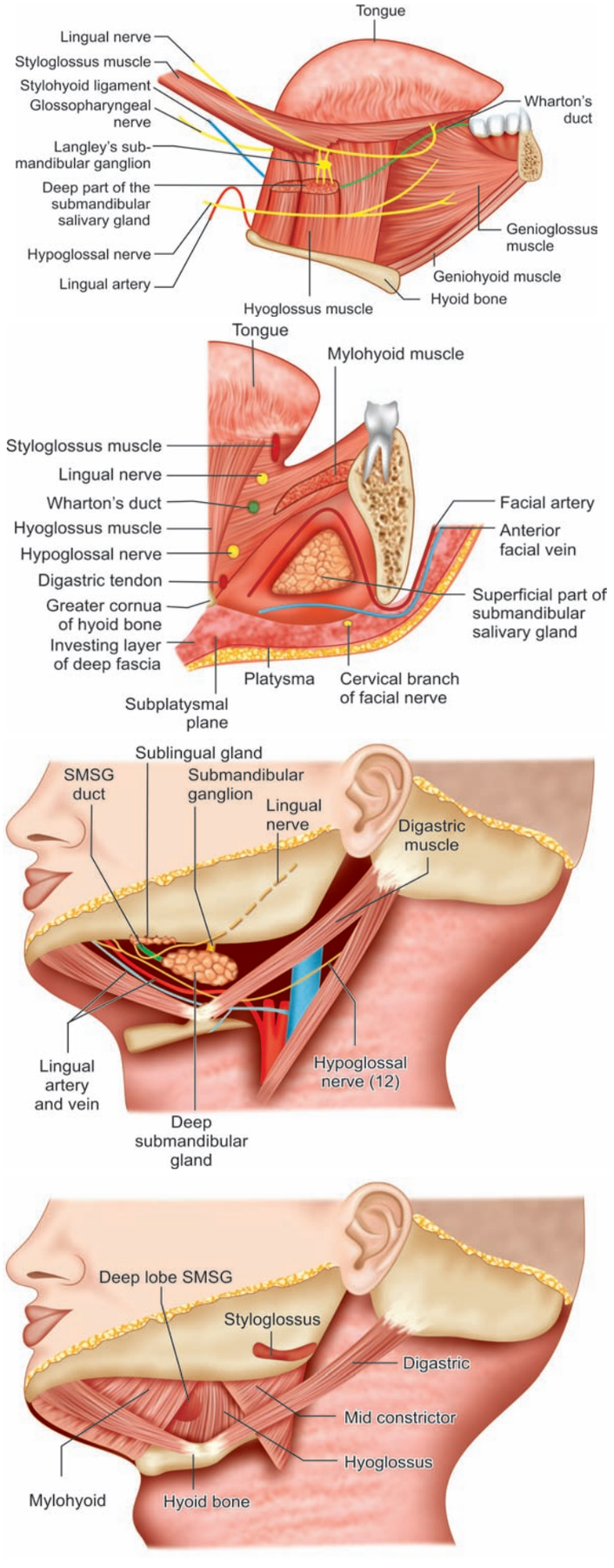


Fig. 17-26: Surgical anatomy of submandibular salivary gland.

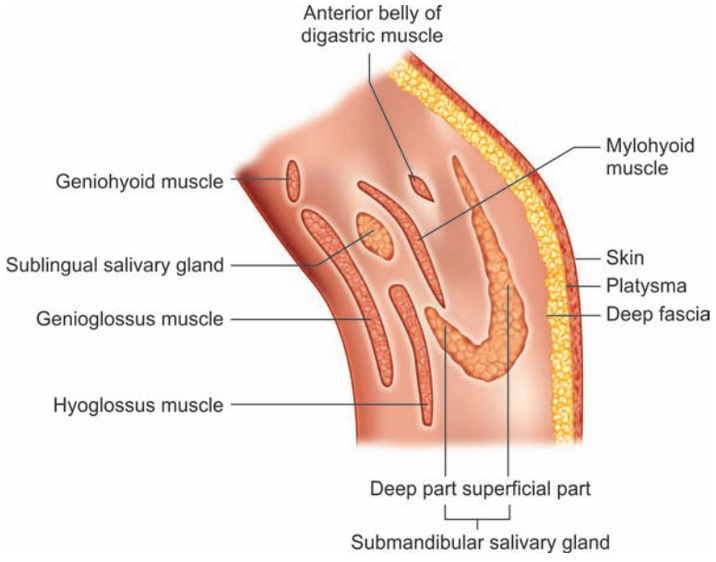


Fig. 17-27: Relations of the submandibular salivary gland.

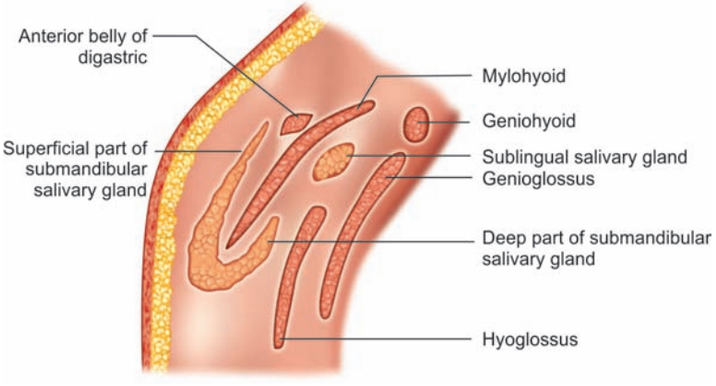


Fig. 17-28: Submandibular and sublingual salivary glands and their muscular relations.

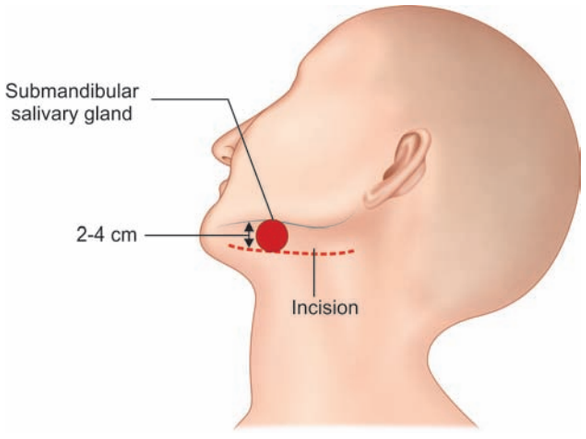
commissure of the eye to end as angular artery. Its tortuosity in neck and face allows movements of pharynx, mandible, cheek and lips. In the neck it lies on middle and superior constrictors of pharynx. In the face it is deep to platysma, risorius, and zygomaticus major but superficial to buccinator and levator labii superioris. Anterior facial vein is posterolateral to the facial artery in the face; but anterior to facial artery in neck. It communicates with dorsal nasal artery of internal carotid artery.

Branches of facial artery are – *in the neck:* ascending palatine artery, tonsillar artery, submental artery, glandular branches; *in the face*: inferior and superior labial arteries, lateral nasal branch (to nasalis) and terminal *angular* artery. Most of the facial muscles are supplied by facial artery.

One has to remember that *transverse facial artery* is a branch of *superficial temporal artery* (not from facial artery) while in the parotid gland. It runs horizontally in the parotid gland substance, between parotid duct and lower border of zygomatic arch resting on the masseter to supply parotid gland and duct and anastomose with facial, masseteric, buccinator and infraorbital arteries.

Excision of the Submandibular Salivary Gland

It is done under *general* anaesthesia. Neck should be *extended* with chin towards opposite side. *Incision* is made 2-4 cm below and parallel to margin of the mandible of 6-8 cm in length **(Fig. 17-29)**.



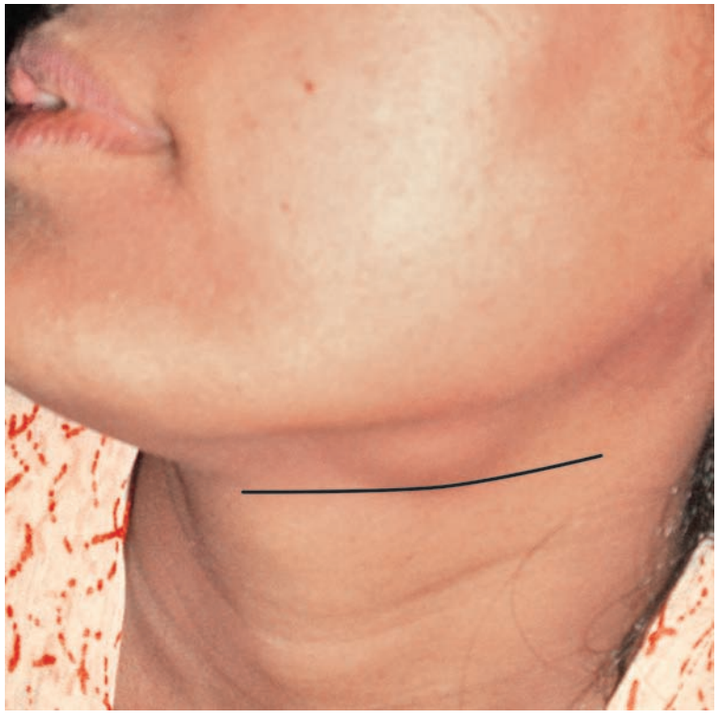


Fig. 17-29: Incision for submandibular salivary gland excision.

Marginal mandibular nerve is in subplatysmal plane in neck; incision should be deepened *across* deep fascia *without* raising subplatysmal plane to avoid injury to this nerve. *Anterior facial vein* (*facial vein anterior tributary of common facial vein*) crossing the superficial part of the gland is ligated using silk or vicryl. Superficial lobe of the gland is exposed fully in *digastric triangle* between two bellies of digastric and stylohyoid muscles below and margin of the mandible above with gland overlapping over mylohyoid muscle medially. Deep fascia of neck covering the gland is visible. Common facial vein with its anterior (facial vein) and posterior (anterior division of retromandibular vein) tributaries are visible deep to deep fascia in close relation to sternocleidomastoid muscle. Few lymph nodes may be present outer to deep fascia also. Dissection begins at the lower end of the gland by incising the fascia just above the digastric muscle. Superficial lobe of the gland is mobilised upwards. *Facial artery* lies in the groove on the deeper aspect of the gland, often either embedding in the gland or runs around the gland with a variable course and so artery has to be ligated twice above anteriorly and below posteriorly. Posterior part of the artery is ligated first using silk or vicryl ligatures. While reflecting the gland upwards from posterior surface hyoglossus

with *hypoglossal nerve* is seen and nerve is safeguarded. Hypoglossal nerve at lower part very close to the digastric tendon which is accompanied with lingual vein (*lingual vein* should be ligated) and *lingual nerve* at upper part is identified and safeguarded. Mylohyoid muscle is retracted so as to remove the deep portion of the gland which is in front of the hyoglossus and mylohyoid. Submandibular ganglion is often seen just above the gland which can be sacrificed. Wharton's duct identification and ligation is done. Dissection is done using fine scissor and monopolar cautery. Closer to nerves it is better to use bipolar cautery instead of monopolar especially whenever there is lot of adhesions due to chronic inflammation. *Chronic inflammation* with fibrosis makes dissection difficult risking the injury of hypoglossal and lingual nerves. *Structures in view* after elevation of the submandibular salivary gland are – lingual nerve, chorda tympani, submandibular ganglion and Wharton's duct above; hypoglossal nerve, digastric and stylohyoid muscles below **(Fig. 17-30)**.

Complications of Submandibular Salivary Gland Excision

Complications of submandibular salivary gland excision include— Haemorrhage; infection; injury to marginal mandibular nerve (drooping of saliva with deviation of the angle of the mouth), lingual nerve and hypoglossal nerve (deviation of tongue towards same side); injury to mylohyoid nerve causing anaesthesia over the submental skin.

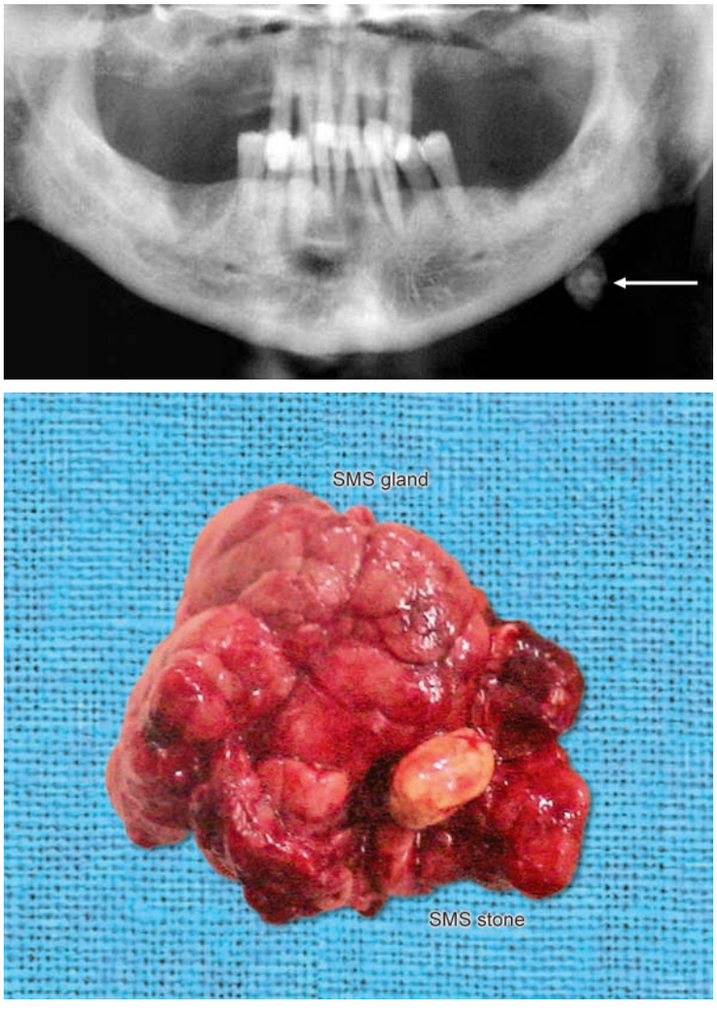


Fig. 17-30: Submandibular salivary gland stone on X-ray and gross specimen after excision. Here excision of the gland through external approach is the treatment.

Radical Excision of Submandibular Salivary Gland

Radical excision is done in malignant tumours of the submandibular salivary gland. Here gland with soft tissues aound is removed. However nerves are sacrificed only if they are infiltrated. It is difficult to retain marginal mandibular nerve in these patients as oncological clearance is priority. Radical neck lymph node dissection is also usually added along with that. Incision is same but much lengthier; it is often extended below posteriorly on the anterior margin of the trapezius or in the centre of the incision if neck dissection is additional added procedure.

Extraction of Stone from the Submandibular Salivary Duct (Wharton's)

Stone in the Wharton's duct is removed per orally under local anaesthesia. Intraoral X-ray or orthopantomogram is done prior to that. Stay suture using 4 zero vicryl is placed on the duct proximal to the stone. A fine dilator or probe is inserted into the duct opening. Longitudinal incision is placed on the duct over the stone. Stone is extracted using fine haemostat. Saline wash is used to clean the duct and clear any debris. Duct is not sutured instead left open into the oral cavity. Patient is sent with antibiotic coverage **(Figs 17-31 and 17-32)**.

MINOR SALIVARY GLANDS

There are around 450 minor salivary glands which are distributed in lips, cheeks, palate and floor of the mouth. Glands also may be present in oropharynx, larynx, trachea and paranasal sinuses. They contribute to 10% of total salivary volume. *Sublingual salivary glands* are minor salivary glands (almond shaped, weighs 4 gram) one on each side; located in the anterior aspect of the floor of the mouth in relation to mucosa, mylohyoid muscle, body of the mandible near mental symphysis, lateral to genioglossus muscle. Gland drains directly into mucosa through around small ducts or through a duct which drains into submandibular duct. This duct is called as *Bartholin duct.* Mikulicz's disease is common in sublingual salivary gland. Minor salivary glands are *not present* in gingivae and anterior portion of the hard palate.

Incision biopsy of minor salivary gland tumour is done under general anaesthesia if it is posterior. Wide excision of minor salivary gland tumour is done under general anaesthesia with nasal intubation. Wide mouth gag is placed to oral cavity for retraction of jaws. Lesion is excised with 1 cm clearance up to the mucoperiosteum when lesion is in the palate. Raw area is allowed to granulate and heal. If palate is involved by disease, palate is excised. Later proper reconstruction is done with the help of reconstructive surgeon **(Fig. 17-33)**.

ECTOPIC SALIVARY GLAND

Ectopic salivary gland also called as aberrant salivary gland/migrant salivary gland is nothing but ectopic lobe of the juxtaposed salivary gland. It is commonly seen in relation to submandibular salivary gland. Commonest ectopic salivary tissue is *Stafne bone cyst*. It is

Fig. 17-31: Submandibular salivary duct (Wharton's) stone on X-ray and on clinical examination.

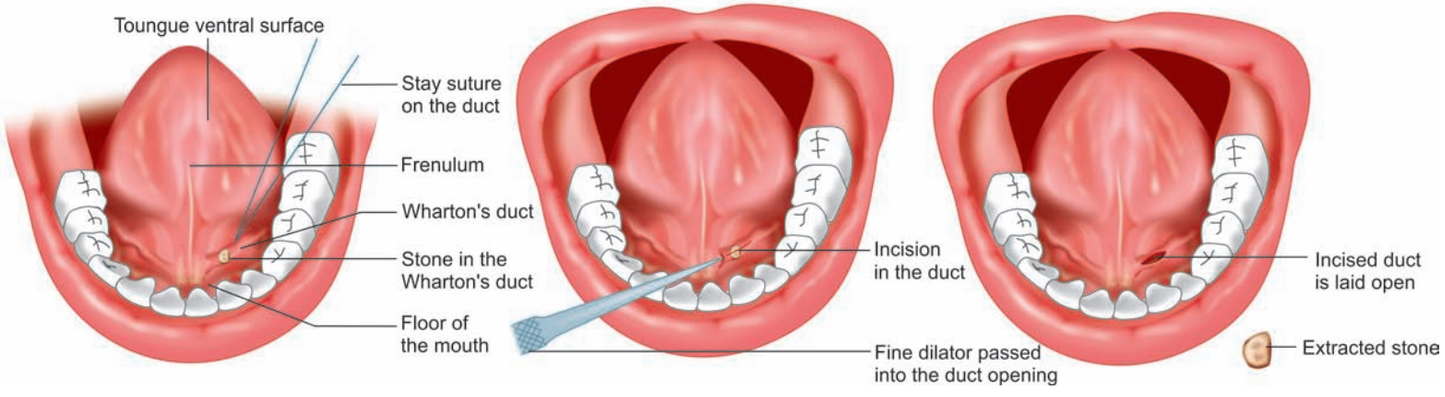


Fig. 17-32: Technique of extraction of submandibular salivary duct (Wharton's) stone extraction.

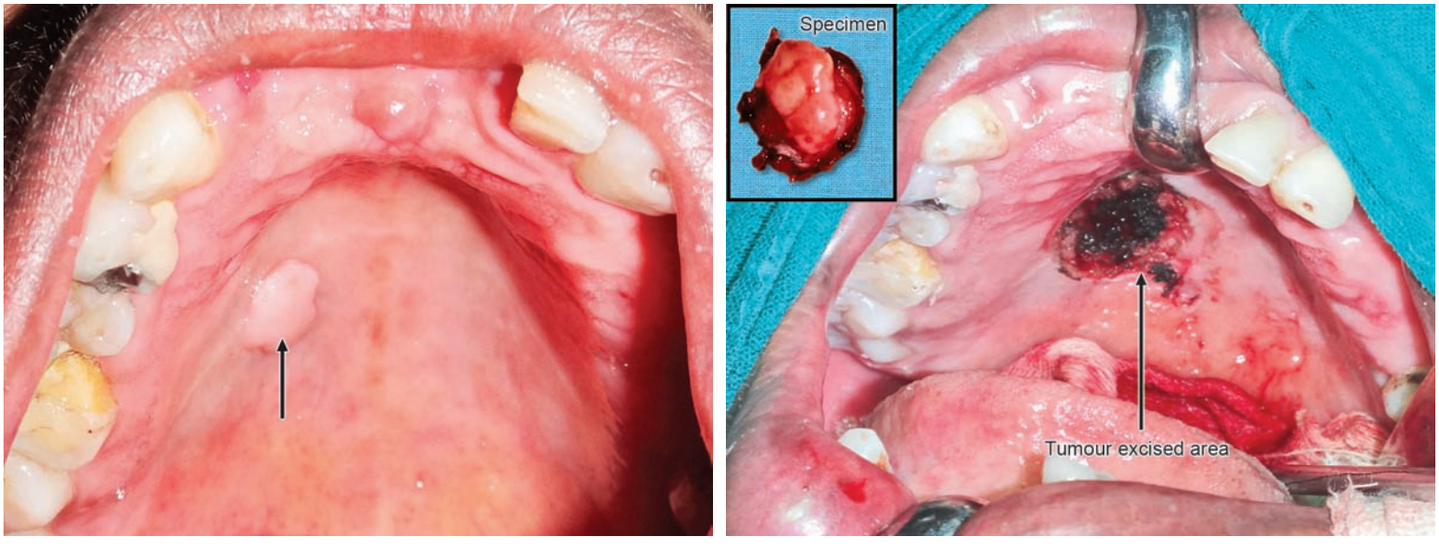


Fig. 17-33: Minor salivary gland tumour. It needs incision biopsy. It is excised as – wide excision under general anaesthesia. Raw area usually granulates and heals by epithelialisation. Larger defect needs reconstruction. Deeper infiltrating tumours need maxillectomy.

invagination of the juxtaposed submandibular salivary gland into the mandible bone on its lingual aspect. X-ray shows radiolucent area due to the cyst below the angle of the mandible, lower to inferior dental vessels and nerve. Jaws, eyelids, middle ear, paranasal sinus, nose, rarely skin of face and neck are other sites wherein ectopic salivary tissue can be demonstrated.

Chapter

18

Basic Principles in Laparotomy and Laparoscopy

GENERAL PRINCIPLES IN LAPAROTOMY

Laparotomy is opening the abdomen for surgical intervention. Laparotomy can be –

1. *Elective laparotomy*

Elective laparotomy wherein proper preoperative diagnosis has been established with various imaging and biochemical analysis. Even though it is done with proper preoperative diagnosis, being a magic box, in spite of all newer diagnostic aids, finding and diagnosis on opening may be entirely different from what was thought during evaluation. At that stage surgeon should be ready to alter the treatment strategy depending on the need.

2. *Emergency laparotomy*

It is done in trauma and acute abdomen like peritonitis. Even here basic investigations like USG/CT abdomen and haematological assessment are done to proceed with laparotomy at the earliest. Midline vertical incision centered on the umbilicus with curve at umbilicus towards left side is done. This incision is called as *incision of indecision/registrar's incision*. It can be extended above or below easily depending on the need. It also can be extended horizontally if needed **(Figs 18-1 and 18-2)**.

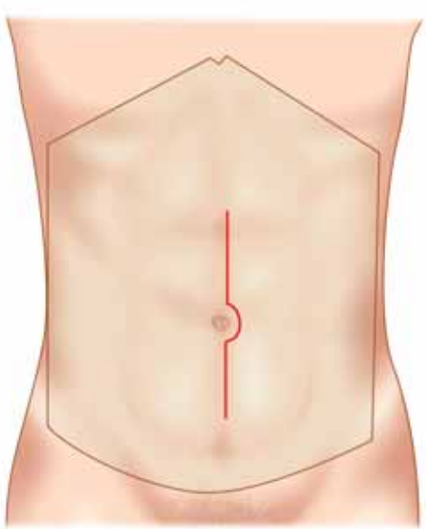


Fig. 18-1: Incision of indecision/registrar's incision.

Proper Bowel Preparation

Proper bowel preparation is essential depending on the type of surgery and condition to which surgery is done. In gastrectomy, pancreatic and biliary surgeries stomach wash, correction of electrolytes is needed; in colorectal surgeries bowel preparation using polyethylene glycol or sodium phosphate is needed. For simple perineal surgeries enema is sufficient. Hydration, bowel antiseptics, keeping ready necessary amount of blood for surgery, antibiotics perioperatively is needed.

Proper Planning

Proper planning should be done in all laparotomy cases. Patient should take proper scrub bath on the morning of the surgery. Skin preparation even though is done on previous night or early morning of the day of surgery, evidence suggests that it should be done on table.

Anaesthesia: General anaesthesia is required. Epidural supplement may be used. Spinal or epidural anaesthesia is sufficient for lower abdominal surgeries.

Position of the Patient

Position of the patient in laparotomy is very important. It may be – *supine*; supine with *one side tilt*; *lateral position* (for kidney/adrenal); *lithotomy position* (for APR/LAR/AR/perineal surgeries/cystoscopic procedures, etc); position for *thoracoabdominal* approach (in Ivor Lewis operation/diaphragmatic surgery/liver surgeries, etc). Head down position is needed in colorectal surgeries to keep small bowel away from surgical dissection field. For upper abdominal surgeries like cholecystectomy head up position is needed often with right up tilt. Strapping of the pelvis and chest wall to the table is needed in patients who need steep head down position.

Other Needs and Principles

Nasogastric tube, urinary catheterisation, central venous line and often arterial line (radial) is needed in major procedures. Often two or three venous lines are needed in major surgery and trauma patients. *Stockings* to both legs from foot to proximal thigh are essential to reduce the incidence of DVT.

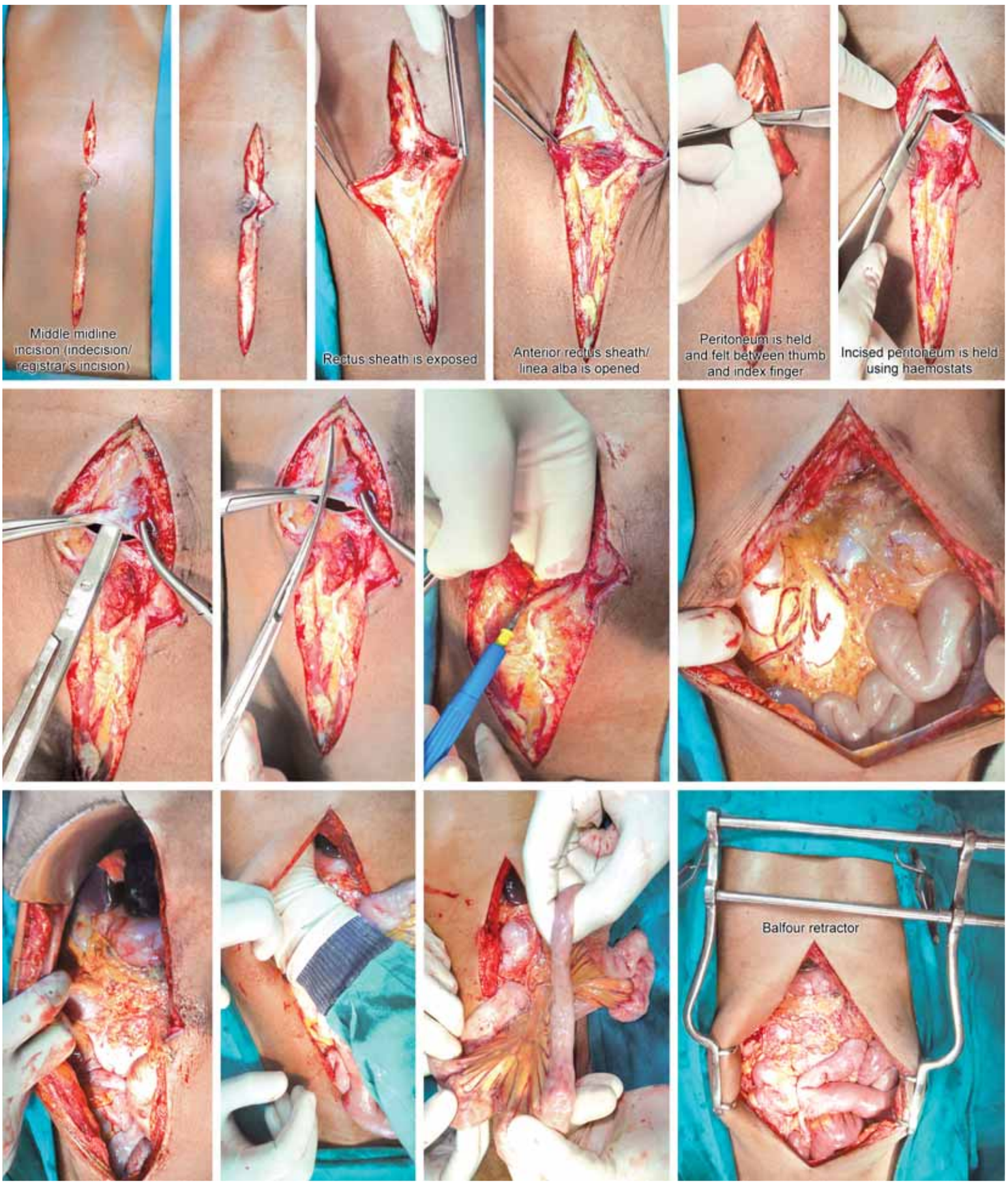

Middle midline incision (indecision/ registrar's incision)
Rectus sheath is exposed
Anterior rectus sheath/ linea alba is opened
Peritoneum is held and felt between thumb and index finger
Incised peritoneum is held using haemostats
Balfour retractor

Fig. 18-2: Emergency laparotomy is done using middle-midline incision which can be extended above or below depending on need.

Right selection of the procedure; right way executing it with right principles at right time is important. Selection; execution; timing; implementing; skill are the essential features of successive surgery with best outcome.

Selection of incision; adequacy of incision; good retraction; exposure of the surgical field; proper dissection; no touch or minimum touch technique; haemostasis; on table decision in relation to surgical principles – are the basic need.

Anticipation of problems; perfection in surgical anatomy; tissue touch are important. Live anatomy differs from cadaveric or clinical anatomy (Live anatomy bleeds and gets injured; cadaveric anatomy does not bleed).

In present era speedy surgery is not important; perfect proper surgery is more crucial. But then undue slowness should not be there, as it causes unnecessary increase in the anaesthesia and field exposure time. Accuracy is more important than speed in surgery.

Proper light; proper position; adequate height of the table; good assistants; avoiding repetitive movements; clean bloodless surgical field; knowing the next step – are needed.

Holding the instrument - Fingertip pressure (finger grip) is better to hold instruments than vise grip

Incision is made using scalpel belly while keeping two fingers of the other hand apart

Depth of the incision is assessed by feel and by vision.

During dissection traction by surgeon's other hand and counter traction by assistant's hand helps rapid separation/creation of the tissue planes.

Dissection can be done using scalpel, scissor, and cautery. It is done using cutting cautery. But cutting cautery may not be haemostatic. Haemostasis is achieved using coagulation cautery. Dissection using coagulation cautery will be haemostatic but causes boiling of fat more tissue trauma leading into wound infection. Over coagulation of tissues during cautery dissection ideally should be avoided.

Tissues are held using forceps by gentle maneuver. Skin and tough structures are held using toothed forceps; soft, smooth, delicate structures should be held using non-toothed forceps.

Needle holder should be held between thumb and ring fingers to achieve rotation movement using wrist (not pushing movement). Index and middle fingers are used to steady the handle. Needle is laced at the junction of proximal 2/3rd and distal 1/3rd of the distal jaws **(Figs 18-3 and 18-4)**.

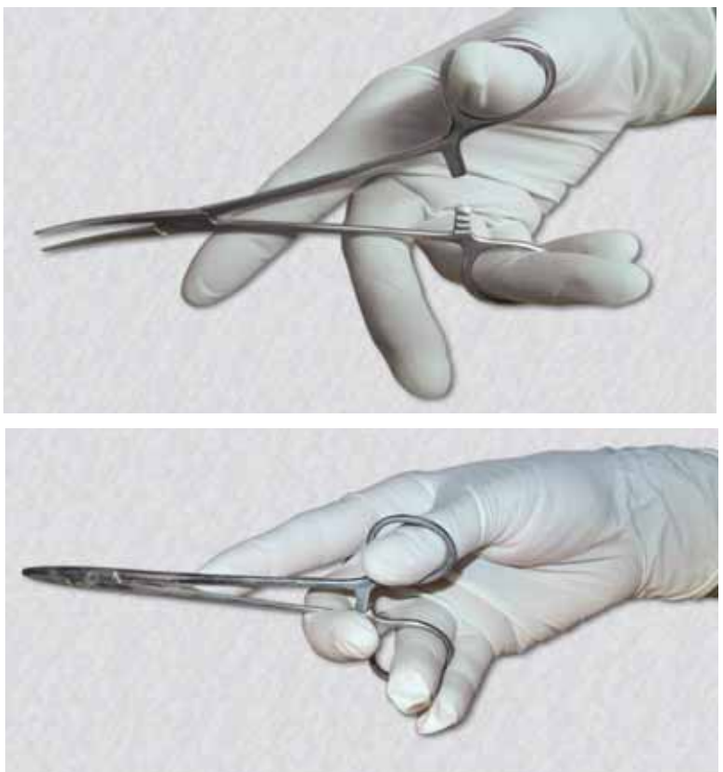


Fig. 18-3: Finger grip holding is better to hold the instrument than vise grip.

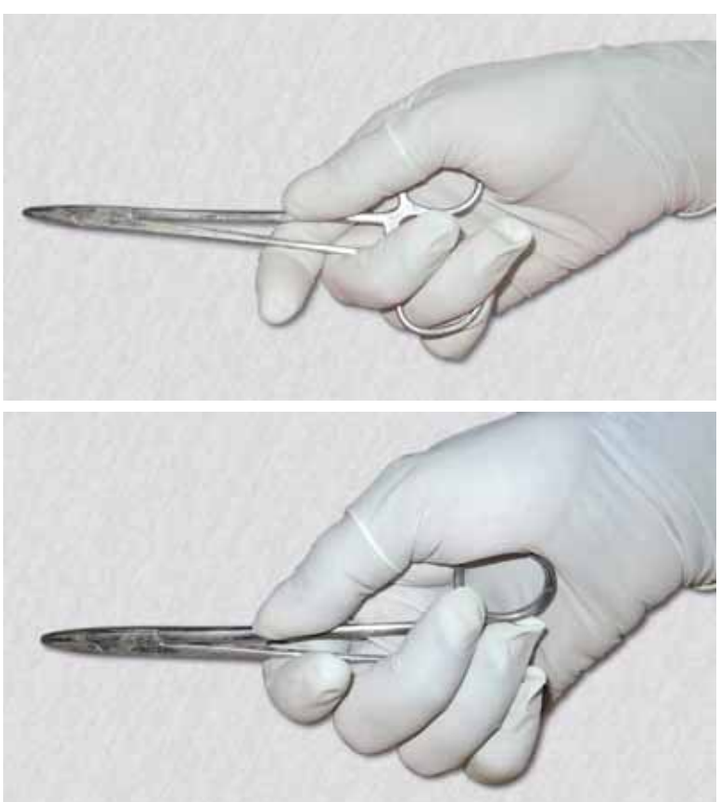


Fig. 18-4: Vise grip to hold the instrument. It is used when extra power is needed while using the instrument.

Cleaning and Draping

Cleaning is done using povidone iodine. Solution is collected in a sterile small bowl, sterile folded/rolled gauze or sponge with Rampley's sponge holding forceps is used to clean the abdomen. In perineal surgery cleaning with proper scrubbing should be done after lithotomy position by OT technician prior to formal cleaning by surgeon. Draping is done using sterile green towel. Often sterile plastic sheet (ioban sheet/plastic surgical adhesive drape/plastic incisive drape) is used on the abdomen over the green cloth drape and incision is made through it. Many studies show that plastic adhesive drape reduces the bacterial contamination of the wound and deeper part compared to cloth drape. There is controversy about pricking the towel clip into the skin of that particular corner point or placing interrupted skin sutures over the drape margins to fix it. It may break the barrier into the deeper plane away from the surgical site incision and it is not much confirmed that such fixation will reduce/prevent the bacterial contamination across **(Fig. 18-5)**.

Fig. 18-5: Draping the surgical site using sterile towels.

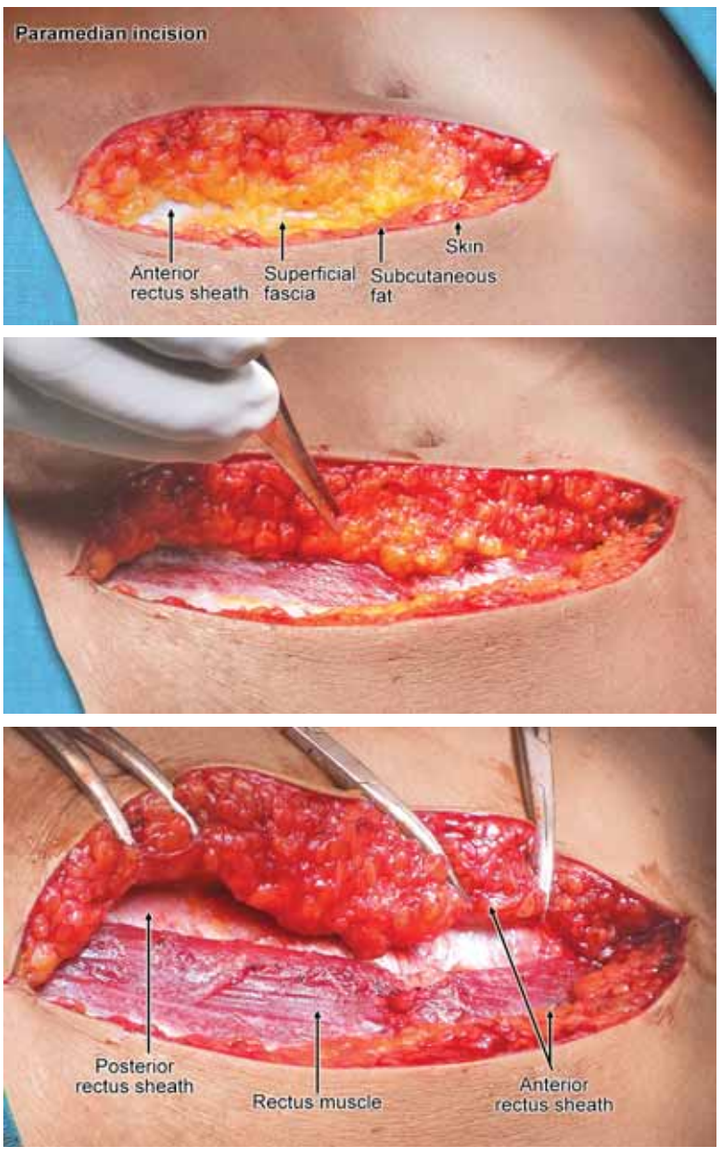


Fig. 18-6: Layers of the abdominal wall – as seen in paramedian incision.

Incision

Type of incision; possible need for extension of incision, direction of extension – all to be thought of prior to starting the incision.

Principles in abdominal surgery

- Adequate incision - Incision should be long enough for a good exposure
- Splitting the muscle is better than cutting, except rectus muscle
- Avoid cutting nerves and vessels in the abdominal wall
- Adequate retraction - Retract muscle, abdominal organs towards the neurovascular supply
- Adequate exposure of surgical site and surrounding field
- Adequate meticulous dissection
- Adequate haemostasis
- Adequate proper closure; if required with a drain (tube). Insert a drainage tube through a separate incision.
- Transverse incisions are better than vertical incisions.

Requirements

- Accessibility
- Extensibility
- Security.

Surgical Anatomy of Abdominal Wall

Anterior Abdominal Wall

The anterior abdominal wall is a musculofascial dynamic structure which maintains intra-abdominal pressure for various physiological functions. It has got three paired flat muscles, two recti abdominis muscles and linea alba in midline. These are anteriorly related to skin, subcutaneous tissue and superficial fascia; posteriorly related to transversalis fascia and peritoneum. *External oblique fascia* (external layer of the fascia of external oblique muscle is also called as *innominate fascia of Gallaudet*) is thin fascial covering of external oblique muscle and fascia which forms intercrural fibres of the superficial inguinal ring; and it extends below into the scrotum as external spermatic fascia. *Anterior abdominal wall* has got anterolateral part which consists of external and internal oblique and transversus abdominis muscles; and a midline part containing rectus abdominis and pyramidalis muscles **(Fig. 18-6)**.

External Oblique Muscle

It arises from middle of body of lower eight ribs running below/downwards, front/forwards and medially inserting into xiphoid process, linea alba, pubic symphysis, pubic crest, pectineal line of pubis and anterior 2/3rd of outer lip of the iliac crest. It is supplied by lower 6 thoracic nerves. Lower free border of the external oblique aponeurosis forms inguinal ligament. Triangular opening in its aponeurosis above the pubic crest is called as superficial inguinal ring **(Fig. 18-7)**.

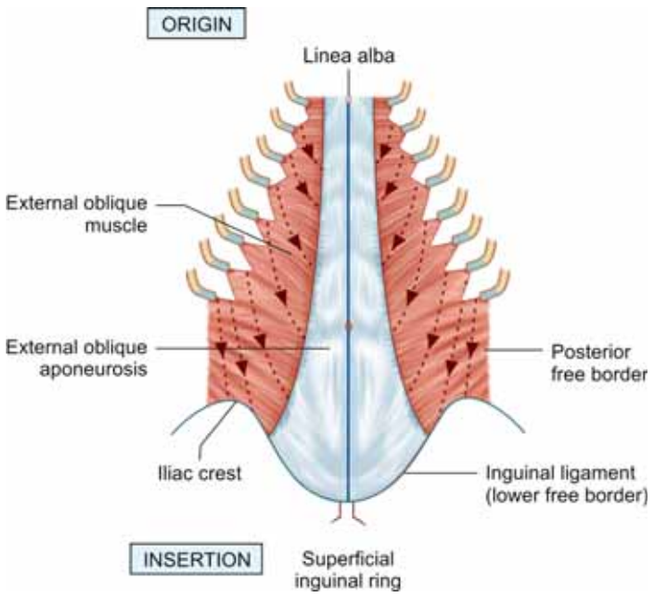


Fig. 18-7: External oblique muscle.

Internal Oblique Muscle

It arises from lateral 2/3rd of inguinal ligament, anterior 2/3rd of intermediate part of iliac crest, thoracolumbar fascia; runs upwards, forwards and medially to insert into lower 4 ribs and cartilages, xiphoid process, pubic crest, pectineal line of pubis. It is supplied by lower 6 thoracic nerves, 1st lumbar nerve. Aponeurosis below the level of umbilicus remains as a single layer forming the anterior rectus sheath and lineal alba. Above aponeurosis splits into anterior lamina which passes medially in front of rectus abdominis and posterior lamina which passes behind rectus abdominis which ends below midway between umbilicus and pubic symphysis as linea *semicircularis of Douglas* (arcuate line). *Semilunar line of Spieghel* lies in lateral border of the rectus sheath from pubic tubercle to the tip of the costal cartilage of 9th rib **(Fig. 18-8)**.

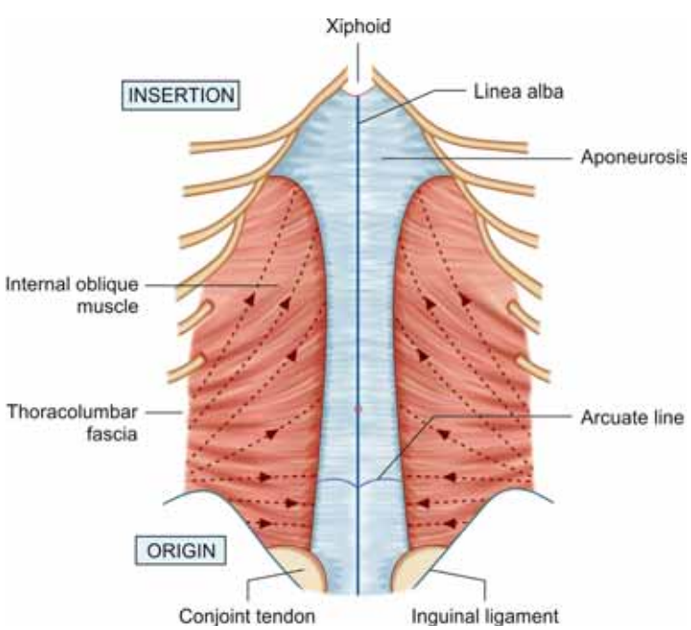


Fig. 18-8: Internal oblique muscle.

Transverse Abdominis Muscle

It originates from lateral 1/3rd of inguinal ligament, anterior 2/3rd of inner lip of iliac crest, thoracolumbar fascia, lower 6 cartilages with fibres running horizontally forwards inserting into an aponeurosis extending from xiphoid process, linea alba, pubic crest, pectineal line of pubis. Lowest fibres fuse with lowest fibres of internal oblique to form conjoined/conjoint tendon. It is supplied by lower 6 thoracic and first lumbar nerves. Neurovascular plane of abdomen lies between internal oblique and transverse abdominis muscles **(Fig. 18-9)**.

Rectus Abdominis Muscle

It arises from lateral part of pubic crest (lateral head) and anterior pubic ligament (medial head) runs vertically upwards to insert into xiphoid process and 7th, 6th and 5th costal cartilages. It is supplied by lower 6 thoracic nerves. There are three tendinous intersections one at xiphoid, one at umbilicus level and another one between two which are adherent to anterior half of muscle and anterior wall of rectus sheath. They are due to embryologic segmental origin of muscle which adds to the power of muscle. Tendinous intersections *do not extend* into the posterior rectus sheath **(Fig. 18-10)**.

Rectus sheath is an aponeurotic sheath which covers the rectus abdominis muscle in front and behind. Rectus sheath contains rectus abdominis muscle and pyramidalis in its lower part. Pyramidalis lies in front of the lower part of the rectus muscle. Superior epigastric artery enters the sheath by passing between the costal and xiphoid origins of the diaphragm crossing upper margin of transversus abdominis muscle behind the 7th costal cartilage running behind the rectus muscle in front of the posterior rectus sheath to anastomose with the inferior epigastric artery. Inferior epigastric artery enters the sheath behind the muscle by passing across the arcuate line. Superior and inferior epigastric veins also accompany the arteries. Terminal branches of the lower 5 intercostal nerves and subcostal nerve enter the sheath after piercing the posterior rectus sheath at its lateral part running in front of the epigastric vessels to pierce the rectus muscle.

Anterior rectus sheath is complete covering rectus entirely from origin to insertion. Its upper ¾ is formed by external oblique

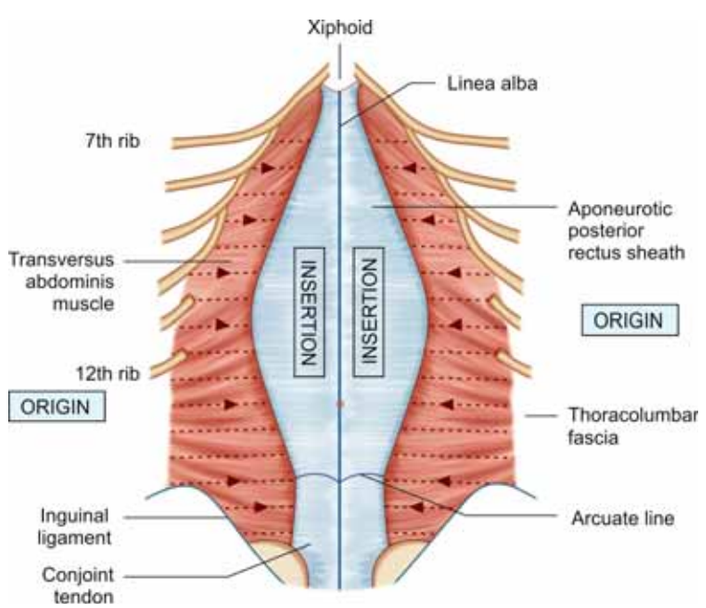


Fig. 18-9: Transverse abdominis muscle.

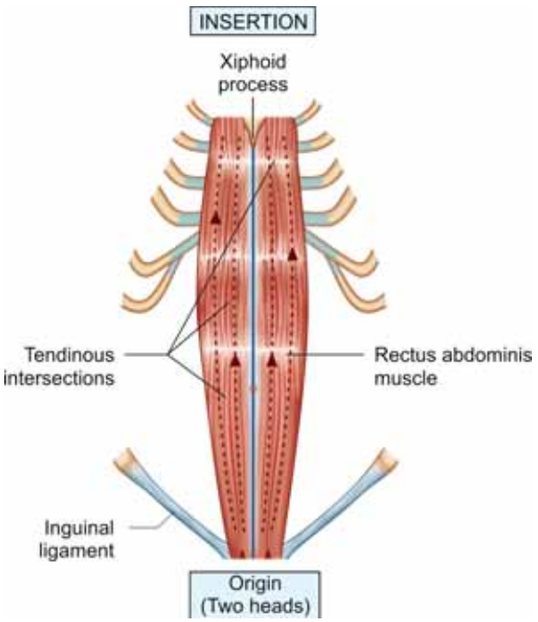


Fig. 18-10: Rectus abdominis muscle.

aponeurosis and anterior lamina of internal oblique. Its lower ¼ is formed by all three aponeurosis. In this part aponeurosis of transversus and internal oblique muscles are fused; aponeurosis of external oblique remains separate.

Posterior rectus sheath is deficient above the costal margin and below the arcuate line. Between the costal margin and arcuate line it is formed by posterior lamina of internal oblique aponeurosis and transversus abdominis aponeurosis. Midway between the umbilicus and pubic symphysis posterior rectus sheath ends as arcuate line/linea semicircularis /fold of Douglas which is concave downwards.

In upper ¾ of the abdominal wall – right and left recti are separated; both anterior and posterior rectus sheaths are present; anterior rectus sheath is formed by external oblique aponeurosis and anterior lamina of internal oblique; posterior rectus sheath is formed by posterior lamina of internal oblique aponeurosis and transversus abdominis aponeurosis; linea alba is well developed; external oblique aponeurosis and fascia is weak.

In the lower ¼ of the anterior abdominal wall - right and left recti are very close to each other; anterior rectus sheath only is present which is formed by all 3 muscular aponeurosis; posterior rectus sheath is absent; external oblique fascia is stronger; lineal alba is not well developed.

Muscles of the Posterior Abdominal Wall

They are psoas major, psoas minor, quadrates lumborum and iliacus.

Psoas major arises from body and transverse processes of all lumbar vertebrae to insert into the tip and medial part of the lesser trochanter of the femur after passing behind the inguinal ligament along with the iliacus tendon (lateral part of the lesser trochanter). It is supplied by L_2, L_3, L_4 spinal nerves.

Psoas minor is small muscle in front of the psoas major arises from bodies of T_{12} and L_1 vertebrae to insert into the pectin pubis and iliopubic eminence. It is supplied by L_1. *Iliacus* arises from upper 2/3rd of inner aspect of fossa of ilium, upper lateral part of the sacrum to insert into lateral part of the lesser trochanter along with psoas major. It is supplied by femoral nerve.

Quadratus lumborum arises from transverse process of L_5 vertebra and inner lip of iliac crest to insert into medial part of the anterior surface of 12th rib and transverse processes of upper 4 lumbar vertebrae. It is supplied by spinal nerves T_{12} to L_4.

Fascia Transversalis (Cooper's Fascia)

It is the fascia that lines the inner surface of the transversus abdominis muscle separated from the peritoneum by extraperitoneal connective tissue. In front it is adherent to linea alba above the umbilicus; behind merges with anterior layer of thoracolumbar fascia and renal fascia; above with diaphragmatic fascia; below it is attached to inner lip of iliac crest, inguinal ligament; medially it is attached to pubic tubercle, pubic crest and pectineal line which prolongs down as anterior layer of femoral sheath. It also forms internal spermatic fascia around the cord. Deep inguinal ring is U/lambda/oval shaped opening 1.25 cm above the midinguinal point (between pubic symphysis and anterior superior iliac spine) which is lateral to inferior epigastric artery, transmits spermatic cord in males and round ligament in females. In the inguinal area transversalis fascia is *bilaminar* enclosing the inferior epigastric vessels. *Space of Bogros* is extension of the retropubic *space of Retzius* which is located beneath the posterior lamina of transversalis fascia and in front of the peritoneum. Inlay preperitoneal mesh repair is done by placing mesh in this space. Thickening of the transversalis fascia at medial side of the internal ring and in front of the inferior epigastric vessels is called as *interfoveolar Hesselbach's ligament*.

Endoabdominal Fascia

Endoabdominal fascia is connective tissue that lines inner aspect of the entire abdominal musculature. Part in relation to transversus abdominis is called as fascia transversalis. It forms iliac, diaphragmatic and renal fascia.

Deep Nerves of the Abdominal Wall

Lower 5 intercostal and subcostal (Lower 6 thoracic primary rami) nerves and iliohypogastric and ilioinguinal nerves supply the anterior abdominal wall. *Lower 5 intercostal nerves* pass through the slips of origin of transversus abdominis muscles; run between transversus abdominis and internal oblique; pierce the posterior lamina of internal oblique aponeurosis to reach rectus sheath; then pass behind the rectus sheath in front of the epigastric vessels, pierce the rectus muscle to continue as anterior cutaneous nerve. Before piercing it supplies the anterior rectus sheath, transversus abdominis, internal oblique, external oblique and rectus abdominis. During its course it also gives lateral cutaneous nerve of the abdominal wall through flat abdominal muscles. *Battle's incision* which is pararectal incision will injure these nerves causing weakening of the rectus muscle and so is avoided.

Subcostal nerve, anterior primary ramus of 12th thoracic nerve after traveling behind the diaphragmatic lateral arcuate ligament, passes in front of the quadrates lumborum and then pierces the transversus abdominis to run like other intercostal nerves. It supplies pyramidalis muscle and gluteal region as lateral cutaneous branch.

Note: There are 11 intercostal nerves and one subcostal nerve.

Blood Supply of Abdominal Wall

It is divided into superficial and deep vessels.

Superficial vessels are superficial epigastric, superficial circumflex iliac and superficial external pudendal arteries – are branches of femoral artery. They travel towards umbilicus in subcutaneous plane. Superficial epigastric artery communicates with opposite superficial epigastric artery and all three communicate with deep arteries.

Deep arteries are posterior intercostal arteries (10, 11), anterior branches of 4 lumbar and subcostal arteries and deep circumflex iliac artery. Deep arteries travel between transversus abdominis and internal oblique muscles. Rectus sheath is supplied by superior and inferior epigastric arteries. *Superior epigastric artery* is one of the two terminal branches of the internal thoracic/mammary artery. It originates at 6th intercostal space enters the abdomen between costal and xiphoid origin of the diaphragm, enters the rectus sheath from above behind the 7th costal cartilage. It descends downwards communicating with inferior epigastric artery behind the rectus muscle. Branches are muscular, cutaneous, hepatic along the falciform ligament and anastomotic to opposite side artery.

Inferior epigastric artery (IEA) originates from external iliac artery just above the inguinal ligament runs upwards and medially in the extraperitoneal connective tissue between peritoneum and posterior lamina of transversalis fascia initially medial to internal ring; pierces the transversalis fascia at the lateral border of the rectus muscle; runs in front of the arcuate line supplying the rectus and ends by anastomosing with superior epigastric artery. Branches are – muscular, cremasteric, pubic, and cutaneous. *Cremasteric branch* after travelling laterally towards deep ring supplies cremaster and runs along the spermatic cord. Pubic branch runs medially along the pubic bone to communicate with pubic branch of anterior division of obturator artery. Often obturator artery may be replaced by this pubic branch of inferior epigastric artery as abnormal/aberrant obturator artery. This pubic branch crosses over femoral ring and Cooper's ligament. This may be injured during fixation of mesh in TEP repair or femoral hernia repair causing torrential bleeding from both cut ends. As medial cut end retracts deep into the obturator fat and fascia it is difficult to control bleeding. This area is often called as *circle of death*. Inferior epigastric vein is medial to IEA.

ABDOMINAL INCISIONS

Principles in Abdominal Incision

- Incision should give adequate proper *access* to the surgical site in the abdomen – well planned; with adequate exposure of adequate length. Patient should lie symmetrical the operation theatre table.
- It should be amenable for *extension* as needed. Muscle should be split as much as possible, not cut in vertical and oblique incisions.
- Incision should be chosen with plan so as to have proper accessibility, extensibility, safeguard of function, cosmetically acceptable and with possible least complications like dehiscence and incisional hernia.
- Care should be taken while opening the peritoneum. Abdominal contents should not be injured especially bowel. This is more important aspect in previous laparotomy patients. Peritoneum should be incised using fine scissor or scalpel after feeling the site of incision using fingers for any adherent bowel or omentum. One should not use cautery to incise peritoneum.
- If there is previous incision scar (re-laparotomy), care should be taken not to injure bowel while opening the peritoneum; it is better to open the peritoneum at a new site.
- Layer by layer incision should be done.
- Extension across umbilicus is done from left side of the umbilicus.
- Further cutting of the peritoneum after incising should be done under vision with two fingers underneath the peritoneum to prevent injury to bowel.
- Wound dehiscence is less in transverse incision than vertical incision.
- Drain should be kept through a separate incision; not through the main wound. If drain is passed through the main wound it will prejudice the strength of the final scar.
- Proper anaesthetic relaxation is essential before closure of the abdomen otherwise closure will be troublesome.

Exploratory Laparotomy

All opened abdomen should be explored by putting hand inside (right hand usually) – It is done through a proper method called as *laparotomy circuit*.

Outer laparotomy circuit	*Inner laparotomy circuit*
Begins at oesophagogastric junction ↓ *Anticlockwise* Stomach duodenum, liver, gallbladder ↓ Right colon, caecum, pelvis ↓ Sigmoid colon, descending colon, splenic flexure ↓ Spleen, left kidney, pancreas, aorta and transverse colon ↓ *Completion of outer circuit.*	Ligament of Treitz ↓ Oblique from left to right Small bowel – jejunum and ileum with their mesentery ↓ To reach Ileocaecal junction ↓ *Completion of inner circuit.*

Complications of Abdominal Incision

- Wound infection.
- Surgical site infection (SSI).
- *Fascial dehiscence* – (Burst abdomen): Dehiscence is due to infection, severe cough and vomiting and sudden raise in intra-abdominal pressure. Initially sudden severe pain occurs; feeling of giving way with serosanguineous discharge is common. Abdominal viscera (bowel) will be visible through the given away wound. Occasionally evisceration occurs with intestine coming out of the abdominal wound. Patient is shifted to operation theatre. Under general anaesthesia, bowel contents are placed inside the abdominal cavity. All layer through and through monofilament interrupted sutures are placed after a through wash. Previously retention (tension) sutures are practiced. Usually patient recovers well unless there is bowel injury. *L. E Hughes double near and far suture* or *modified Smead-Jones* single layer sutures are better in such situation.
- *Incisional hernia* – It is due to wound sepsis, peritoneal cavity infection, malnutrition and deficiencies, nerve injuries, weak rectus, obesity, precipitating causes like cough, straining, urinary problem and constipation.

- Injury to bowel during laparotomy.
- Fistula formation. Gastrointestinal fistula may be biliary, faecal or pancreatic. It may be end or lateral; high or low output.
- *Nerve injury* - Wound pain. Nerve injury can occur in muscle cutting incisions, lateral incisions, laparoscopic dissection. Ilioinguinal nerve may get injured after appendicectomy causing right sided direct inguinal hernia. Open inguinal hernioplasty may cause inguinodynia postoperatively. Intercostal nerves may get injured in Kocher's subcostal incision or thoracoabdominal incision. Pfannensteil incision may injure hypogastric nerve.
- Adhesion and its complications.
- *Paralytic ileus* – it is common after 12-24 hours; but depends on the type and condition for which surgery is done. Causes like electrolyte imbalance, sepsis should be ruled out. Often nasogastric aspiration and flatus tube insertion may be required.

Factors affecting the strength of the scar

- Type of surgery (acute abdomen, surgery for malignancy, major surgery)
- Obesity
- Pregnancy
- Straining
- Cough
- Ascites
- Nutrition
- Diabetes
- Immunosuppression
- Type of incision

Abdominal Incisions may be –

- Vertical or transverse. Vertical may be midline or paramedian. Horizontal incisions are better.
- Incision may be with extension or without extension.
- Incision may be upper or lower. Upper incisions are better.
- Muscle retraction or muscle splitting or muscle cutting **(Fig. 18-11)**.

Different Abdominal Incisions (Figs 18-12 to 18-14)

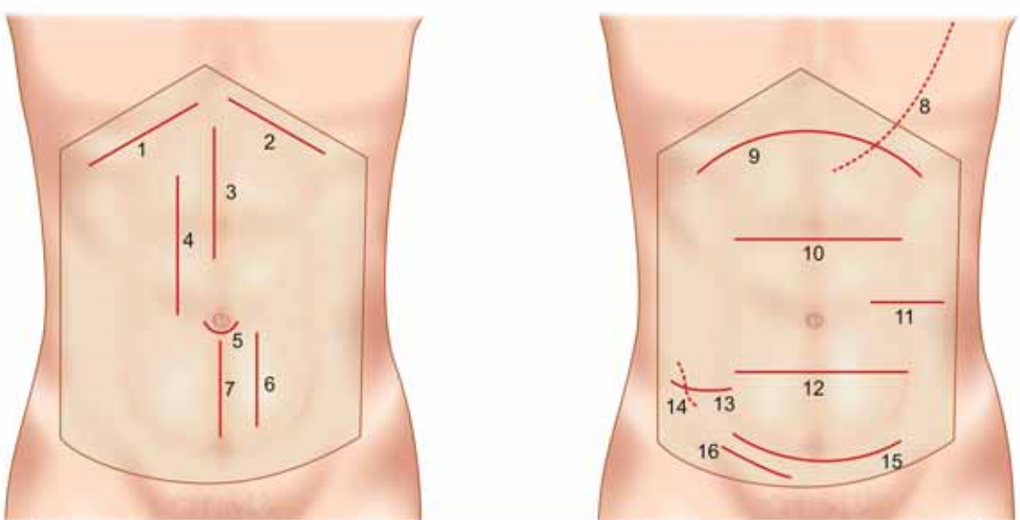
- Upper midline.
- Upper right paramedian.
- Upper left paramedian.
- Kocher's incision (right subcostal).
- Left subcostal.
- Bucket handle.
- Upper horizontal.
- Thoracoabdominal.
- Umbilical crease incision.
- Subumbilical.
- Incision for lumbar sympathectomy.
- Lower midline.
- Lower right or left paramedian.
- Incisions for appendicectomy—McBurney's, Rutherford Morison's, Lanz, laparoscopic.
- Pfannenstiel incision.
- Lower horizontal .

Classification of abdominal incisions

Vertical incision
- *Midline incision* – upper, lower or entire length from xiphoid to pubis
- *Paramedian incisions* – right, left, upper, middle, lower. Muscle retracting/muscle splitting/pararectal (Battle's)

Transverse incisions
- *Upper abdominal* transverse – one or both sides
- *Lower abdominal* transverse
  - Transverse muscle dividing lower abdominal incision
  - Maylards incision
  - Joel Cohen's incision
  - Pfannenstiel incision
  - Cherney's incision
  - Kustner's incision

Contd...



1. Right subcostal incision
2. Left subcostal incision
3. Upper midline
4. Right upper paramedian
5. Subumbilical
6. Left lower paramedian
7. Lower midline
8. Left thoracoabdominal
9. Rooftop (Chevron) incision
10. Upper horizontal
11. Left lumbar sympathectomy incision
12. Lower horizontal
13. Lanz incision
14. McBurney's incision
15. Pfannenstiel incision
16. Incision for inguinal hernia

Fig. 18-11: Different abdominal incisions.

Contd...

- Turner Warwick's incision
- Subumbilical incision

Oblique incisions

- *Kocher's* subcostal Incision
  - Classical rectus muscle cutting
  - Modified rectus muscle retracting
  - Mini lap Kocher's incision
- Chevron (Roof top modification) incision
- Mercedes Benz modification
- Appendicectomy incisions
  - *McBurney's* /Mac Arthur's Grid iron muscle splitting incision
  - *Rutherford Morrison's* muscle cutting (laterally upwards) incision
  - *Rocky Davis or Elliot's* muscle cutting (medially and downwards) incision
  - *Lanz crease* (interspinous crease) line incision
  - Oblique iliac incision (*Abbernethy's*), muscle cutting incision

Abdominothoracic incisions

Fig. 18-12: Incision for liver resection.

MIDLINE INCISION

It is commonly advocated incision. It can be upper midline/lower midline or both upper and lower lengthy midline incision. Midline incision is easier to reach across linea alba with rapid access, minimum blood loss, and also quicker and easier to close. Extension above or below will be easier and faster. In emergency surgeries and common elective surgeries midline incision is better. Midline incision gives excellent adequate exposure of the abdomen. It can be extended below, above, horizontally or obliquely or as thoracoabdominal when needed. Gastrectomy, pancreaticojejunostomy, hiatus hernia repair, pseudocyst surgery, exposure of aorta, colectomy and biliary tract surgeries can be done with midline incision **(Figs 18-15 to 18-18)**.

Upper Midline Incision

Skin is incised vertically in midline from xiphoid to umbilicus. Superficial fascia, external oblique fascia is incised. Whitish crisscross tough linea alba is visible. It is incised using monopolar cautery or 22 no. blade. Once incised in full depth linea alba separates away to visualise the extraperitoneal pad of fat and peritoneum. Extraperitoneal pad of fat is separated of the peritoneum gently. Peritoneum appears like a shiny whitish thin structure. It is carefully held using a haemostat during expiration phase. One should be sure not to hold the deeper contents. Another haemostat is applied 5-10 mm away on the peritoneum horizontally so that peritoneum fold is lifted properly. Lifted fold of peritoneum is gently moved to make any content if at all to get dislodged and fold is pinched between the thumb and fingers to confirm that no content is felt. Peritoneum is incised using blade obliquely or using scissor towards just left of the midline which is avascular. Once peritoneum is opened air enters inside to distend peritoneum and content to fall deep. Both haemostats are reapplied to cut edges of the peritoneum. Using scissor peritoneum is cut above and below under vision or by placing fingers under the peritoneum to guard the contents with forward lift of the abdominal wall. One should be careful about the adhesions in the peritoneum in the line of cut. Extension down is done by curving the incision left side of the umbilicus. Right side of umbilicus is vascular and falciform ligament is attached towards right side hence incision is made on the left side of the umbilicus. Few advocate incision vertically through the umbilical midline. Only abdominoperineal resection (APR) for carcinoma rectum incision is extended above from right side of the umbilicus as permanent colostomy is placed on the left side in left iliac fossa. Occasionally when approach to the OG junction is inadequate

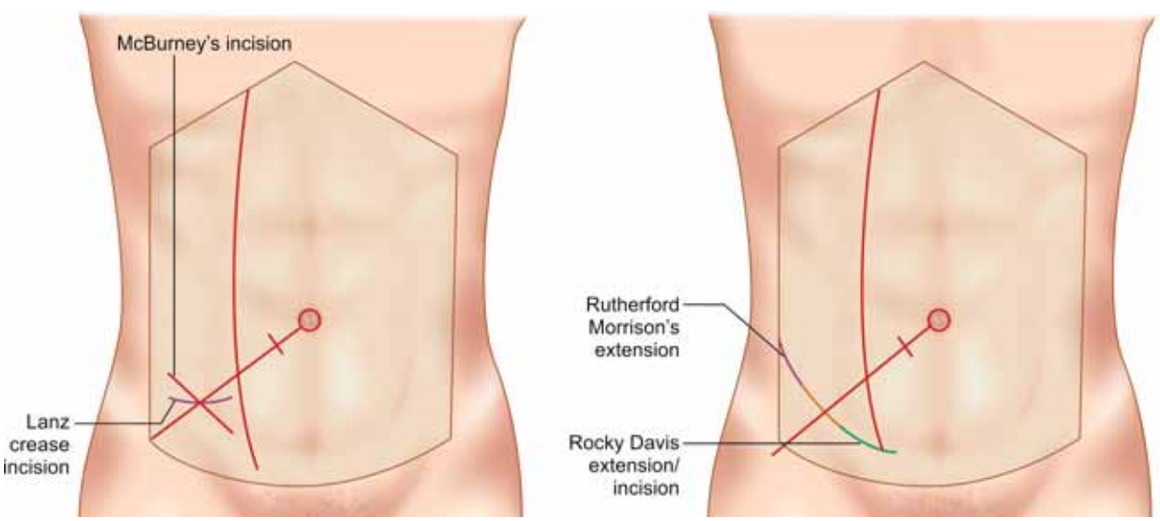


Fig. 18-13: Incisions used for open appendicectomy.

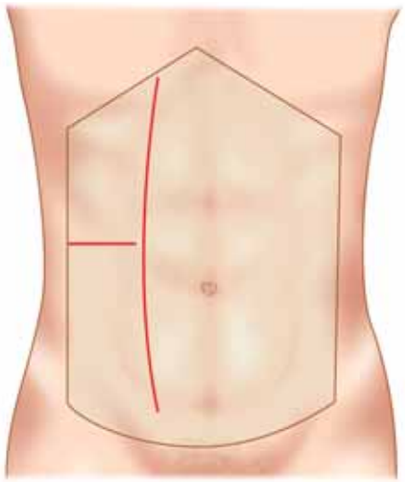


Fig. 18-14: Horizontal incision at umbilical level.

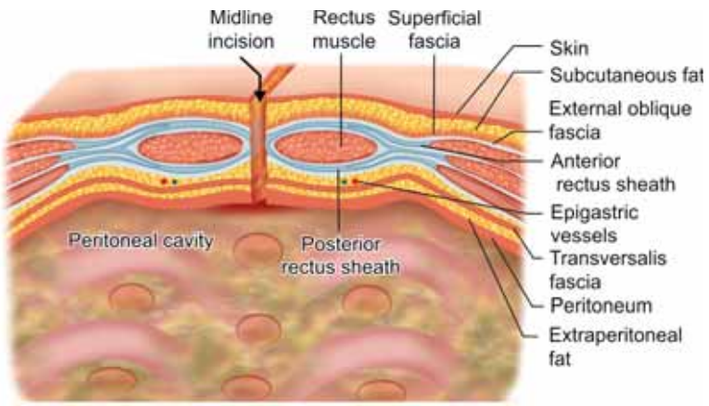


Fig. 18-15: Layers which will come across while making the midline incision.

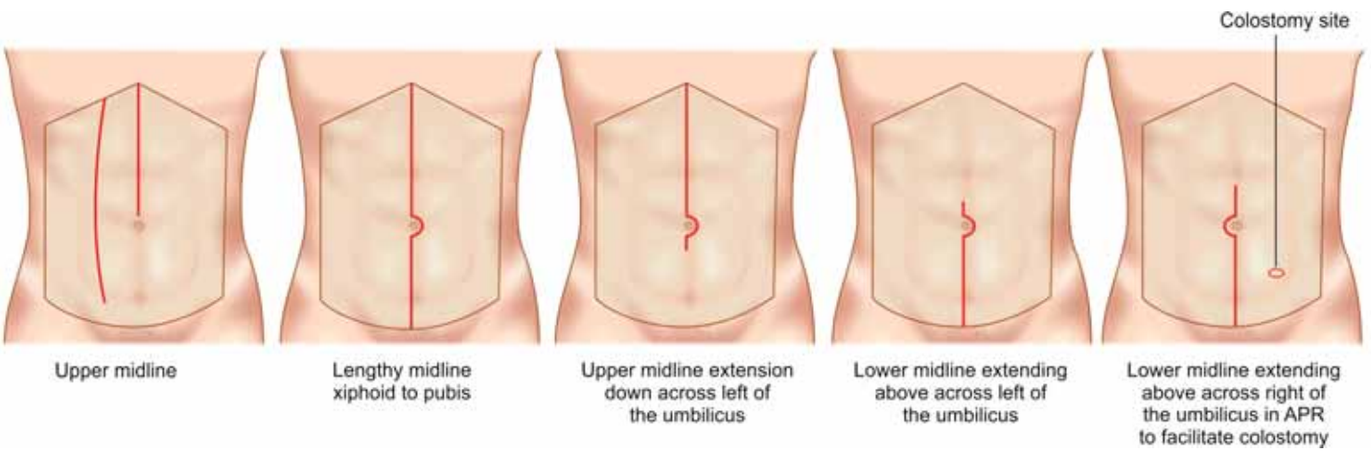

Colostomy site
Upper midline
Lengthy midline xiphoid to pubis
Upper midline extension down across left of the umbilicus
Lower midline extending above across left of the umbilicus
Lower midline extending above across right of the umbilicus in APR to facilitate colostomy

Fig. 18-16: Different types of midline incisions.

proximal extension is done by cutting the xiphoid process. Care must be taken not to injure terminal branches of internal mammary artery which can cause bleeding **(Fig. 18-19)**.

Lower Midline Incision

In the lower midline incision posterior rectus sheath is deficient, making incision downwards needs care as urinary bladder may get injured. Prevesical fat should not be incised. This fat cannot be separated of the deeper bladder. Bladder should be emptied before giving anaesthesia or an indwelling urinary catheter may be needed.

Midline Incision Closure

It is done using nonabsorbable monofilament suture material *number zero or 1*. Polyethylene/polypropylene/nylon/PDS (polydioxanone) is used. Silk and catgut are not used. Many advocate delayed absorbable suture material like no. 0 or 1 vicryl; but it is not as ideal as nonabsorbable monofilament suture material. *Continuous mass closure* is sufficient. Often locking sutures are placed. Peritoneum bite is not always necessary/compulsory as it will appose naturally when anterior layers are sutured. During continuous suturing in between supporting knots are placed at few points to prevent loosening and giving way of the suture line. Minimum distance to be kept between each bite is 1 cm; each bite should be taken 1 cm away from the cut margin. Linea alba/anterior rectus sheath may retract after incision; and often bite is taken only from external oblique fascia of Gallaudet's instead of rectus sheath especially in the lower abdomen. This fascia is not strong and so will eventually dehisce to cause incisional hernia. One should maintain adequate uniform tension on the suture material. Over pulling may cause tissue strangulation. Length of the suture material required is 3 times the length of the abdominal wound. One should be careful while closing incision close to pubis due to close proximity of bladder. Inadvertent bite of the urinary bladder should be avoided. Similarly closing incision adjacent to umbilicus should be perfect otherwise defect may be left leading to incisional hernia at that site **(Figs 18-20 to 18-22)**.

Ending of the continuous suture is done using needle holder by knotting to the previous bite loop. It is better and stronger. At least 4-5 knots should be placed to make it stronger. Knot of the nonabsorbable suture material will persists and may project towards skin causing pain on the skin later and so knot should always be buried under the rectus sheath. Many use Aberdeen knot at the end in continuous suture. Interrupted single layer mass closure using nonabsorbable suture material is also used with each suture 1 cm apart. Again often peritoneum is closed first by continuous suturing using 2 zero vicryl and rectus sheath is closed by continuous or interrupted (*layer by layer)* suturing. But now it is proved that there is no additional advantage by layer by layer closure.

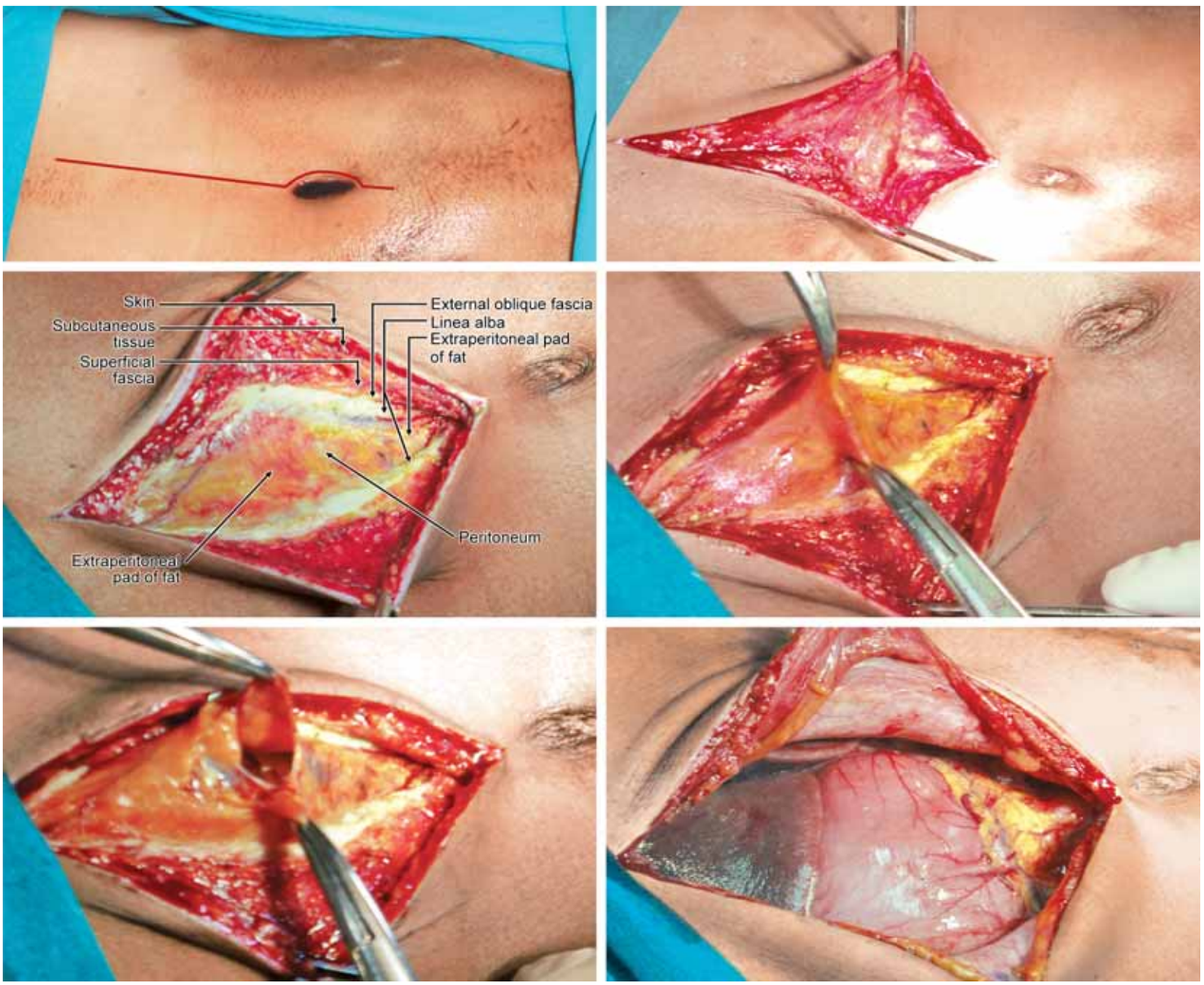


Fig. 18-17: Upper midline incision. It can be extended downwards from left of the umbilicus.

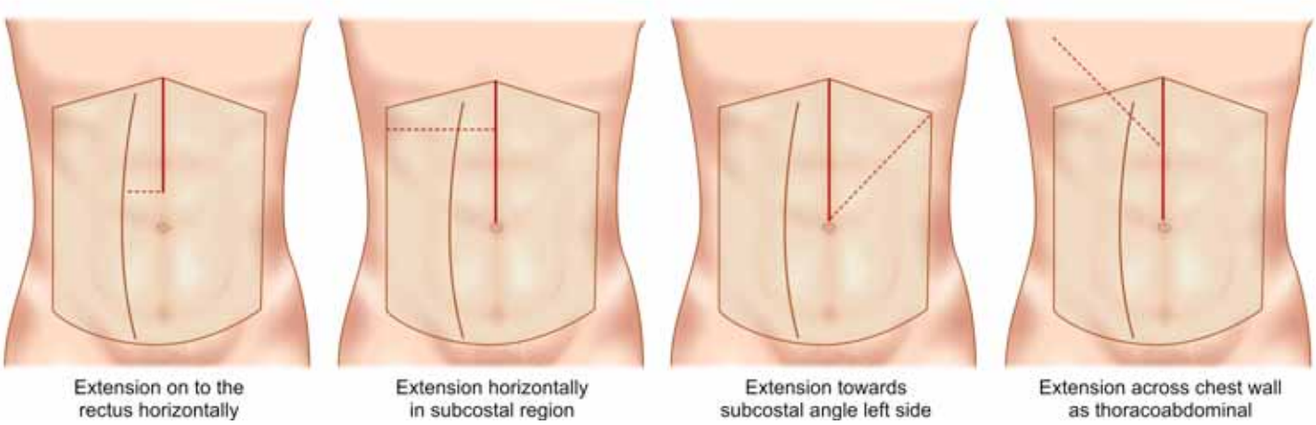

Extension on to the rectus horizontally
Extension horizontally in subcostal region
Extension towards subcostal angle left side
Extension across chest wall as thoracoabdominal

Fig. 18-18: Extension of midline incision in different ways – horizontally, obliquely, or as thoracoabdominal.

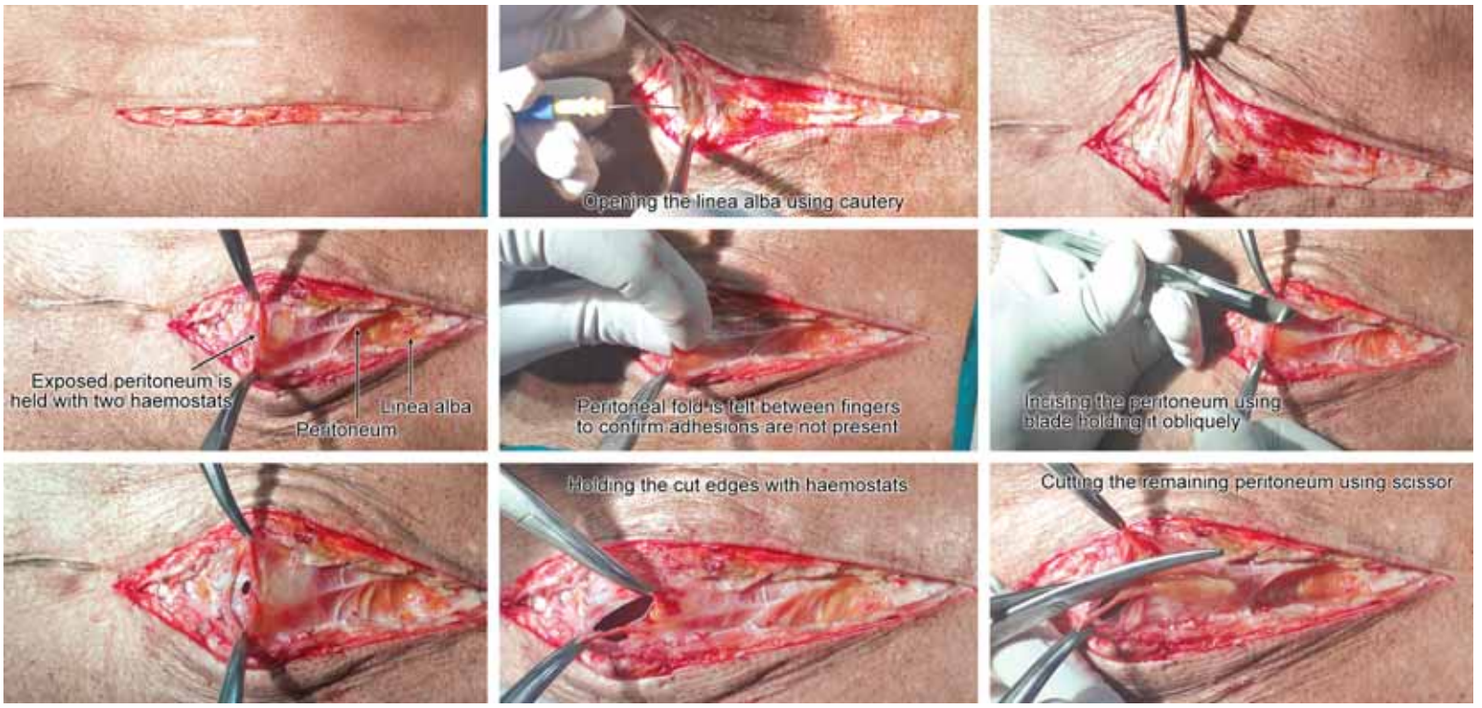

Opening the linea alba using cautery
Exposed peritoneum is held with two haemostats
Linea alba
Peritoneum
Peritoneal fold is felt between fingers to confirm adhesions are not present
Incising the peritoneum using blade holding it obliquely
Holding the cut edges with haemostats
Cutting the remaining peritoneum using scissor

Fig. 18-19: Midline incision approach to peritoneal cavity.

Sergeant retractor is used during abdominal closure
Skin stapler used here to close the skin
Interrupted mattress nonabsorbable sutures can also be used

Fig. 18-20: Technique of closure of the midline.

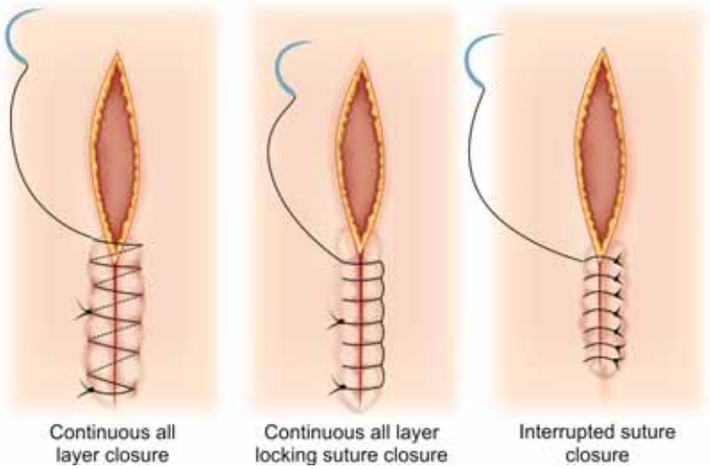


Fig. 18-21: Different methods to close the midline.

Fig. 18-22: Counting mops properly is very important prior to closure. Number of mops taken to theatre table should be written in the theatre board.

Fig. 18-23: Left paramedian incision scar.

PARAMEDIAN INCISION

In olden days paramedian incision was the most commonly advocated one; but now it is not commonly used. Paramedian incision is placed vertically parallel and 2.5 cm away from midline. It can extend from costal margin to pubis.

Right upper paramedian incision is used for cholecystectomy, biliary surgery, pyloroplasty, approach to right adrenal gland and liver cyst. Right mid-paramedian is used for laparotomy in doubtful/unknown/unsure diagnosis, approach to intestines and this approach is later extended depending on the pathology found after opening the abdomen. Right lower paramedian is used in burst appendicitis with peritonitis, right hemicolectomy. Left upper paramedian incision is used in vagotomy, gastrectomy, hiatus hernia repair and splenectomy. Left lower paramedian incision is used in left hemicolectomy **(Fig. 18-23)**.

Skin, subcutaneous tissue, superficial fascia, external oblique fascia, anterior rectus sheath are incised layer by layer using no. 22 blade with no. 4 knife handle. Medial edge of the anterior rectus sheath is held upwards using series of haemostats. Rectus muscle is retraced laterally. In the upper part anterior rectus sheath is adherent to muscle on the medial part through tendinous intersections. These intersections should be released using monopolar cautery or sharp dissection. Posterior rectus sheath is visible behind rectus muscle. Vessels and nerves are in the middle level of the rectus muscle. Vessels run vertically. Segmental nerves after piercing posterior rectus sheath run laterally in front of the vessels and enter the muscle at same level just lateral to the middle of the rectus muscle. Posterior rectus sheath is deficient below the arcuate line. Fascia transversalis and extraperitoneal fat is incised; peritoneum is held using two haemostats and incised using blade after confirming that no content is present; cut edges are held using haemostats and by guarding abdominal contents using two fingers peritoneum is opened at both ends along its entire length of incision **(Figs 18-24 to 18-27)**.

Modifications of Paramedian Incision

Rectus muscle may be split in the line of incision on the medial part of the muscle bulk to avoid injury to nerves and also be used for quick access.

Battle's incision which is pararectal incision will injure these nerves causing weakening of the rectus muscle and so is avoided.

Mayo–Robson incision: Right upper paramedian incision may extend upwards towards xiphoid process in midline as Mayo–Robson incision. One should ensure that in such extension, superior epigastric artery is not injured or otherwise should be securely ligated to prevent troublesome haemorrhage.

Paramedian incision can be extended into the thorax whenever needed as thoracoabdominal incision **(Fig. 18-28)**.

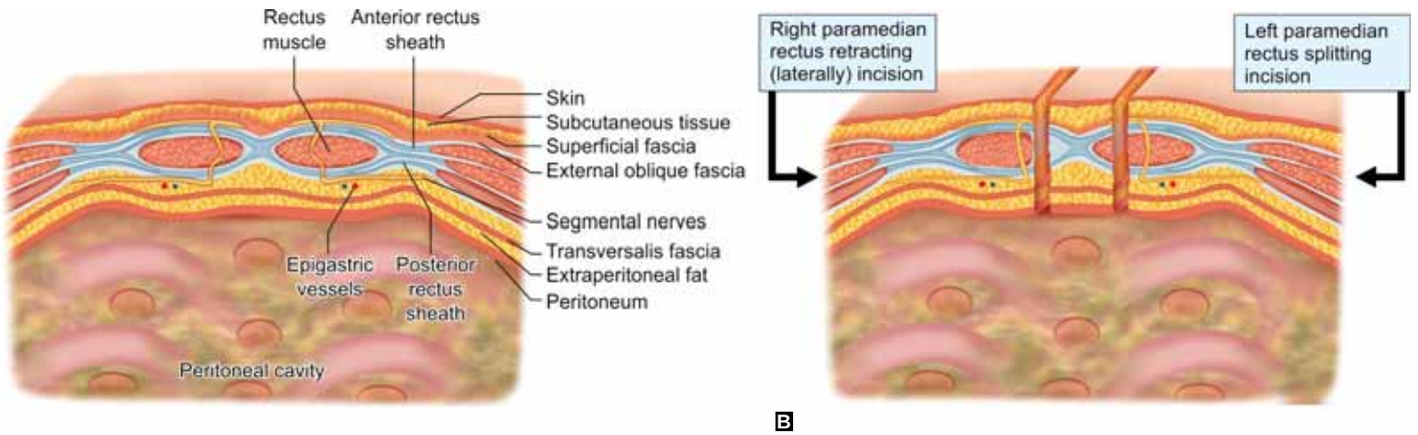


Fig. 18-24: Layers in paramedian incision approach.

Closure of Paramedian Incision

Paramedian incision is closed in layers. First posterior rectus sheath with peritoneum is closed using monofilament nonabsorbable or *delayed absorbable* like vicryl suture material. Anterior rectus sheath is closed using *monofilament nonabsorbable suture* no. zero polyethylene or polypropylene or nylon as continuous sutures.

Advantages

Paramedian incision is safe without cutting the muscle. It creates strong scar with 'trap door' effect.

Disadvantages

Rectus muscle is exposed and dissected and so there are chances of muscle getting atrophied. Incision is laborious and time consuming and difficult to extend above and below which invariably damages muscle and often nerves. Access to the contralateral abdomen is usually inadequate.

TRANSVERSE INCISIONS

It may be upper transverse or lower transverse incision. It is the incision used in infants and early childhood. It is muscle cutting incision. Muscle is cut in line of incision.

Upper Transverse Abdominal Incision

It is placed at transpyloric plane or midway between xiphoid and umbilicus. It is muscle cutting incision. Rectus muscle is cut; but its nerve supply is not interfered as it has got segmental nerve supply. Rectus muscle in upper abdomen after cutting will not retract due to tendinous intersections. It extends from anterior axillary line on one side to other side; but length depends on the side of the pathology which can be variable as needed. Skin, subcutaneous tissue, fascia, superficial fascia, anterior rectus sheath on both sides, recti on both sides, external and internal oblique muscles on both sides, transverse abdominis muscles on both sides are cut. Vessels deeper to rectus muscle are ligated securely. Posterior rectus sheath and transversalis fascia are incised. Peritoneum is held with two haemostats and incised. It is cut in the line of incision transversely. Muscles are cut using monopolar cautery. Postoperative pain is less and chances of wound dehiscence and incisional hernia are rare.

In infants and early childhood, costal angle is obtuse, abdomen is small and wide, muscles are thin, and pelvis is not yet developed and so not deep. Approach to entire abdomen is possible; contracture will not occur compared to vertical scar; cosmetically better. Umbilical vein in falciform ligament may be patent and so requires firm ligation. (In infants while putting infraumbilical transverse incision, one has to be aware of that two umbilical arteries in paramedian positions on either side may be patent and so needs ligation).

Closure of upper transverse incision is done either as layer by layer using vicryl; or lateral muscles are closed as mass closure with suturing posterior rectus sheath, rectus muscle and anterior rectus sheath.

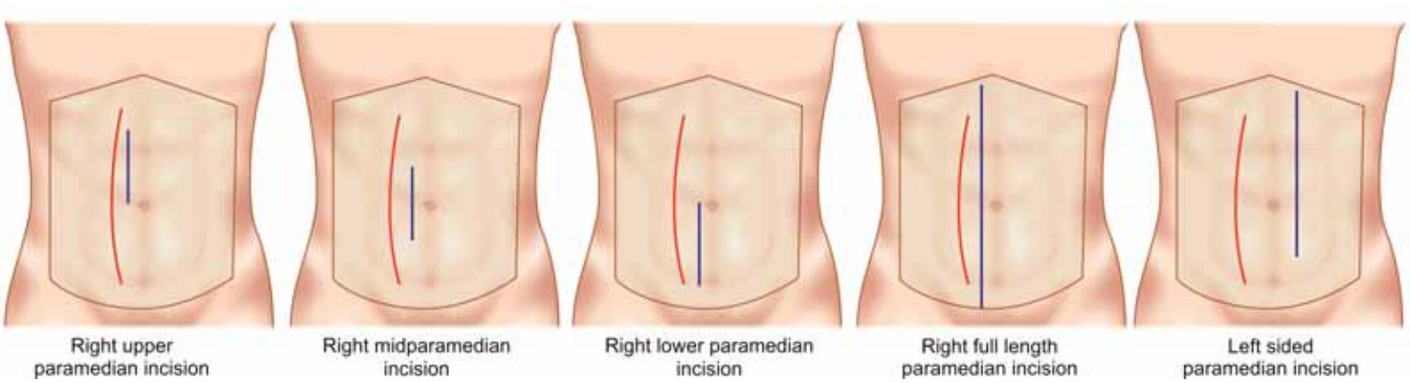

Right upper paramedian incision
Right midparamedian incision
Right lower paramedian incision
Right full length paramedian incision
Left sided paramedian incision

Fig. 18-25: Different types of paramedian incision.

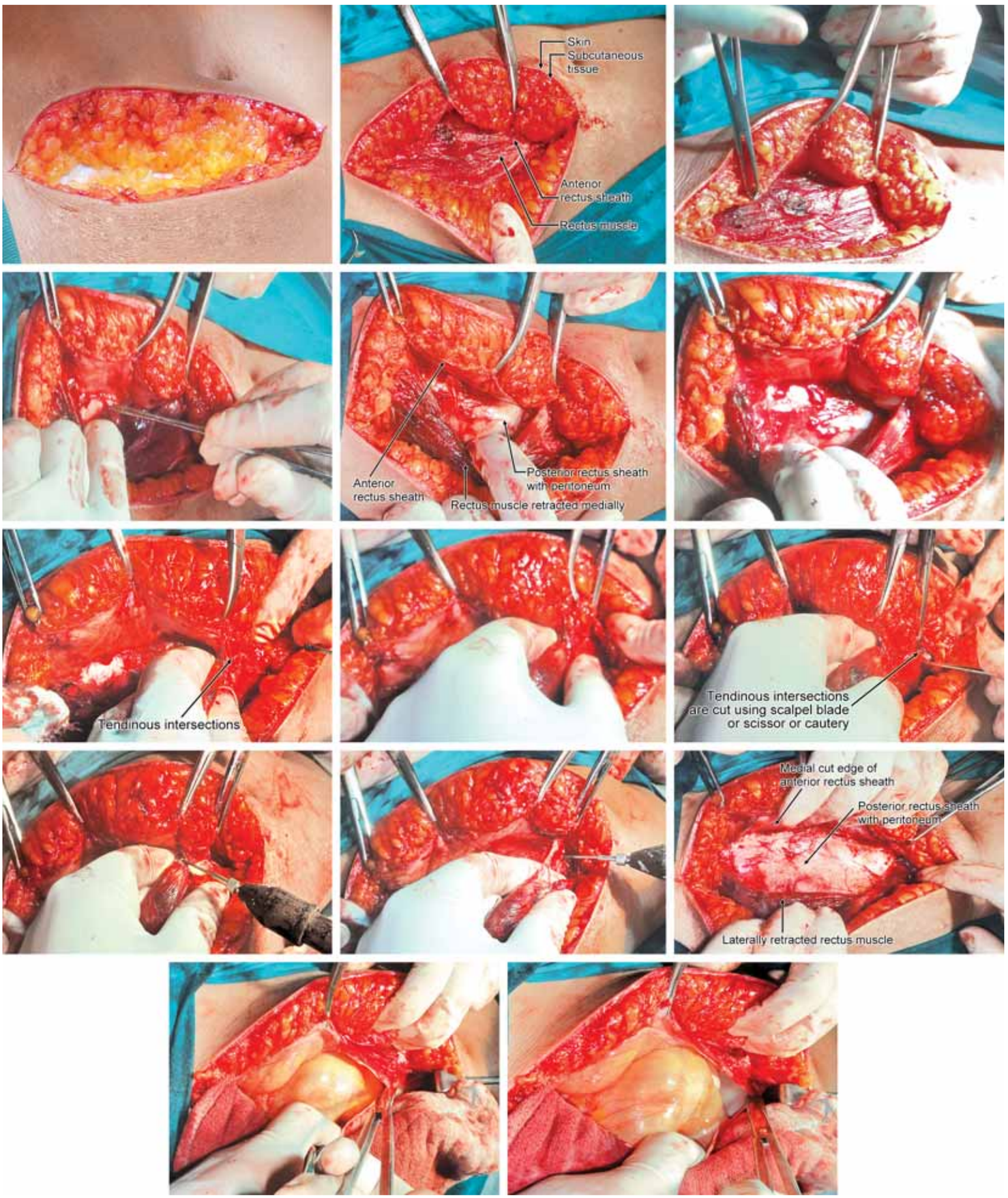

Skin
Subcutaneous tissue
Anterior rectus sheath
Rectus muscle
Anterior rectus sheath
Posterior rectus sheath with peritoneum
Rectus muscle retracted medially
Tendinous intersections
Tendinous intersections are cut using scalpel blade or scissor or cautery
Medial cut edge of anterior rectus sheath
Posterior rectus sheath with peritoneum
Laterally retracted rectus muscle

Fig. 18-26: Technique of paramedian incision.

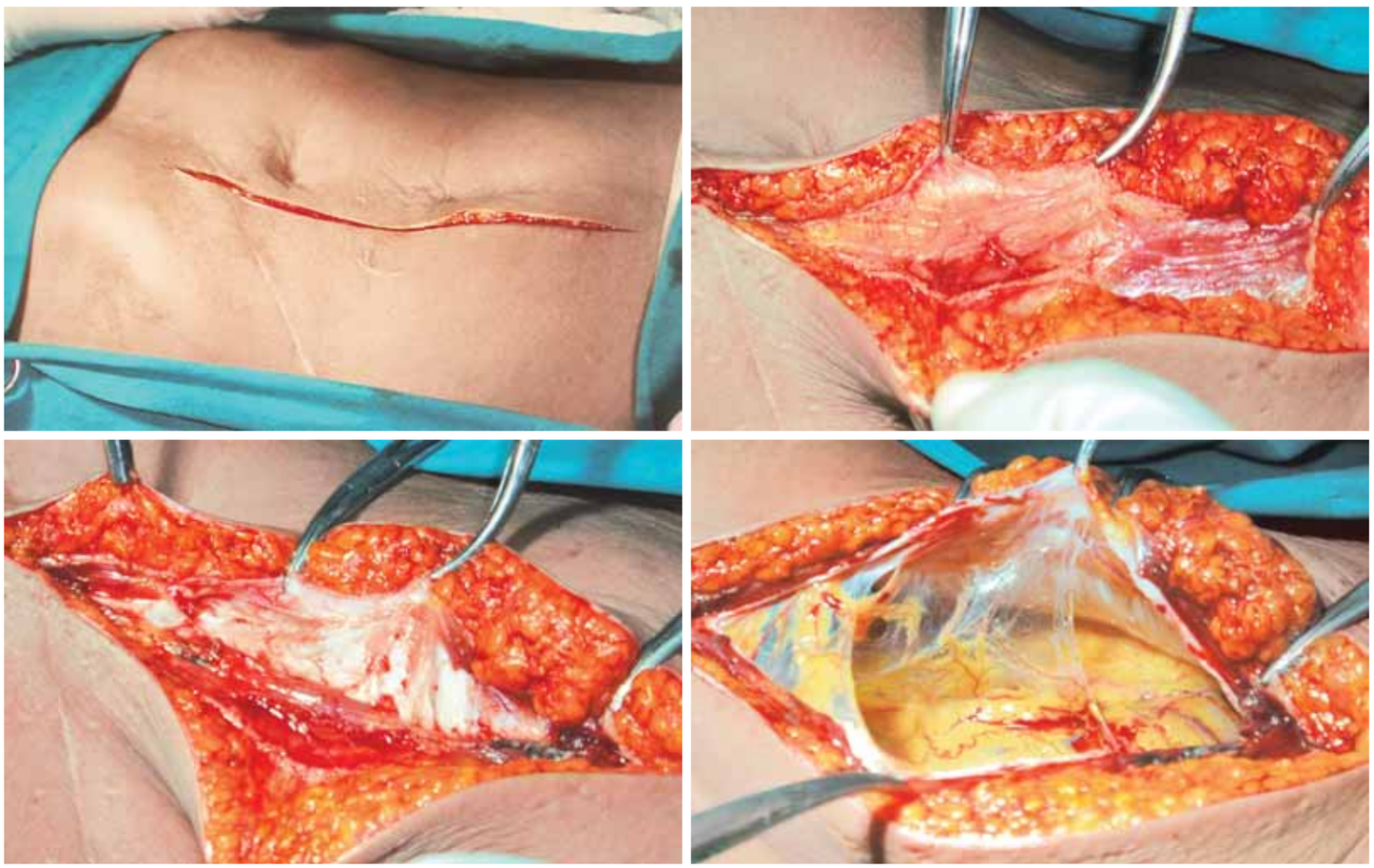


Fig. 18-27: Right paramedian incision.

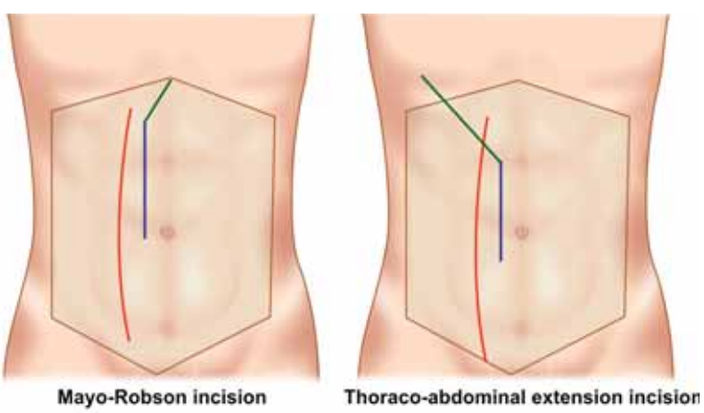


Fig. 18-28: Extensions which can be done in paramedian incision.

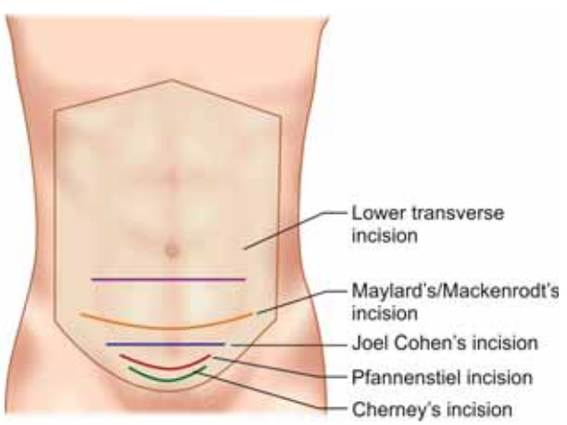


Fig. 18-29: Different types of lower abdomen transverse incisions.

Advantages

It gives good exposure of the upper abdomen. Healing is supported by muscle contraction which pulls it transversely. Segmental nerve supply is preserved. Scar contracture is less here compared to vertical.

Disadvantages

Bleeding from epigastric and muscular vessels is troublesome. It takes long time to complete the incision.

Lower Transverse Abdominal Incisions

It is not commonly used; instead Pfannenstiel incision is used. Lower infraumbilical transverse incision is often used in infants and children; here posterior rectus sheath is not formed; recti muscles will retract as there are no tendinous intersections; and so often cause difficulty in apposing the recti firmly. Layers are closed in similar fashion as upper transverse incision **(Fig. 18-29)**.

Pfannenstiel Incision (Pfannenstiel Hermann Johann 1862–1909; German Gynaecologist)

It is rectus *muscle separating/retracting* transverse incision. It is used to approach pelvis. It is commonly used in gynaecological surgery like caesarean section or hysterectomy. In urology procedures also this incision is used like in retropubic urethroplasty.

Incision is placed in suprapubic region 1 cm above the pubis with slight convexity downwards. Laterally incision extends beyond outer margin of the rectus muscle. Skin, subcutaneous tissue and superficial fascia are incised. Anterior rectus sheath is incised in the line of incision; upper flap of the sheath is raised upwards towards umbilicus using scissor; lower flap is raised up to the pubis. Recti are separated from midline laterally. Peritoneum is visualised with extraperitoneal pad of fat. Urinary bladder is visible in the lower part. Peritoneum is held with two haemostats in the upper part midline. It is incised and opened vertically in both directions above and below. Below it is incised until the dome of the urinary bladder. One should be careful below not to incise urinary bladder. Head down position with self retaining retractor facilitates further operative steps **(Figs 18-30 and 18-31)**.

Closure of Pfannenstiel Incision

Closure of Pfannenstiel incision is done layer by layer; peritoneum vertically using vicryl continuous suture; rectus muscle is just apposed using few interrupted vicryl sutures (it should not be very tight so as to strangulate the muscle); anterior rectus sheath is closed using continuous monofilament nonabsorbable sutures. Subcutaneous tissue is closed using interrupted 3 zero vicryl; skin is closed using subcuticular suture.

Advantages

It is cosmetically better; less painful; heals rapidly; less chance of incisional hernia compared lower midline incision.

Disadvantages

It is difficult to extend more laterally if needed in case large gynaecological tumours. It may cause injury to inferior epigastric vessels causing troublesome bleeding. It may injure the T 11 nerve, iliohypogastric nerve and subcostal nerve causing muscle weakness. Entrapment of ilioinguinal or iliohypogastric nerve can occur. Lateral extension may predispose to inguinal hernia. Haematoma, seroma, abscess formation can occur. Femoral nerve injury can occur occasionally. This incision *should not be used* in oncological surgery due to limited access to lymph node clearance. Its proximity to infected area (perineum) may predispose sepsis.

Joel Cohen's Straight Transverse Lower Abdominal Incision

It is used for caesarean section delivery. It is a straight transverse incision through skin only, 3 cm below the level of the anterior superior iliac spines (higher than the Pfannenstiel incision). The subcutaneous tissue is opened only in the middle 3 cm. The fascia is incised transversely in the midline then extended laterally with blunt finger dissection. Finger dissection is used to separate the rectus muscles vertically and outwards laterally and to open the peritoneum. All the layers of the abdominal wall are stretched manually to the extent of the skin incision. The urinary bladder is pushed below by gentle blunt finger dissection. The uterine muscle is incised transversely in the midline but not to breach the amniotic sac, then opened and extended laterally with finger dissection. It is found that this approach for caesarean section delivery reduces the operating time, blood loss and postoperative hospital stay.

Cherney's Incision

Incision is like Pfannenstiel but still lower than it with *tendon detaching approach*. After incising the skin and subcutaneous tissue above the pubic symphysis, anterior rectus sheath is incised transversely which is separated from underlying rectus and pyramidalis muscles above and below. Posteriorly these muscles are separated from the urinary bladder by blunt finger dissection. Tendons of these muscles are cut 5 mm above the pubic symphysis. Muscles with tendons are retraced and reflected above to expose the peritoneum which is incised transversely. Cherney's incision provides excellent access and exposure to the retropubic space of Retzius for retropubic urethropexy and paravaginal repair. Exposure is the main advantage to Cherney's incision. It is more time consuming due to the dissection required to separate the muscles and tendons from the underlying tissues. Injury to inferior epigastric arteries is a possibility. Reattachment of the tendons to the pubic symphysis is a must during closure which is tedious.

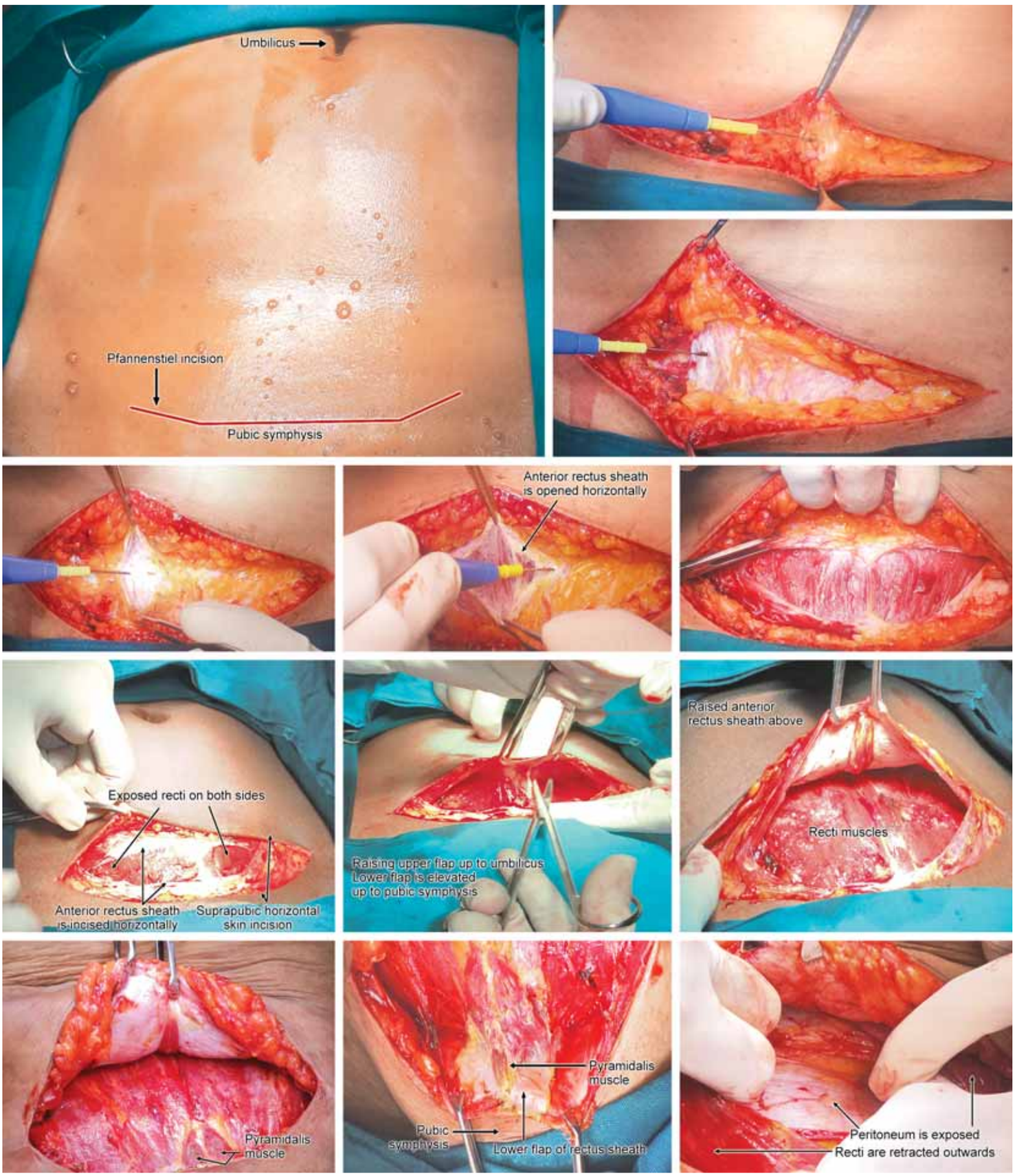
Maylard's Incision

It is muscle cutting transverse incision. It is also called as *Mackenrodt incision.* Incision is placed at the level of anterior superior iliac spine with convexity downwards. Anterior rectus sheath is incised but not separated from the rectus muscle to prevent it from getting retracted on either sides; (often after cutting the rectus muscle, its edge is sutured to cut edge of the anterior rectus sheath to prevent retraction using mattress vicryl sutures). Incision over the anterior rectus sheath is extended laterally through the aponeurosis of the abdominal wall up to 2 cm medial to the anterior iliac crest. Rectus muscle is cut transversely using cautery or scalpel. Inferior epigastric vessels are dissected, ligated and divided. Transversalis fascia and peritoneum are incised transversely to expose the abdomen. All layers are cut at the level of anterior superior iliac spine. Here exposure to lateral pelvis is excellent and so oncological procedures like pelvic lymphadenectomy and staging can be done exponentially. It is also very useful for pelvic endometriosis. This incision should be placed with a preoperative plan. Pfannenstiel incision cannot be modified as Maylard's incision. Drain is kept usually after Maylard's exposure as oozing and collection is common in this incision.

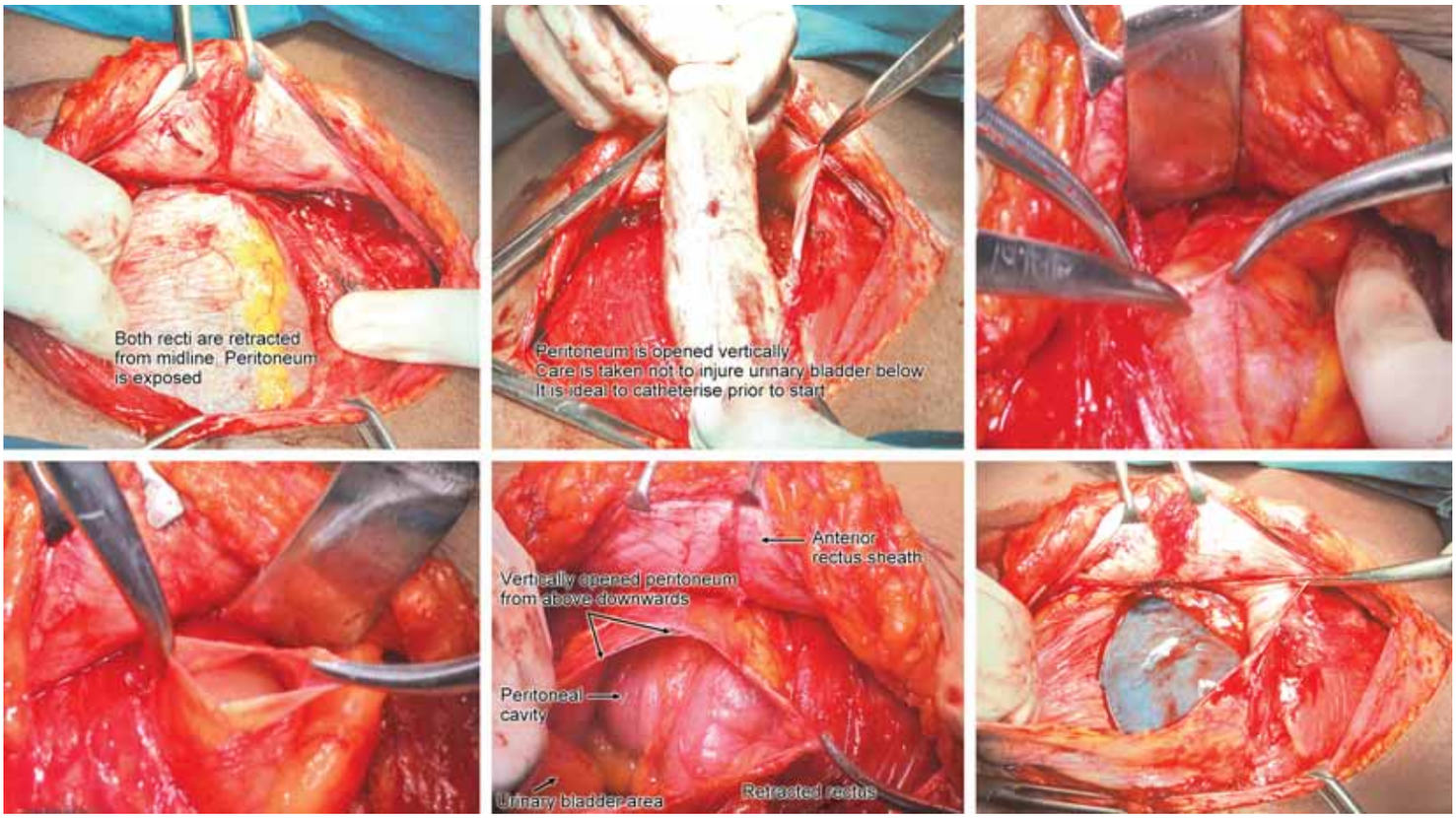
Disadvantages: Haemorrhage, haematoma, seroma formation and infection can occur. Injury to ilioinguinal and iliohypogastric nerves or their entrapment during closure can occur. Lateral femoral cutaneous, genitofemoral and femoral nerves can get compressed during retraction causing neuropraxia.

Kustner's Incision

A transverse incision is made 5 cm above the symphysis pubis and below the anterior iliac spine. The subcutaneous tissue is then separated in the midline to expose the linea alba. A vertical midline incision is made through the linea alba. Superficial epigastric vessels are ligated. This incision is not commonly used as there are no advantages over Pfannenstiel incision and it limits in adequate exposure and cannot extend if needed also.


Umbilicus
Pfannenstiel incision
Pubic symphysis
Anterior rectus sheath is opened horizontally
Exposed recti on both sides
Anterior rectus sheath is incised horizontally
Suprapubic horizontal skin incision
Raising upper flap up to umbilicus
Lower flap is elevated up to pubic symphysis
Raised anterior rectus sheath above
Recti muscles
Pyramidalis muscle
Pyramidalis muscle
Pubic symphysis
Lower flap of rectus sheath
Peritoneum is exposed
Recti are retracted outwards

Figs 18-30(1)


Both recti are retracted from midline. Peritoneum is exposed
Peritoneum is opened vertically
Care is taken not to injure urinary bladder below
It is ideal to catheterise prior to start
Anterior rectus sheath
Vertically opened peritoneum from above downwards
Peritoneal cavity
Urinary bladder area
Retracted rectus

Figs 18-30(2)

Figs 18-30(1 and 2): Pfannenstiel incision – steps.

Fig. 18-31: Pfannenstiel incision closure.

Turner-Warwick's Incision

Incision is placed 2 cm above the symphysis pubis and within the lateral borders of the rectus muscles. The sheath overlying the rectus muscles at the symphysis pubis is released for about 4 cm transversely, and the incision angled up to the lateral borders of the rectus muscles. The lateral edges of the incision remain medial to the internal oblique muscles. The recti are separated and the incision is made in the midline. This type of incision is good for exposure of the retropubic space. Pelvis and abdomen is not exposed adequately in this incision.

OBLIQUE INCISIONS

Kocher's Subcostal Incision (Emil Theodor Kocher)

Right subcostal incision is used for open cholecystectomy and to approach biliary system and liver. Incision extends from anterior axillary line towards xiphisternum up to midline 2–2.5 cm below the costal margin. Skin, subcutaneous tissue, superficial fascia, anterior rectus sheath, rectus muscle, external and internal oblique muscles and transverse abdominis muscle are cut using monopolar cautery. Anterior rectus sheath once cut in front of the rectus muscle, long haemostat (artery forceps) is passed behind the rectus muscle and lifted forward to cut the muscle horizontally using cautery. Superior epigastric vessels deep to rectus muscle are ligated securely. 8th thoracic nerve which is smaller is cut. It is ideal to identify larger 9th thoracic nerve and preserve it to prevent weakening of abdominal muscles. Peritoneum is incised in the line of incision. Large bowel will be very close to this incision and so care should be taken not to injure it inadvertently while opening the peritoneum.

Incision is often *modified* by not cutting the rectus muscle but retracting it after incising the anterior rectus sheath **(Figs 18-32 and 18-33)**.

Smaller subcostal incision < 10 cm in length is used by many surgeon as *mini lap cholecystectomy* without incising the rectus sheath. It causes less postoperative pain, early recovery and good cosmesis. But Calot's dissection is difficult and often is done blindly. Advent of laparoscopic cholecystectomy as standard approach made this a surgical legacy.

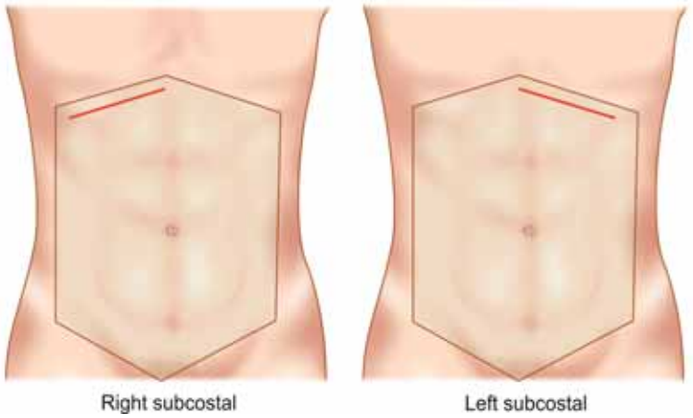


Fig. 18-32: Right and left subcostal incision.

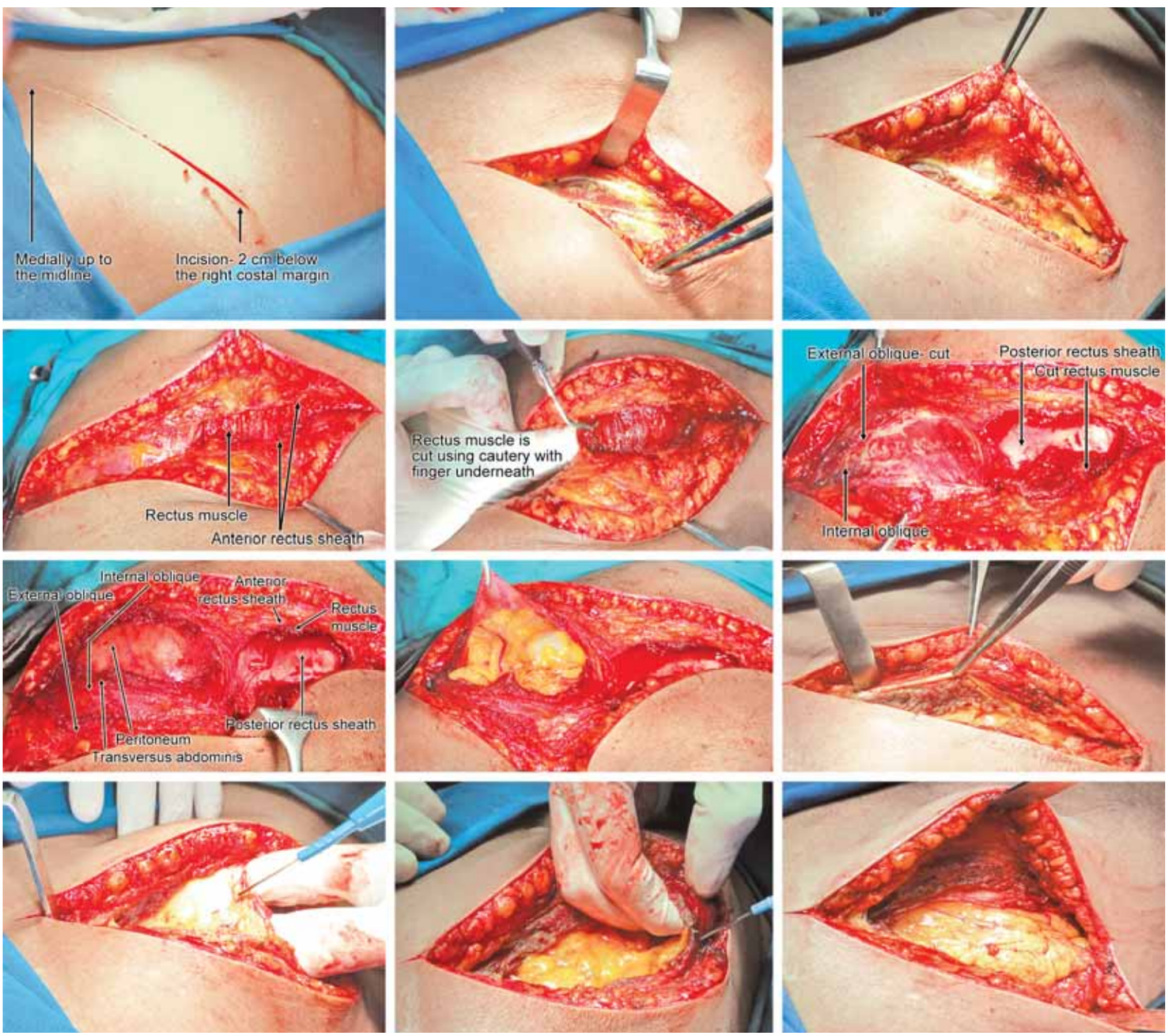
Closure of Kocher's incision is done by closing posterior and rectus sheaths separately and rectus muscle with vicryl sutures. Rectus has got segmental nerve supply and due to its upper tendinous intersections it will not retract and fibrous scar itself causes additional support to the muscle.

Advantages: It gives very good exposure to Calot's and biliary system. It can be extended towards opposite side if needed.

Disadvantages: Injury to 9th thoracic nerve causes muscle weakness and loss of sensation below the scar. Hernia if develops in Kocher's incision is difficult to manage **(Fig. 18-34)**.

Left Subcostal Incision

Left subcostal incision is used for splenectomy, distal pancreatectomy.



Figs 18-33(1)

Figs 18-33(2)

Figs 18-33(1 and 2): Typical right subcostal Kocher's incision and scar.

Fig. 18-34: Incisional hernia along Kocher's incision scar.

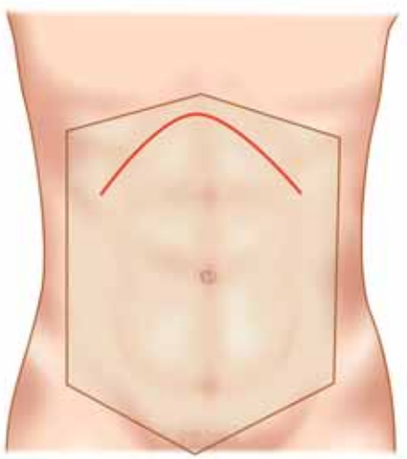


Fig. 18-35: Rooftop incision.

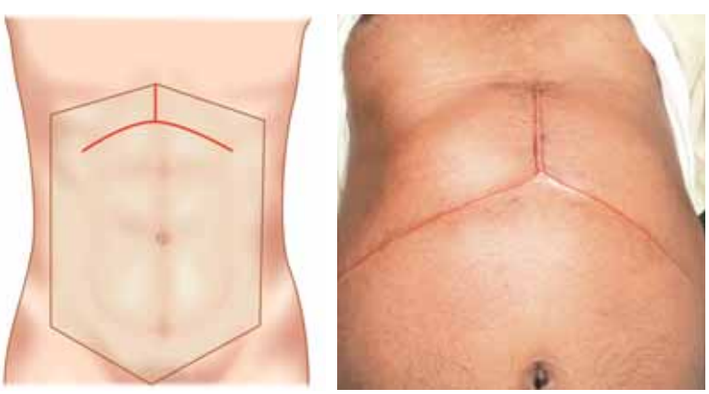


Fig. 18-36: Mercedez Benz incision.

Chevron Incision (Rooftop Incision)

In this incision a cut is made on the abdomen below the rib cage. It is actually bilateral subcostal incision. The cut starts from the mid-axillary line below the ribs on the right side of the abdomen and continues all the way across the abdomen to the opposite mid-axillary line leading into cutting of entire width of the abdomen providing access to the liver for liver resection/transplantation, oesophagogastric junction for oesophagectomy, surgery for renovascular hypertension, pancreatic surgeries, bilateral adrenalectomy. The average length of the incision is about 60-80 cm **(Fig. 18-35)**.

Mercedes Benz Incision

It is bilateral lower Kocher's incision (about 3-5 cm below the costal margin) with a middle vertical upper limb passes towards and through the xiphisternum. It gives very good exposure to liver, oesophageal hiatus **(Fig. 18-36)**.

Oblique Iliac Incision (Abbernethy's/Modified Gibson's)

It is used for *extraperitoneal approach* for ureteric stone, urinary bladder and lumbar sympathectomy. It is muscle cutting incision. It can be used as transperitoneal also **(Figs 18-37 and 18-38)**.

Position is partial or complete lateral, depends on the side surgery is needed. Incision is placed from mid-axillary line at the level of the umbilicus directing downwards and forwards towards

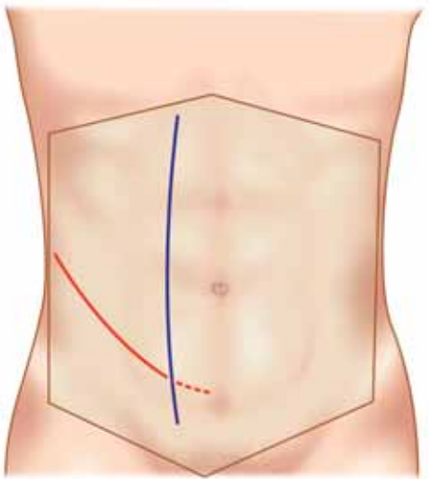


Fig. 18-37: Oblique iliac incision.

pubic symphysis up to the lateral margin of the rectus muscle. Skin, subcutaneous fat, superficial fascia, external oblique muscle and aponeurosis below are incised layer by layer in the line of incision. Internal oblique and transverse abdomen muscles are also cut in the line of incision. Under transversalis fascia extraperitoneal fat and peritoneum is visualised. In extraperitoneal approach, peritoneum is swept forward from behind by blunt finger dissection. Psoas major muscle, genitofemoral nerve and inferior vena cava are identified. Ureter with its typical look and peristalsis is also identified. Depending on the type of surgery further procedure is undertaken. Muscle is retracted using self retaining retractor. Peritoneum if inadvertently opened, it can be sutured using 2 zero vicryl.

LOIN INCISIONS

It is mainly used to approach kidney, adrenal and retroperitoneum. Patient is placed in loin position. Full lateral position with kidney bridge raise with flexion of the knee of the leg which is on the theatre table is done. Flat wide pillow should be kept between legs. Arm facing upwards is positioned towards head end with a support. Patient is strapped firmly to prevent tilting or changing the position during surgery. Back support is often needed. Mayo's table is placed on the leg side after draping which facilitates to keep instruments safely. After cleaning and draping, incision begins posteriorly behind the posterior axillary line in posterior subcostal line extending forward towards the outer margin of the rectus muscle. Rectus is usually not cut. Skin, subcutaneous tissue and superficial fascia are cut. Posteriorly latissimus dorsi, serratus posterior inferior and quadratus lumborum are cut; anteriorly external and internal oblique muscles are cut. Usually 12th or 11th is cut. Rib is identified. Incision is made over its periosteum. Periosteum is reflected using periosteal elevator. Care should be taken to avoid injury to vessels underneath which often need proper ligation. Rib after mobilization, is cut using bone cutter. Cut end is often smoothened using bone file. Pleura is very close to the rib which should not be opened. If opened pneumothorax develops; which is usually managed by placing vicryl sutures to pleura while anaesthetist is ventilating the lung with adequate expansion. Usually intercostal tube is not necessary. Postoperative check chest X-ray needed for the evidence of pneumothorax. Transverse abdominis muscle is usually split from posterior to anterior. Peritoneum is adherent to the abdominal wall in front. So care should be taken not

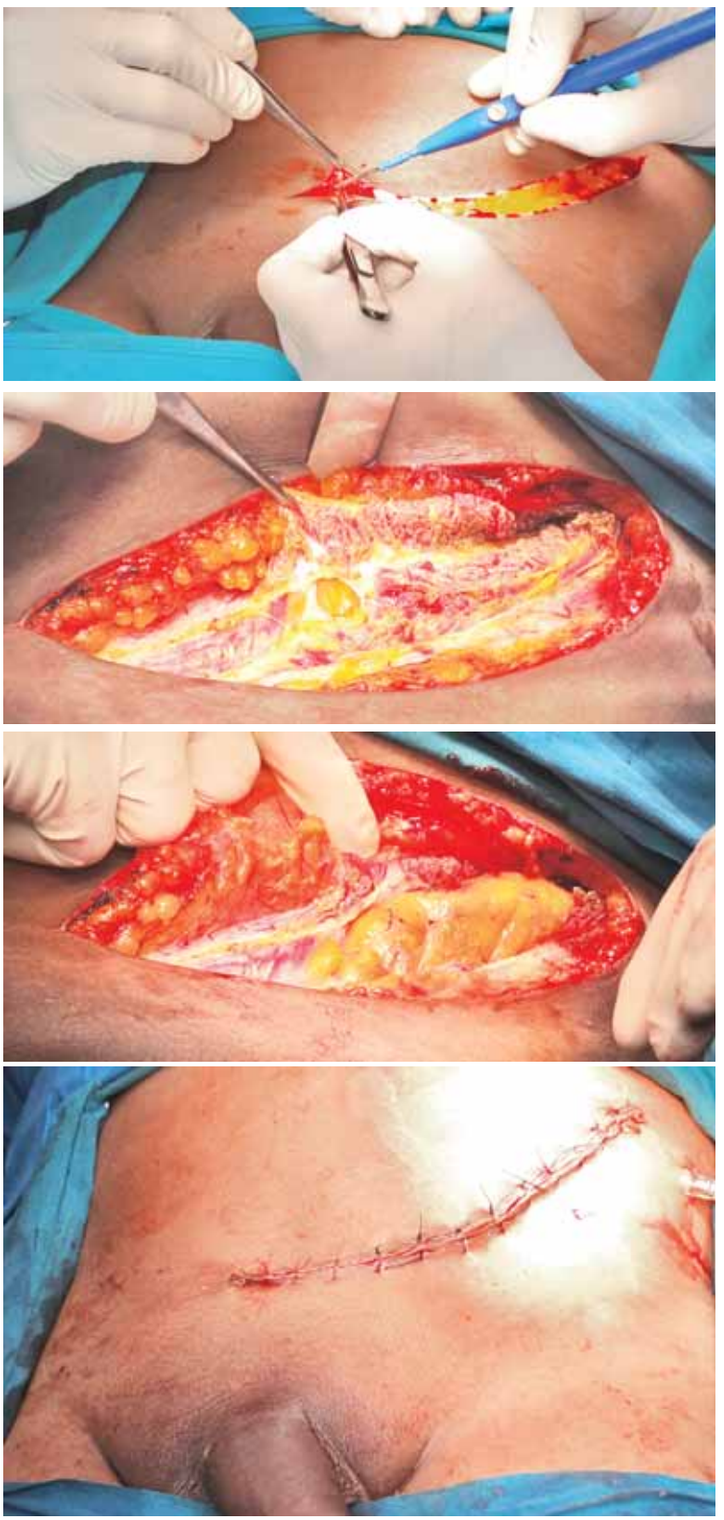


Fig. 18-38: Oblique iliac incision and closed wound also.

to tear on the anterior aspect. Peritoneum is swept forward to reach the Gerota's fascia **(Fig. 18-39)**.

Closure of the Loin Wound Approach

It is done in two layers. Transversus abdominis and internal oblique muscles are closed using continuous vicryl suture as inner layer. External oblique is closed using nonabsorbable or delayed absorbable

Fig. 18-39: Lateral kidney position to approach kidney for various surgeries like nephrectomy, pyeloplasty.

continuous suture as outer layer. Covering fascia should be included in the bite which is stronger than muscle itself. Drain when needed should be kept below the lower margin of the wound and on the anterior aspect in front of the level of the anterior superior iliac spine; through a separate stab incision.

Incision can be extended into the thorax or into the peritoneal cavity as needed.

High 11th rib excision approach is called as *Nagamatsu approach* which is used in approaching upper pole renal cell carcinoma (RCC).

Lumbotomy Incision (Gil-Vernet)

It is vertical posterior incision from 12 rib level to iliac crest. Incision is along the lateral border of the sacrospinalis. It is deepened through latissimus dorsi, serratus posterior inferior, lumbosacral fascia, quadratus lumborum. It is done in prone position. Both sides' two separate incisions can be placed in bilateral approach. It is used bilateral partial nephrectomies and bilateral adrenalectomies.

PRINCIPLES IN CLOSURE OF THE ABDOMINAL INCISION WOUND

Layer by layer closure is good old standard. But it is now proved that peritoneum closure is not necessary.

In Layer by Layer Closures

Peritoneum is closed using vicryl or polypropylene; rectus sheath is closed with continuous locking monofilament nonabsorbable sutures; (interrupted sutures may be better if there is sepsis); subcutaneous tissue is closed using 3 zero rapid vicryl (ideal) or plain catgut; skin closed using interrupted mattress sutures. Skin stapler can be used as it is quicker and easy to remove; but it is not haemostatic, skin edge bleeding may occur.

Single Layer

Mass closure is also used. It is also equally good; rapid. Usually continuous suture is placed; but interrupted sutures also can be used. Skin is apposed separately.

Retention sutures, used earlier after an emergency surgery, is more often replaced by modified Smead Jones sutures. Retention suture is still practiced in many centers of world.

Modified Smead–Jones Sutures

It is interrupted specialised sutures used in the closure of abdomen as single layer excluding the skin. Linea alba is held with Allis' forceps. *Number one* polyethylene or PDS suture material is used. First bite on one side taken 3 cm away (width) from the margin from outside to inside; it is then passed through the corresponding opposite edge with 3 cm width from inside to outside; later again one small loop of 5 mm width from the edges of each side of the wound from first bite site to second bite site is taken; suture is knotted on the free edge of the first bite side. Full thickness bite holds the suture and maintains the tension in the wound. Smaller loop keeps the linea alba in apposed place. Large curved *Ferguson needle* is better to place these sutures. Each suture is placed at 2 cm interval. This is the type of suturing used at present in acute abdominal conditions instead of the retention sutures. Here also it is better to place all sutures under proper vision and knotting is done at the end. At least four knots should be placed. Excessive tension should be avoided. In upper abdomen peritoneum need not be included in the bite; but in lower abdomen as linea alba is indistinct, peritoneum is included in this **(Fig. 18-40)**.

L. E. Hughes Double Near and Far Suture

It is similar with same indications as Smead-Jones, with double near and far sutures placed to have a strong loop with knot on one side **(Fig. 18-41)**.

While taking bite from the peritoneum, care should be taken not to take bites from bowel; if inadvertently taken leads into dangerous faecal fistula. Guarding the bowel using finger lift or using mop or using sergeant retractor is a must. Before finishing the final bites it is

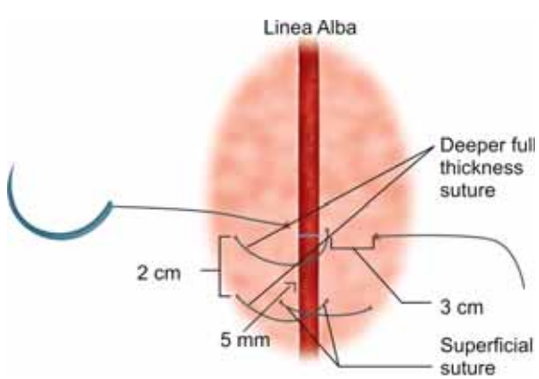


Fig. 18-40: Modified Smead-Jones sutures. These sutures are better than placing retention sutures.

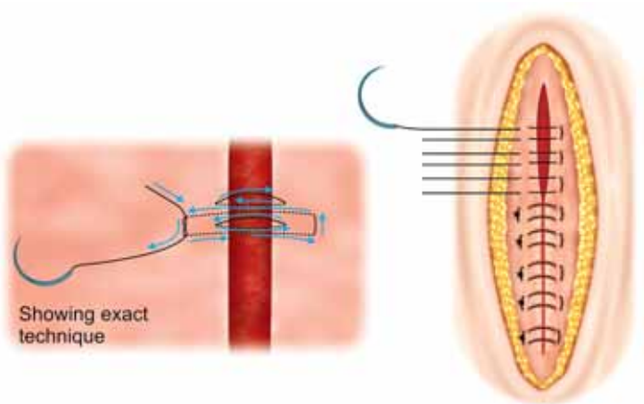


Fig. 18-41: L E Hughes double near and far suture.

ideal to place index finger under the sutured peritoneum to confirm that suture line is perfect and without any bowel entangling.

Drain if needed to place, it should be placed away from the min incision; usually along the anterior axillary line; side and site (upper or lower) is decided depending on the type and area of surgery. Often double drains are placed on the same or both sides.

Retention Sutures

In this suturing the all abdominal layers are held together without tension; the sutures take the tension off the wound edges.

Uses

It is used for patients who are debilitated (malnutrition, old age, immune deficiency or advanced cancer); patients suffering from conditions associated with raised intra-abdominal pressure like obesity, asthma or chronic cough; those with impaired healing; burst abdomen.

Material used

Monofilament nonabsorbable suture material no. 1 (nylon/polyethylene/polypropylene) is used **(Fig. 18-42)**.

Technique

Retention sutures are inserted through the entire thickness of the abdominal wall leaving them untied in the beginning. All sutures are passed first. Sutures are through and through all layers from skin, rectus sheath, rectus muscle and peritoneum on one side and back on the opposite edge with a sufficient gap of 1.5-2 cm from the edges of the wound. Sutures may be simple or mattress. Later peritoneum is closed with continuous vicryl sutures and then continuous or interrupted anterior rectus sheath, subcutaneous tissue and skin (interrupted).

After completion of skin suture, each untied retention suture is threaded with (sleeve) 1-2 cm length of plastic or rubber tubes/sleeves. Plastic sleeves can be placed earlier itself; often it is practiced to place two tubes/sleeves on either sides of the wound to complete the vertical mattress sutures. Now sutures are apposed and tied but without any tension. Undue tension may compromise the blood supply of the tissues at wound edges. Horizontal mattress retention sutures are also used by many.

Retention sutures are left in place for 14 days.

Many surgeons advocate closure only by placing retention sutures with skin sutures without placing the apposition sutures on peritoneum and rectus sheath **(Fig. 18-43)**.

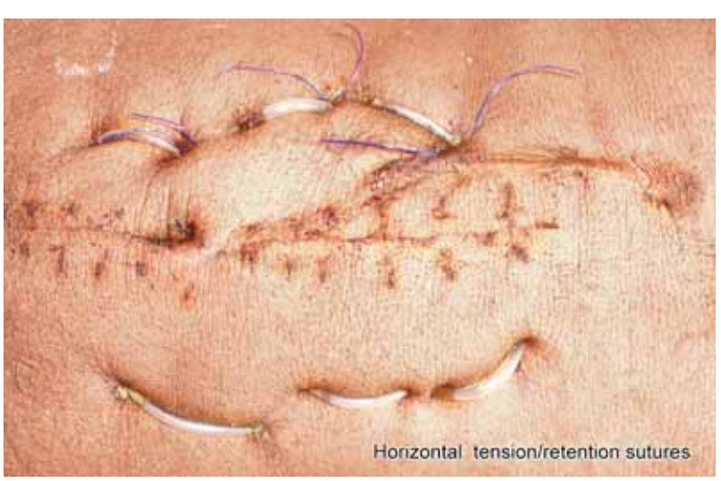


Fig. 18-42: Retention sutures – horizontal.

Controversy

Presently use of retention sutures is controversial. Hughes far and near sutures or Smead-Jones sutures are said to be better. However retention sutures are used wide worldwide even now **(Fig. 18-44)**.

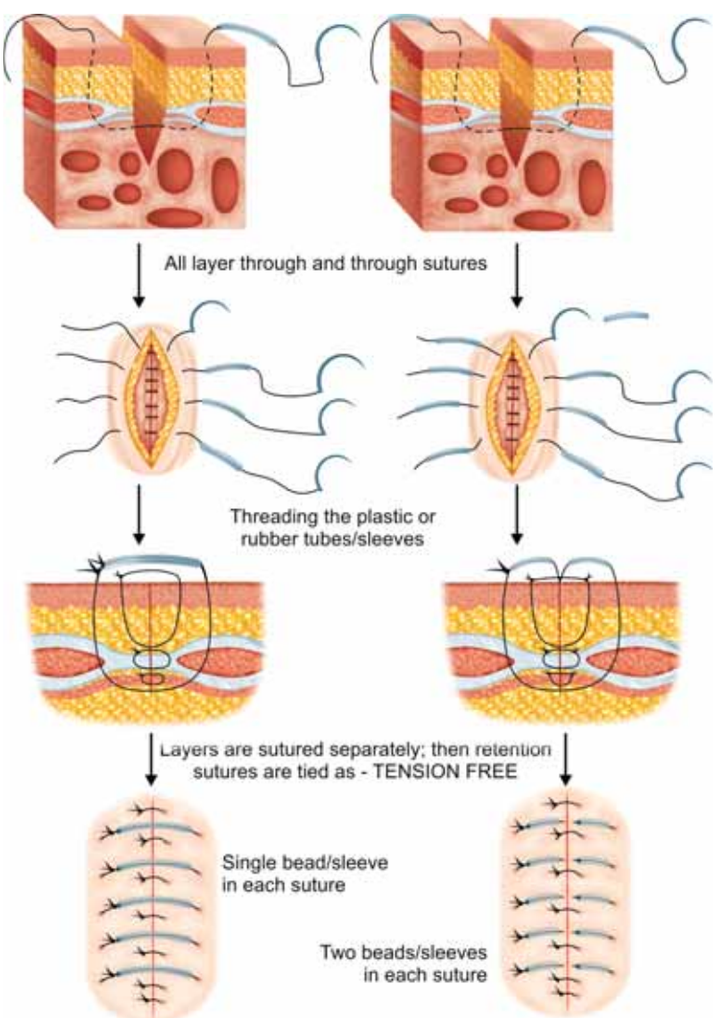

All layer through and through sutures
Threading the plastic or rubber tubes/sleeves
Layers are sutured separately; then retention sutures are tied as - TENSION FREE
Single bead/sleeve in each suture
Two beads/sleeves in each suture

Fig. 18-43: Retention sutures.

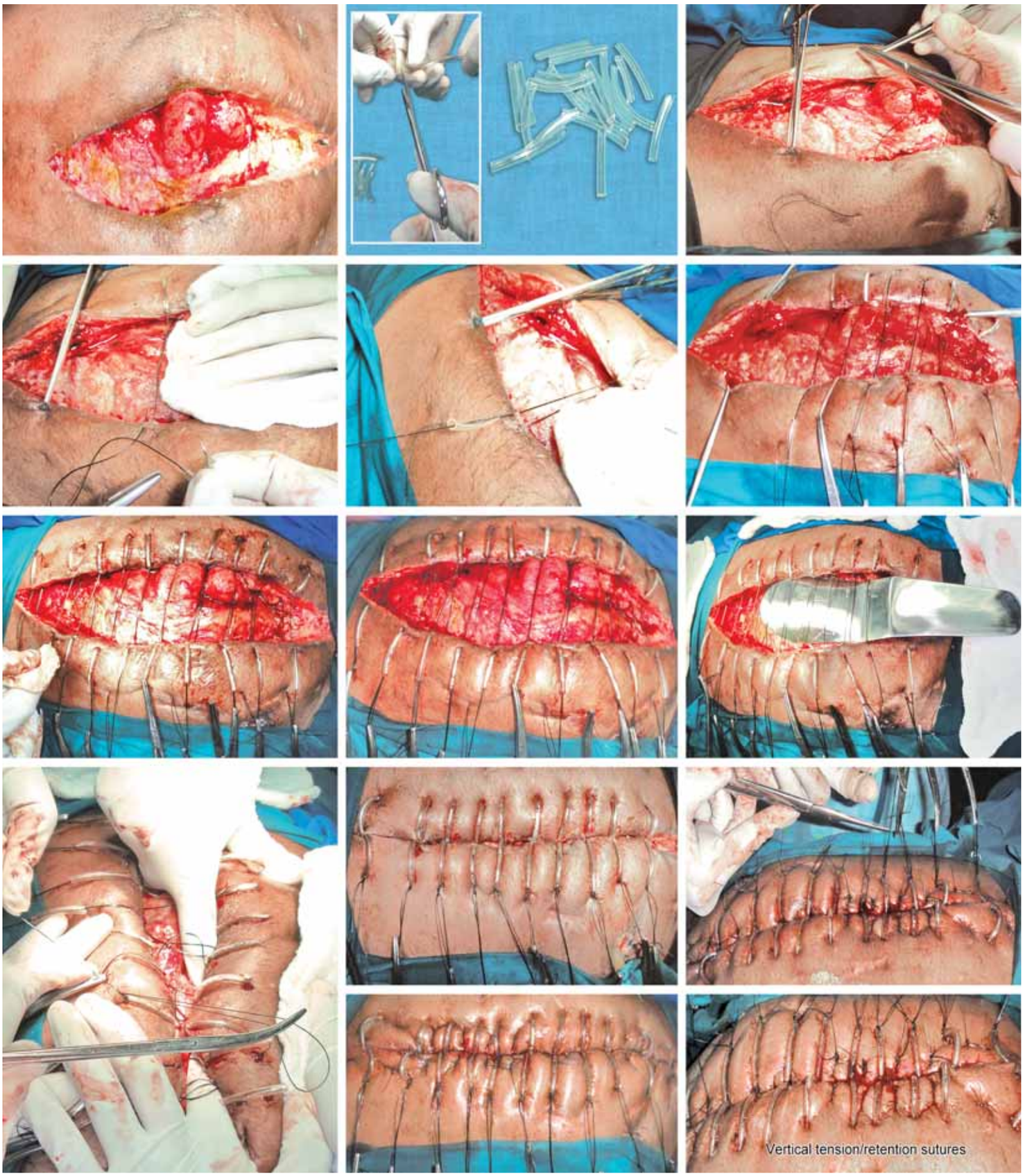


Fig. 18-44: Burst abdomen – placing retention/tension sutures using monofilament nonabsorbable sutures.

Note

Continuous sutures are started from far point of the wound towards surgeon.
Forehand suturing is better during closure which makes shoulder, arm and wrist less straining allowing surgeon to do more precise firm strong sutures at specified sites. Here forearm moves from pronated to supinated position.
In *backhand suturing*, supinated hand rotates to pronated position; here needle should be directed towards surgeon's right foot (right hand surgeon).
Scalpel incision and dissection needs backhand movement.
Proper foot positioning is important in various levels of suturing to make suturing easier and perfect.
During scissor dissection, scissor tip should be directed towards surgeon's left foot.
By changing the body and foot position in perpendicular direction (parallel to table) forehand movement can be used in all forehand suturing.
Left foot of the surgeon should be more close to the operating table; right foot should be more lateral.
All instruments should be held in fingertip position.
Instruments should be held with finger grip rather than tight vise grip. Relaxed wrist movements are essential to avoid wrist tremors.
When suturing comes towards the end of the abdominal wound; last few sutures should not be tied if they are interrupted or last few bites and their loops is kept loose until last bite is taken to avoid injury to deeper structures (bowel).
Suture bite and stitch should not be taken blindly without seeing the tip (point) of the needle at all the time.
Optimum tension only used; excessive tension should be avoided.

ABDOMINAL RETRACTORS

Retractors are essential for all abdominal surgeries. Simple Langenbeck to complex self retaining chain retractors are used in various procedures. Retraction facilitates the surgery in the deeper plane.

Self-retaining or Manual Retractors

Manual retractor is held by assistant constantly. It fatigues the assistant in lengthy procedures and retraction varies depends on the assistant who holds the retractor. But retractor can be temporarily relaxed when not needed so that tissues underneath (muscle) can be allowed to relax in between to reduce crushing effects on the muscle mass. Its position is adjustable in time to time.

Self-retaining retractors are either fixed through its own beams or bars or through a specialised devices strong chain or handle to the side beam of the operation table. They are continuous non-altering (in-position) mechanical retractors. These self-retaining retractors allow assistant's hands to be free for other works like suctioning, passing ligatures, cauterising, etc. But self-retaining retractors may cause more damage to the muscle as retraction is persistent and constant for long period. *Upper hand retractor* is often used with a steel bridge which is attached to both sides of the operating table crossing across the sternum at 5 – 10 cm height. Retractor blades are placed and fixed on to this steel bridge to facilitate the retraction at the operating site **(Figs 18-45 to 18-47)**.

Precautions

While using the retractor care should be taken to avoid entangling of the vital structures bowel, soft tissues, organs, etc.

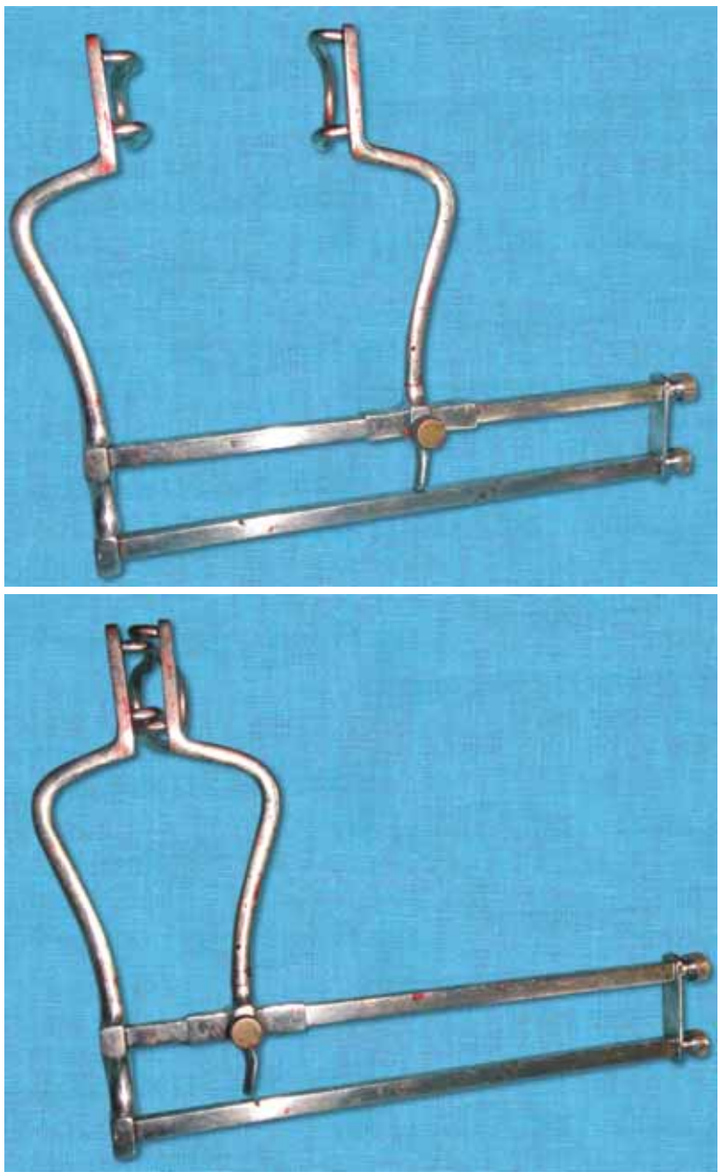


Fig. 18-45: Balfour's self-retaining retractor.

Undue retraction may injure the wound edges leading into wound infection, dehiscence, etc.

Deeper ends of the retractors may not be visible and often assistant won't be having proper control on it allowing ends of the retractors to injure organs like liver or spleen.

It is often better to place a mop underneath the deep retractor to avoid injury to organs underneath.

DRAINS IN LAPAROTOMY

Even though advantages are under *debate and controversial*, drain is used to prevent the collection in dead space; to allow the escape of fluid or air from the cavities; to prevent infection; to promote healing.

When there is an abscess or pus inside peritoneal cavity, drain is a must. Here it is therapeutic. Drains commonly advocated are tube drains which are connected outside to a sterile bag or container. Drains placed in other situations are rather prophylactic.

Drain is placed to allow escape of bile, pancreatic and intestinal juices, lymph, serum, blood and pus from peritoneal cavity. Drain

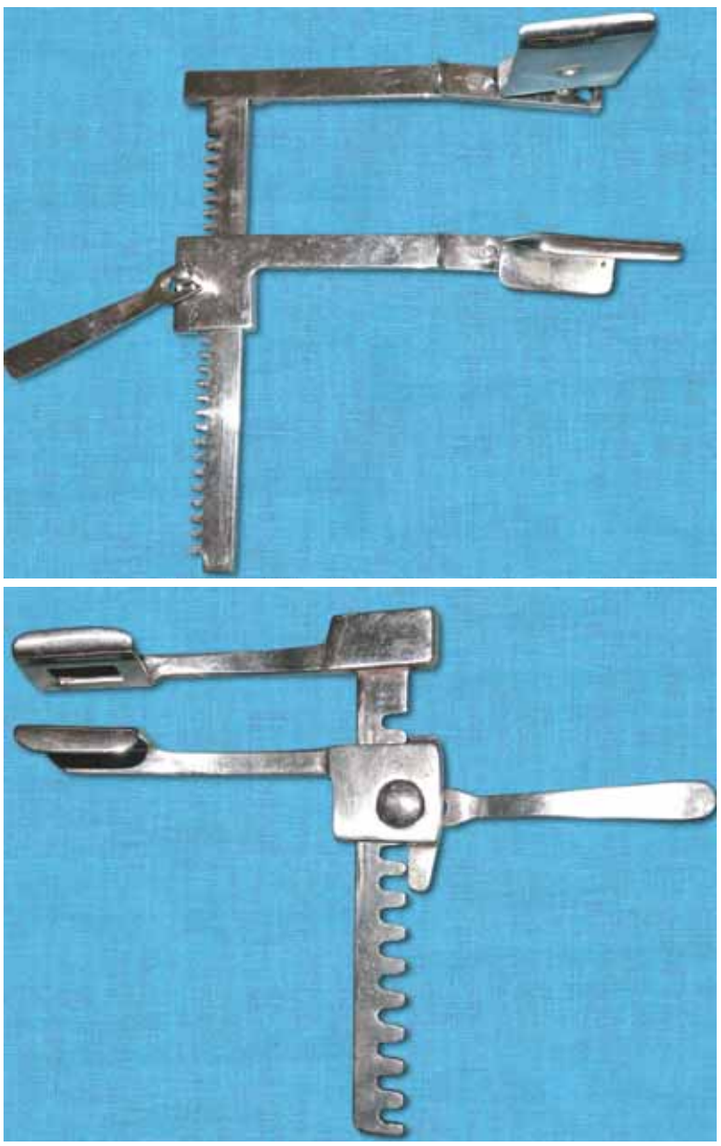


Fig. 18-46: Finochietto retractor.

Fig. 18-47: Mop should be kept under retractor to prevent trauma to the viscera.

Fig. 18-48: Corrugated drain is a passive drain which drains by gravity and capillary action. It is rather an overflow.

creates a track and walls off the leaking/infected site from peritoneal cavity and so prevents the spread of infection. This is said to promote the healing of the area, preventing the sepsis by fluid collection. It is no doubt that it is useful in sepsis, peritonitis, and in abscess. Prophylactic peritoneal drainage is controversial even though it is done in anticipation of possible disruption of the anastomotic site and so that to reduce its dangerous consequences. Drain creates a controlled fistula so that peritoneal cavity is safeguarded from sepsis or contamination. But concept of drain preventing wound infection and promoting faster wound healing is questioned/disproved? Drain as a foreign body action, can be a focus for infection from outside. Drain may erode vessels, bowel or organs.

Drains may be passive or active. *Passive drain* like Penrose or corrugate function depending on the pressure difference between inside and outside abdominal cavity and high pressure inside forces the fluid outside. *Active drains* use low or high negative pressure (suction) to remove accumulated fluid from a wound. Active drains require some special device and maintenance. The collection reservoir of an active drain expands as fluid is collected by exchanging negative pressure for fluid; if the vacuum is lost, the drain will lose its effectiveness. The fluid collection reservoir is either a manually activated, or through bulb evacuator or a spring-loaded device that has variable preset suction levels.

Drains may be *closed or open system*. Drains may be allowed to function naturally by gravity or by capillary action (corrugated drain) or by suction device. It may be connected to wall suction to have continuous or intermittent vacuum suction in wounds.

Drain should be observed daily for its nature and volume of content accurately. Depending on the quantity of the drain, duration of keeping the drain in situ is decided. Open drains like Penrose and corrugated should have protective dressings over it. Amount of soiling should be assessed for possible quantity of drainage and type – bile/faecal/serous/serosanguineous/purulent/gastric.

Passive Drains

Passive drains even though used by many surgeons, are not very suitable as their efficacy is inadequate and complications are more. Penrose drain and corrugated rubber drains are commonly used. Tube drains like Malecot's/Foley's catheters/nasogastric tubes are also often used for this purpose. Flat drains outside are covered by dressing pads. Tube drains are connected to sterile container (urosac bag) or sterile glove outside. Tube drains are better than flat drains **(Figs 18-48 to 18-50)**.

Penrose Drain

A *Penrose drain* is a named for the American gynecologist Charles Bingham Penrose (1862–1925), placed in a wound to drain fluid. It consists of a soft rubber tube placed in a wound area, to prevent the buildup of fluid. It is a passive open drainage system. A Penrose drain removes fluid from a wound area. It is used after a surgical procedure is complete to prevent the area from accumulating fluid, such as blood, which could serve as a medium for bacterial infection. In podiatry (diseases and management of foot diseases), a Penrose drain is often used as a tourniquet during a nail excision or ingrown toenail excision. It can also be used to drain CSF in a hydrocephalus patient. It is a quadrangular flat tube made up of radiopaque thin rubber sheet. It is available as prepacked sterile drain with a safety pin. Safety pin prevents drain getting retracted into the wound while in use. Head of the safety pin should be crimped and closed to prevent injuring the patient's skin. Different sized Penrose drains are available. Multiple Penrose tubes can be placed. It is inexpensive and creates fibrosis to form a tract in 10 days. It drains passively by mere gravity and overflow. In oozing area blood may clot and block the drain. Infection into the area from outside is a possible drawback **(Fig. 18-51)**.

Fig. 18-49: Tube drains placed in the peritoneal cavity.

Fig. 18-50: Tube drain placed in biliary surgery. Note the bile collected in the reservoir bag (urosac).

Active (Negative Pressure) Drains

Negative pressure causes – continuous wound cleaning thereby decrease the bacterial burden in the wound, remove substances that inhibit wound healing; promotes continuous removal of fluid like exudates so that prevents the mechanical compression by accumulated exudates into the capillaries at the site which restricts the flow of blood into wound site; causes wound retraction and approximation of wound edges; creates externally applied mechanical stress in the tissues stimulating matrix synthesis and cell proliferation; promotes healthy granulation tissue formation; decreases interstitial oedema which improves the blood flow.

Negative Pressure Wound Therapy

It is used in infected wounds often in abdominal wall. It creates continuous or intermittent suction of the wound content to keep the wound surface drain which promotes formation of healthy granulation tissue and so wound healing.

Low Pressure Vacuum Drain

Low-pressure vacuum drains have a plastic bulb-shaped reservoir or spring reservoir and a drainage tube (Jackson-Pratt or Romovac), with multiple side holes in the end of the tubing that is inserted into the wound. When the bulb is compressed, air is forced out, which creates low negative pressure to evacuate excess fluid and air gently **(Fig. 18-52)**.

Fig. 18-51: Penrose drain.

Fig. 18-52: Low suction drain.

Jackson-Pratt Drain

It is often called as *JP drain*/bulb drain is the flexible plastic tube which connects to an internal plastic drainage tube; it drains excess fluid by constant low suctioning. Due to low pressure vacuum system, intraabdominal contents like omentum and bowel will not get sucked through the drain thus preventing the possibility of ischaemia of bowel and perforation. Air pressure within the drainage system is removed by removing the plug and squeezing the bulb. Drain is kept folded during uncapping and recapping.

High Negative Pressure Vacuum Drains

They are sealed, closed circuit drain systems (bottled vacuum system) that are easily monitored and allow safe disposal of the drainage. This type of system consists of a clear, plastic/bottled reservoir with a rubber cap and indicator wings that monitor the presence of vacuum pressure and an opening in which the drainage tube connects. When a vacuum is present in the system, the wings on the rubber cap are close together; when the vacuum is lost, the wings are apart. The end of the drainage tube inserted in the wound has numerous openings to evacuate fluid from the wound. The wound should be closed before opening the clamps on the drain; otherwise the vacuum will be lost as the tube pulls in atmospheric air. Bottled vacuum drains are available **(Fig. 18-53)**.

Drain Insertion

Technique of insertion of drain is important. When a drain is required, it is inserted at the end of the surgical procedure just prior to closure of the wound. Drain is inserted through a separate stab wound, which is created a few centimeters away from the primary incision which reduces the risk of a postoperative wound infection and dehiscence. Skin incision for drain is usually made at anterior axillary line. Incision is usually of within 1 cm in length, transversely placed. Drain should not be inserted towards posterior side as supine position of the patient may be difficult and also drain may get kinked preventing its function.

Drain that has a sharp trocar attached to the tube is inserted by piercing the attached trocar to the skin from inside the wound/peritoneal cavity at the desired site; the attached tube is then pulled out through the stab wound; the inner end of the tube is placed at the required site and the trocar is detached. Drain is secured into skin with proper suture (shoe lace suture). Once the wound is closed, tube is connected to the reservoir; suction is attached to facilitate the drainage.

Drains that do not have an attached trocar is placed by passing a long haemostat across the abdominal wall from inside out and skin over it is incised using a scalpel to allow tip of the haemostat to come out which is opened and drain is passed by holding through the haemostat towards inside. Drain is placed in desired location and is fixed to skin securely. Once wound is closed, the drain tube is connected to a reservoir.

Drain without trocar can often also be inserted from outside in. Skin is incised first at separate site from primary incision. Long curved haemostat is gently forced with rotation movements inside into the peritoneal cavity while surgeon or assistant's one of the hands should keep bowel away from the site of puncture and guides the tip of long haemostat inside the cavity. Once peritoneum is punctured drain is held and pulled out under vision to prevent entangling of any content into the drain site wound **(Fig. 18-54)**.

Complications of the Drain

Drain may cause retrograde bacterial contamination of the abdominal cavity. Drain may erode into the bowel or vessels. Drain acts as a foreign body. Suction drain may suck the bowel or omentum. Drain site after removal forms a puckered scar due to healing by secondary intention. Breakage of drain can occur and inner broken part may be left inside which can cause sepsis. Breakage usually occurs only if drain used is already damaged due to nick by scissor or scalpel. Damaged drain should never be used.

While inserting the drain, injury to bowel or vessel can occur and so care should be taken.

Drain may get blocked giving false impression of healing inside. Blocked drain when suspected should be checked properly either by irrigating the tube with saline or changing the position of the drain. Drain tube can be gently squeezed and released at different points to remove small clogging. If it is presumed that already track is formed then drain can be removed and a newer blunt tipped (Foley's) tube drain can be gently replaced with care along the same tract.

Pain and discomfort at the drain site is common which often hinders the early mobilisation of the patient.

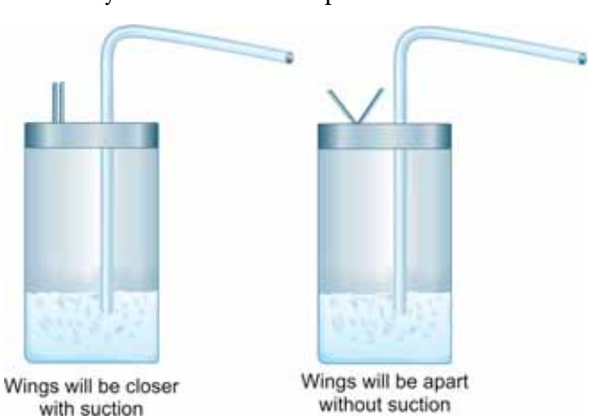


Fig. 18-53: High vacuum suction device. When vacuum is present, wings will be closer together; when vacuum is not present wings will be apart.

Fig. 18-54: Insertion of drainage tube (without trocar) into the peritoneal cavity.

Drain may fall of on its own either by insecure fixation or by pulling by patient himself. In such situation first thing to be confirmed is whether drain has come out completely or not should be checked. If part of the drain is left inside, then formal exploration of drain site wound into deeper plane is needed to remove the retained part of the drain.

Inadvertent pulling of drain while transferring the patient or by entangling into linen or clothes or by patient himself may cause bleeding and pain.

Skin around drain site may get excoriated with redness and pain. Often leak occurs on the side of the drain. Skin in such situation around the drain should be dressed using zinc oxide cream.

When drain is kept for long time removal may be difficult due to adhesions and entrapment into the tissue. In such situation exploration at the site may be required to remove the drain.

Drainage may suddenly stop or suddenly increase which should be assessed seriously for the proper cause. It may be more leak or blockage or erosion. Change in colour and odour after more drainage is also important to be noticed. Nowadays drains commonly used are radiopaque, X-ray of part or ultrasound helps in finding out the cause, site of drain or any collection. Often contrast CT imaging maybe required to reassess the situation.

Since drain is passed across the fascial plane, drain site hernia can occur. If pathology in the deeper plane or distal obstruction persists then leak at the drain site may occur.

Removal of Drains

Drains should be removed once purpose is served. Drain placed to cover preoperative bleeding is removed in 48 hours; to drain serous collections it is removed in 2-5 days; in intestinal anastomosis it is removed in 7 days; T tube is removed in 10-14 days. If leak persists it is kept until leak stops after confirmation that source is cleared by imaging method. Drains are removed when draining is of negligible amount (less than 25 ml per day; less than 1 ml per hour).

Skin suture (stay suture) is cut using sterile scissor and drain is gently pulled using continuous constant traction. Drain wound is covered with sterile dressing. Wound usually heals fast without any problem. If drain wound site shows large quantity of drainage then stoma bag can be placed until drainage of fluid stops.

BASIC LAPAROSCOPY

In laparoscopic surgery the prime difference of indirect access to the internal structures means that we have to acquire different set of skills to tackle the given surgical problem. Since there is no open access to the viscera it is very important to have the right kind of instrumentation before we embark on doing laparoscopic surgery. As the most versatile of all the working instruments, the surgeons "hand" is out of bound. Knowing about few technical details about laparoscopic instrumentation helps a long way as often in the operating room the surgeon knows best about electronic equipment. This also ensures proper handling of the expensive equipment and prolongs the life of the same.

History of Laparoscopic Surgery

First laparoscopic cholecystectomy was done by Muhe of Germany in 1985 and by Mouret in Lyon in 1987. McKeran and Saye performed the first laparoscopic cholecystectomy in USA in 1988. First laparoscopic appendicectomy was done by Semm as prophylaxis. First laparoscopic appendicectomy for acute appendicitis was done by Schreiber in 1987.

Semm changed 75% open gynaecological surgeries into laparoscopic surgeries.

Prof TE Udwadia, Mumbai did first laparoscopic cholecystectomy in India.

Advantages of Laparoscopic Surgery

It is relatively less painful compared to open surgery. Trauma of access is very less. Shorter hospital stay and early return to work; faster postoperative recovery; better visualisation of the anatomy, i.e. better approach for dissection and visualisation of other parts of abdomen for any other pathology; instrumental access to different abdominal locations is many times better compared to open method and minimal scar on the abdomen – makes laparoscopy more acceptable than open method. Trauma of dissection is also less. Bowel manipulation and exposure is less. Less postoperative ileus facilitates early feeding. Need for intravenous infusion and analgesic is lesser.

Instruments Used

- *Zero* degree laparoscope is commonly used. Side viewing scopes are also used to have better visualisation 30°.
- Cold lights source either halogen lamp or Xenon lamp is used. Halogen lamp is used commonly and is cheaper. Xenon lamp gives high visualisation.
- Camera: 3 chip camera is commonly used with high resolution.
- Video-monitor to display images.
- CO_2 insufflator.
- Long fine dissectors like in open surgical techniques.
- Hooks and spatulas are used along with cautery for dissection.
- Clip applicators.
- Needle holders.
- Endostaplers.
- Veress needle.
- Suction-irrigation apparatus.
- Trocars of different sizes—10 mm, 5 mm.
- Reducers to negotiate smaller instruments through larger parts.

LAPAROSCOPIC SET

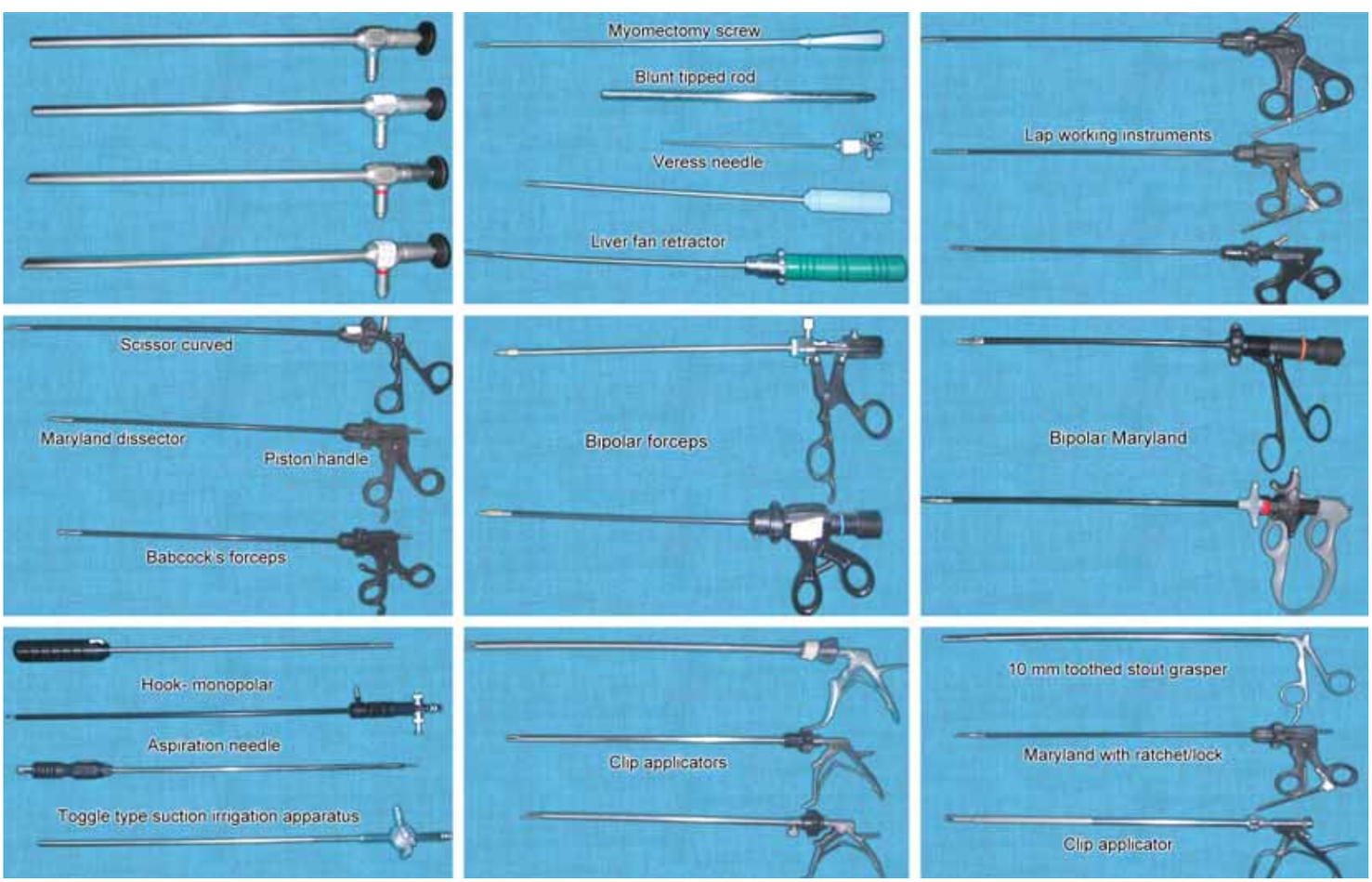
The most basic to the best equipment shall be briefly described for the reader to get over all picture of equipment. The laparoscopy set up consists of 5 important components.

1. Laparoscopy camera and telescope.
2. Light source and cable.
3. Carbon dioxide insufflator.
4. Monitor.
5. Hand instruments **(Fig. 18-55)**.

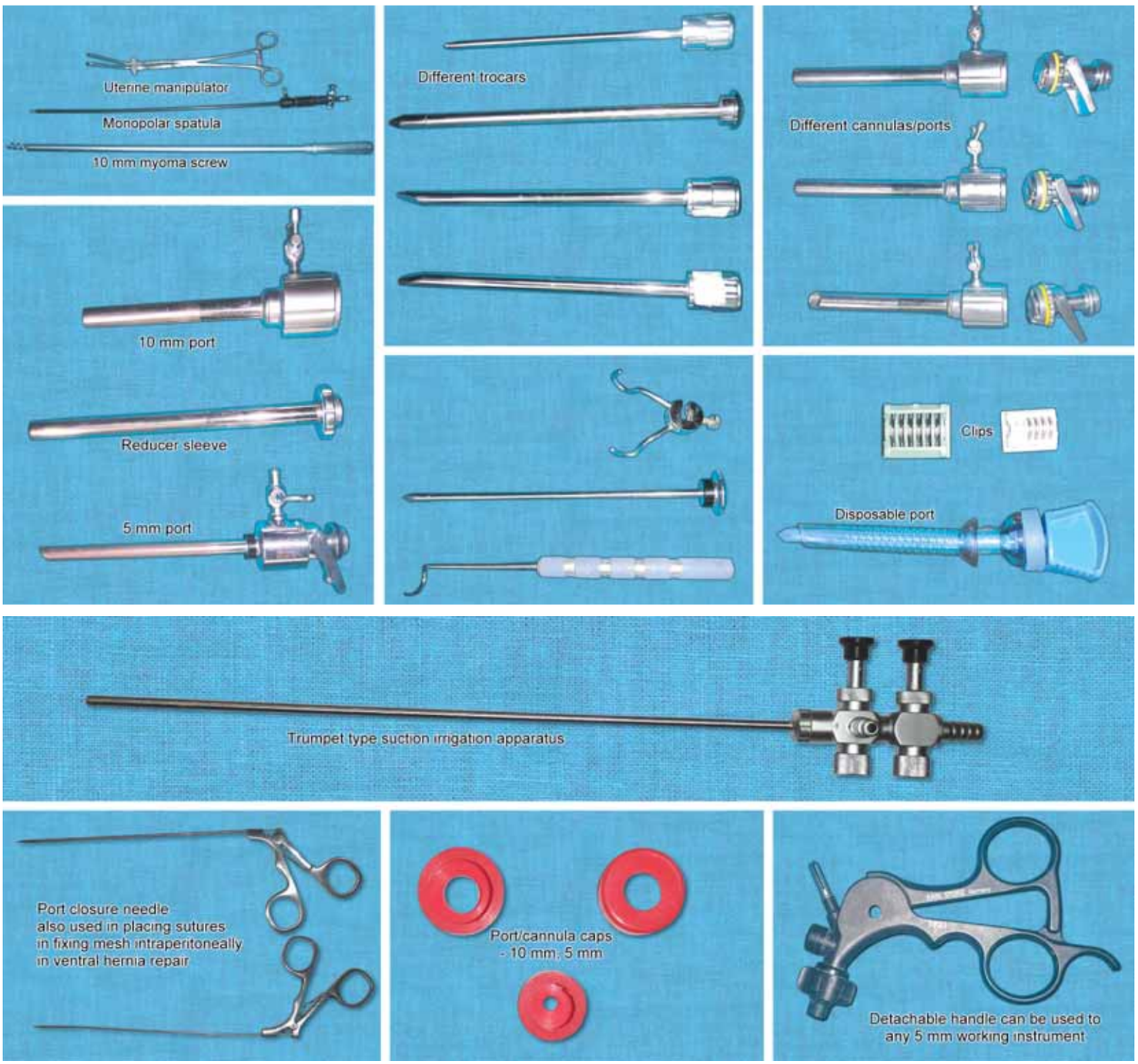
Laparoscopy Camera and Telescope

The laparoscopic camera is like the retina for perception of images during surgery. Without a good camera it is dangerous to embark upon laparoscopic surgery as there cannot be safe surgery without clear vision of the structure on which you operate. The laparoscopic camera has three different components.

a. Camera head
b. Coupler
c. Connector



Figs 18-55(1)



Figs 18-55(2)

Figs 18-55(1 and 2): Different instruments used in laparoscopic surgery.

Camera Head

As mentioned already the camera is the most important component of the equipment which makes the procedure comfortable for the surgeon and safe for the patient. The camera is responsible for production of quality pictures in all dimensions such as clarity, colour reproduction and contrast. The light reflected from the viscera is captured by the camera head and is transmitted to the console via the connecting cable. The camera head contains what is termed as charged coupled device or CCD. This chip perceives light and converts the signal into digital form. The basic cameras contain only a single chip or CCD which perceives light as a whole without dividing it into its component red, green and blue light like in a 3 CCD *(Charged Coupled Device)* camera. The resolution of a 3 chip camera is better because the 3 chips individually produce pixels thus increasing the resolution from 470 lines (single chip) to up to 1080 lines which is HD (high definition) quality. Single monochrome CCD chip creates alternate red, green and blue illumination to form a colour image; 3 chip camera has got three separate colour filters which create high quality image with better resolution. Higher resolution can make a difference between a good

surgery and a great one only in the hands of an expert with sufficient skills and while performing advanced procedures. For day to day practice and for small set ups latest generation single chip camera is adequate. Karl Storz single chip camera and Stryker single chip cameras are the more popular ones but there are always other makes available.

Monitor resolution needs 400-600 lines. White balancing should be done before introduction of the camera into the abdominal cavity. With light source on Camera with telescope is focused on a white gauze and white balance button in the camera source is pressed until 'white balancing is complete' sentence appears on the monitor. Zoom adjustment also can be done in the camera **(Fig. 18-56)**.

A good camera is always complemented by a good telescope/laparoscope. This is akin to the lens of the eye. The clearer the optics of the lens of the telescope better is the vision. A poor telescope with improper optics makes the picture look bad and the illumination is inadequate. The telescope incorporates the Hopkins rod lens system where in the sheath of the telescope is packed with series of glass lens with air pockets intervening to produce magnified images at the opposite end. The rod lens system is surrounded by optic fibres carrying light from the camera end to the tip of the telescope. If these optical fibres are damaged then the illumination produced at the distal end is poor. Telescopes are available in a variety of diameters and in different forward viewing angles.

Semiflexible and flexible laparoscopes are available. It may be *conventional fibre optic flexible type* but in which image undergoes distortion. In newer type, *digital monochrome CCD single chip camera* is used wherein image is changed to electric signals which maintain the image quality high. It increases vision four ways improving the viewing angles.

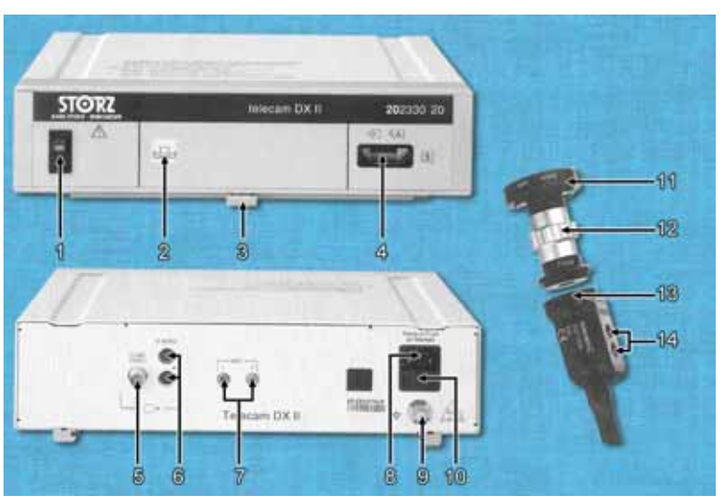


Fig. 18-56: Single Chip camera Karl Storz.

1. Power switch.
2. Automatic white balance.
3. Abridged instructions.
4. Camera cable receptacle.
5. BNC video output connector.
6. S- Video output connector.
7. Accessory control outputs.
8. Power cord receptacle.
9. Potential equalization connector.
10. Power fuse holder.
11. Grasping mechanism.
12. Focusing ring.
13. C-Mount connection.
14. User control buttons.

Telescope/Laparoscope

In 1952 Hopkins British physicist invented the laparoscope. Originally conventional lenses were used separated by air gaps which give poor quality images. Present laparoscope has got rod lens system with an outer rim of optical fibre. Light is passed through the optical fibres inside the cavity and image is transmitted through rod lens system to the camera which is processed there and projected at monitor. 10 mm scopes are commonly used either end viewing or side viewing. 5 mm scope transmits lesser light (10-30% of 10 mm scope). 3mm scope is used in paediatric surgery. 2 mm scope is also available.

Cold laparoscope when introduced into the peritoneal cavity, *fogging* of the lens at the end of the telescope occurs (it is also due to passage of the cold CO_2 through camera port) which is prevented by dipping the tip of telescope into warm saline kept in a thermo flask. Cleaning the tip using warm saline soaked gauze and povidone iodine solution prevents this problem. Antifogging solutions, electric warmer flasks are available. Once other ports are placed it is better to change the CO_2 insufflation tube to one of the other ports **(Fig. 18-57)**.

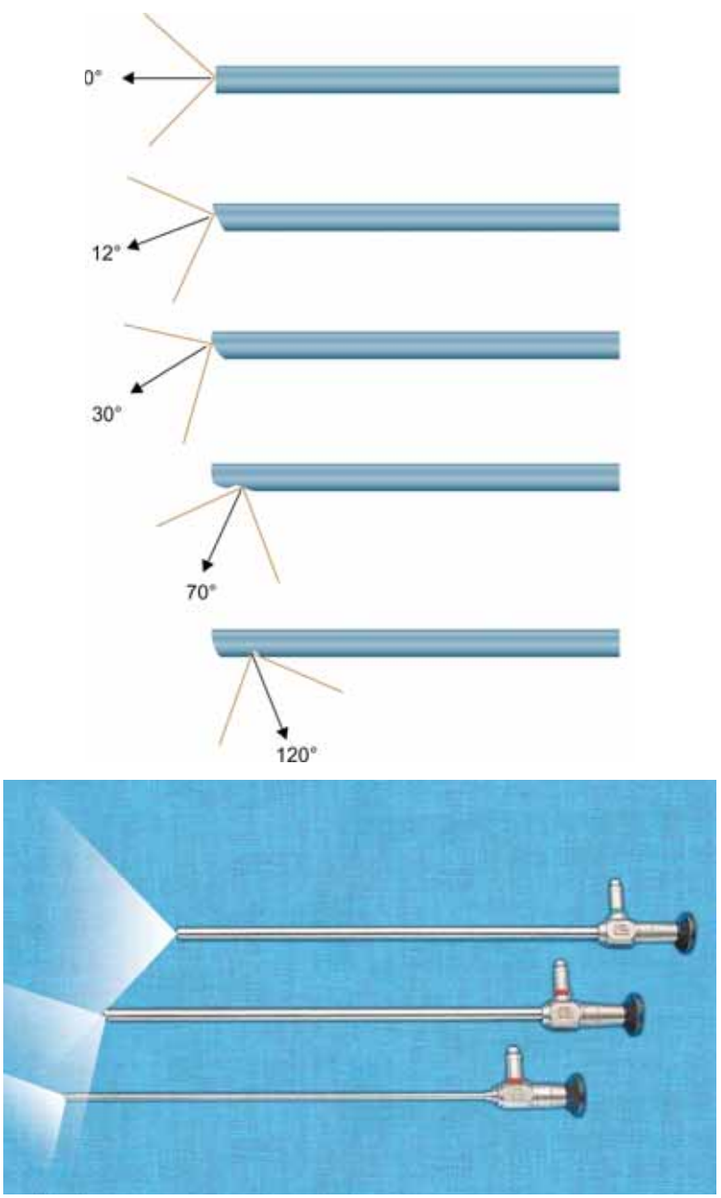


Fig. 18-57: Telescopes of various diameters and viewing angles.

Commonly used in basic surgeries is the 10 mm 0 degree (end on viewing) telescope. This is a versatile telescope and can be handled by a scrub nurse as well. The 30 degree oblique viewing telescope is good for viewing the Calot's triangle during posterior dissection and also in viewing the lateral sides during TEP (Total extra peritoneal) inguinal hernia repairs. They are also used for dissection at gastro-esophageal junction and rectal mobilisation. Suturing is better aided by 30° telescope. 45 degree oblique viewing scopes are commonly used in bariatric surgeries. The usual working length of the telescopes is around 330 mm. The telescopes used in bariatric surgeries can be up to 450 mm in length to provide access to stomach at a depth. 5 mm diameter laparoscopes are used in patients according to the convenience of the operating surgeon. This further reduces the size of the umbilical incision. Although the light transmitted via the 5 mm telescope is only 10% of that transmitted by a 10 mm telescope, a good camera and suitable monitor can provide a clear operating field. A 3 *CCD (Charged Coupled Device)* camera and xenon light source are good enough to produce clear pictures even in a 2 mm needle scope. These scopes are used for entry site port in paediatric cases and in patients with previous laparotomy wounds.

Light Source and Cable

Having a good light source is a priority as the entire surgery is dependent on the images received on the monitor. It is an important component of the triad of camera, light source and monitor. For performing safe surgery visualization of structures in its best colour contrast is essential. For this white light produced by a *xenon light source is best*. The light source is composed of replaceable bulb, a heat filter (as the light is condensed by a lens before output, the temperature generated at the tip can be as high as 6000K in xenon lamps) and an intensity control. Depending on the make of the light source the intensity of the light can be either manually or automatically controlled. The average life of the xenon bulb is around 500 hours and some light sources even track the life of the bulb. Xenon lamps are of either 175 or 300 Watts. 300 Watts is ideal and standard. Even though xenon light source is cold light source it produces significant heat at the tip of the telescope and hence tip should not touch bowel, vessels, drapes and skin as burn injury and its dangerous consequences can occur. *Halogen light sources* are country cousins of xenon sources. They are inexpensive and can be acquired for a fraction of the cost. The main disadvantage is the yellow colour of the light that is produced. The field appears yellow and the distinction of vessels becomes difficult in cases such as cholecystectomies. Besides this the intensity of the light is less compares to xenon and the peripheries of the visual field are much darker making identification of structures difficult. Halogen light sources can be used for performing diagnostic laparoscopy and laparoscopic appendectomies but xenon light source is recommended for doing cholecystectomies and inguinal hernia repairs **(Fig. 18-58)**.

Transmission of the light from the source to the telescope is equally important. Two types of light cables are available for use:

1. Fibre optic cable.
2. Fluid filled/ gel filled cable.

The fibre optic cable is used frequently. Multiple tiny fibre optic cable are bundled together to transmit light. The individual fibre optic cables are fragile and during use there is gradual loss for fibres thus ending the useful life of the cable. This can be assessed by pointing the light at white surface and observing for the dark spots within the field. It is recommended that the light cable be changed if there is loss of more than 20% of the optical fibres in the bundle. The tip of the light cable becomes extremely hot after a while and due precaution should be taken while handling it to prevent burn injury to the patient or operating staff. Transparent case around the optical fibres makes fibres visible for any damage.

The fluid or gel filled cable transmits more light than the fibre optic cable but also has the disadvantage of transmitting more heat and being more fragile and difficult to handle than the fibre optic cable. It is also more expensive than the fibre optic cable. It cannot be sterilized by autoclave; it shows poor flexibility and fragile and so causes difficulty in manoeuvring the camera.

Carbon Dioxide Insufflator

Creation of pneumoperitoneum is the first step in any laparoscopic surgery. Although gasless laparoscopy can be performed, pneumoperitoneum causes fewer traumas and the equipment is easily available and easy to use. Carbon dioxide is ideally suited as it is non-combustible, absorbed by the body, inexpensive and easily available. Air insufflators have been used by many and are still being used by few but carbon dioxide insufflators are safer for the patient as there is risk of air embolism if there is any injury to vascular structures during the procedure. The standard insufflators has an indicator for amount of CO_2 present in the cylinder. It is wise to know the stock of your CO_2 cylinder before proceeding as it avoids the embarrassing situation where the case is converted due to empty CO_2 cylinder **(Fig. 18-59)**.

Fig. 18-58: Karl Storz Xenon light source.

Fig. 18-59: Karl Storz Thermoflator.

There are three indicators in the console. First one denotes the intra-abdominal pressure with setting. This can be set from 0 to 25 mmHg in most insufflators. The usual intra-abdominal setting used is of 12 mmHg. Higher pressure setting may be used in case of TEP hernia repair to maintain the pre-peritoneal space. The calibration of the instruments is required for patient's safety point of view as the cut off flow of CO_2 at set pressure is important. The second indicator is for the flow rate. The flow rate can be set from 0 to 16, 25, or even 40 with high flow insufflators. For routine procedures a 16 lt/min insufflator is adequate although some prefer high flow insufflator for TEP hernia repair, one can manage to successfully perform the surgery with 16 lt/min insufflator. The third indicator is for the total amount of CO_2 used for the particular case. In addition to these standard indicators some newer insufflators has come with additional feature of warming the carbon dioxide to body temperature before it enters the abdomen. This reduces the temperature difference when the telescope is introduced into the abdomen thus preventing fogging of the telescope.

Monitors

The final picture emerging out of a good telescope and camera is complemented by a suitable medical monitor. For a single chip camera which produces images of resolution of around 470 lines, a standard monitor of resolution around 400 lines and above is required. This can easily be substituted by use of our regular television sets. Although a 14 inch colour television is adequate, a 21 inch flat television increases comfort level of the surgeon and the team. For the 3CCD cameras however the television monitor is not adequate as the camera produces up to 1080 lines (HD) and the picture would not translate well on ordinary television. A HD television or a HD monitor is required for a three chip camera to produce best results with a resolution of > 1600 lines. Various types of output signals are delivered out of the camera console. There are RGB out, Y/C out, S video out, composite out and some camera consoles even have a USB out so they can be directly connected to a computer or laptop. Commonly used are composite or RGB out for connecting a television monitor and S video out to connect to a medical monitor. Presence of a USB out can make digital recording of the surgical procedure very simple and inexpensive. A parallel out to the computer allows for recording in the computer thus eliminating the need for a separate recording device.

Hand Instruments

Once the main consoles of the laparoscopy set are arranged we turn out attention to hand instruments. They are available in various makes and qualities. Imported as well as locally manufactured indigenous instruments are available. Imported instruments such as those provided by Karl Storz although expensive lasts very long without any problems and in the long run are better value for money than the local instruments. However, the locally made instruments are inexpensive and can be replaced with ease in case of any problem. Trocars and often instruments are available as disposable and reusable. Disposable trocars are single use precise one making insertion of trocar very easy, quick and perfect.

Following is an indicative list of instruments suggested for basic laparoscopic surgeries:

1. Veress needle.
2. Trocars
   10 mm – 2 in number
   5 mm – 2 in number
3. Reducer sleeve 10 mm to 5 mm.
4. Maryland dissector.
5. Atraumatic grasper (Universal grasper) 5 mm.
6. Traumatic (Toothed) grasper 5 mm.
7. Gallbladder extracting forceps 10 mm.
8. Curved scissors 5 mm.
9. Suction irrigation system 5 mm/10 mm
10. Clip applicator for LT300/ LT400
11. Monopolar hook and spatula
12. Aspiration needle.
13. Bipolar forceps.
14. Knot pusher.
15. Port closure needle (Optional).

Veress Needle

Veress needle was first developed in 1932 by *Janos Veress*, a Hungarian internist working with tuberculosis patients. At the time, one of the mainstays of treatment was to collapse an infected lung and allow lesions to heal. The needle was introduced as a safer technique to give patients such pneumothoraces. It was in 1938, he published his invention in the German literature. Veress needle is a spring locked needle with a cutting sheath and a blunt tip. It is 2 mm in external diameter and 12-15 cm in length usually. The outer cannula consists of a beveled needle point for cutting through tissues of the abdominal wall. A spring-loaded, inner stylet is positioned within the outer cannula. This inner stylet has a dull tip to protect any viscera from injury by the sharp, outer cannula. Direct pressure on the tip, when penetrating through tissues, pushes the blunt stylet into the shaft of the outer cannula. When the tip of the needle enters a space such as the peritoneal cavity, the blunt, inner stylet springs forward. *Parts are* – beveled needle; stylet; spring action part; lock for valve; head or knob proximally. Instrument should be held below the lock at proximal part of the needle as – guard position. Central sheath has got connector which connects to insufflation tube.

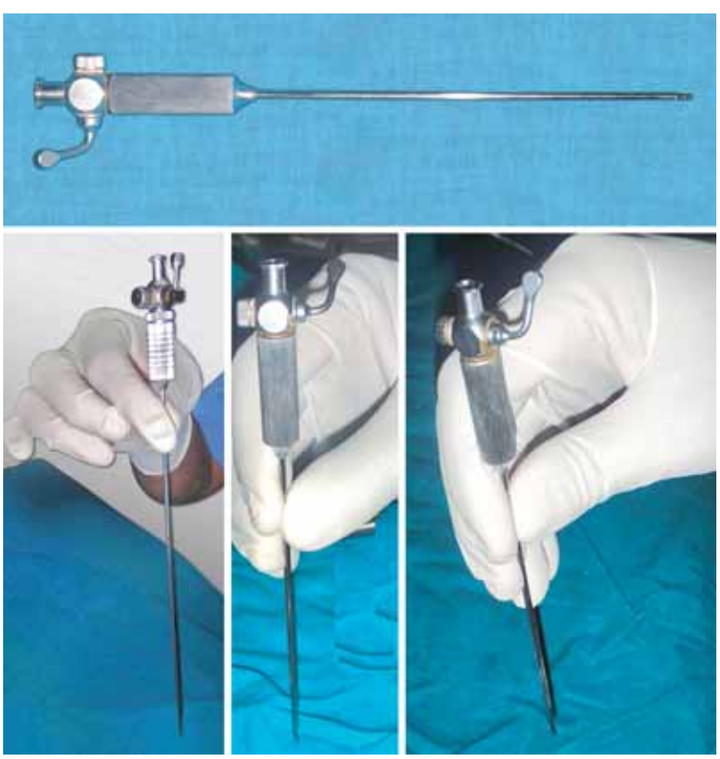


Fig. 18-60: Veress needle and methods of holding it.

http://dpebooks.ir

Veress needle is available at various diameters and lengths. It may be disposable or reusable **(Fig. 18-60)**.

It is used as closed method to access peritoneal cavity for laparoscopic procedure. Before using the Veress needle its patency should be checked by flushing it with saline. Spring mechanism has to be checked before every use. The spring action in the blunt tip prevents the sheath from injuring the viscera once it enters the peritoneal cavity. Lock for the valve should be in open position. Patient is in supine position as in this position bowel will be in uniform spread inside the peritoneal cavity (Many use Trendelenburg position with 15° tilt; but often it is presumed that bowel may come closure to umbilicus in this position). After making the subumbilical incision, Veress needle is passed inside across abdominal wall by holding it only slightly oblique, with other hand holding the abdominal wall forward to act initially as counter pressure. Abdominal wall should be held at the level of the umbilicus laterally (not very close to umbilicus) either one side or both sides or below. Assistant can help in holding the abdominal wall. Abdominal wall is held firmly using thenar eminence and fingers of the hand. Length of the needle needed is often assessed by finding the thickness of abdominal wall fat (thickness in cm + 4 cm conventionally). Veress needle should be held below the knob (*gurading position*), not at the head/knob. Initially needle is passed inside with 90° direction; later made obliquely. Often 45° oblique angle towards anus is also used to avoid injury to the major vessels. Passing through the layers of the abdominal wall – rectus sheath, transversalis fascia and peritoneum can be felt while pushing the needle. Once peritoneum is reached due to loss of resistance, blunt tip springs forward thus preventing injury to viscera and vessels. Two click sounds can be heard (if there is no noise in theatre) and felt; one during passage of the rectus sheath and other during forward springing of the blunt tip. With 5 ml syringe, initially aspiration through the needle is done to check for any blood or bowel contents will come or not. Then normal saline is flown by pressure using syringe into the needle and aspirated; if saline does not return then it is in the peritoneal cavity; if saline returns back that means needle tip is not inside the peritoneal cavity. Again drop wise saline is allowed to enter the proximal part of the Veress needle to confirm free entry of the saline into the peritoneal cavity (water/saline drop test; hanging drop test). Saline filled syringe can be connected to the Veress needle knob to observe free flow of the saline into the peritoneal cavity. Veress is connected to CO2 insufflator tube to create pneumoperitoneum. Veress needle will not allow insufflation flow more than 2.5 litre of CO_2 /minute. Veress needle should not be passed in close vicinity of the previous scar.

Confirmation of proper positioning of the Veress needle

- Two click sounds are heard and/or felt.
- Irrigation – aspiration method.
- Hanging drop test.
- Free flow of saline through a syringe.
- Through distension of abdomen while gas is on flow by confirming the resonant all over the abdomen

Note:

81% gynaecologists use Veress needle to create pneumoperitoneum (due to lax abdomen in females); whereas only 48% of surgeons use the same.

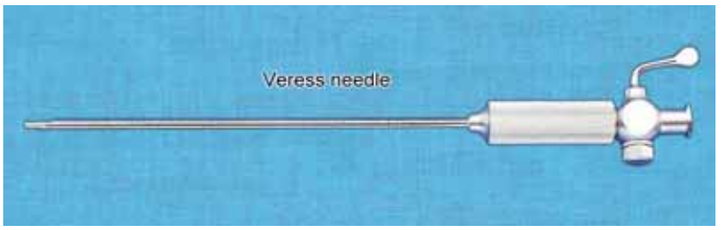


Fig. 18-61: Veress needle available in 120 mm and 150 mm lengths.

Veress needle can be used for port closure also. It is also used to pass stay suture to retract internal organs like in gallbladder in single incision laparoscopic surgery (SILS) or two port laparoscopic surgery **(Fig. 18-61)**.

Trocars

Trocars are needed to access the peritoneal cavity during the surgery and for maintaining pneumoperitoneum when the instruments are exchanged. Various types of trocars are now available. Commonly used are reusable trocars which can be autoclaved. The disposable ones are convenient to use but the cost factor has to be borne in mind. The trocar has an obturator with pyramidal cutting tip which pierces the sheath and muscle during entry. Bladeless trocars are available in disposable type which cause minimum damage to the muscle and leave a minimum defect on removal. Trocars are available in various sizes with outer diameter of 11 mm, 5.5 mm ones being used frequently in most procedures. Special devices such as endo GI staplers are introduced into abdomen through 13 mm trocars. Tip of trocars may be conical or pyramidal. Pyramidal tip penetrates the wall by sharp dissection and thus reducing the insertion force. Optical view trocars are passed under visual guidance by passing laparoscope into the trocar. Electrosurgical trocars are available wherein thermal energy is used to create track rather than conventional physical force. There are plastic tip trocars with a diathermy loop on the tip. Similarly ultrasonically activated trocars are also available in the market.

Hasson's trocar and cannula is used as an alternate for open method instead of Veress needle approach. It contains three parts – a cone shaped sleeve; plastic or a metal sheath with a trumpet or flat valve; blunt tip obturator. On the sheath or sleeve two struts are present to fix fascial sutures tightly around to fix trocar firmly and to prevent gas leak. Skin is incised subumbilically. Rectus is incised vertically. With haemostat open dissection is done to reach peritoneum which is opened under vision and Hasson's cannula with blunt obturator is passed. Obturator is removed. Hasson's cannula can be passed and used as an outer sheath with other 10 mm cannulas also. Incidence of vessel injury is very much less in Hasson's cannula; but bowel injury can occur if bowel is adherent to port insertion site. But overall injury rate is less compared to Veress needle method **(Fig. 18-62)**.

Free Web Resources

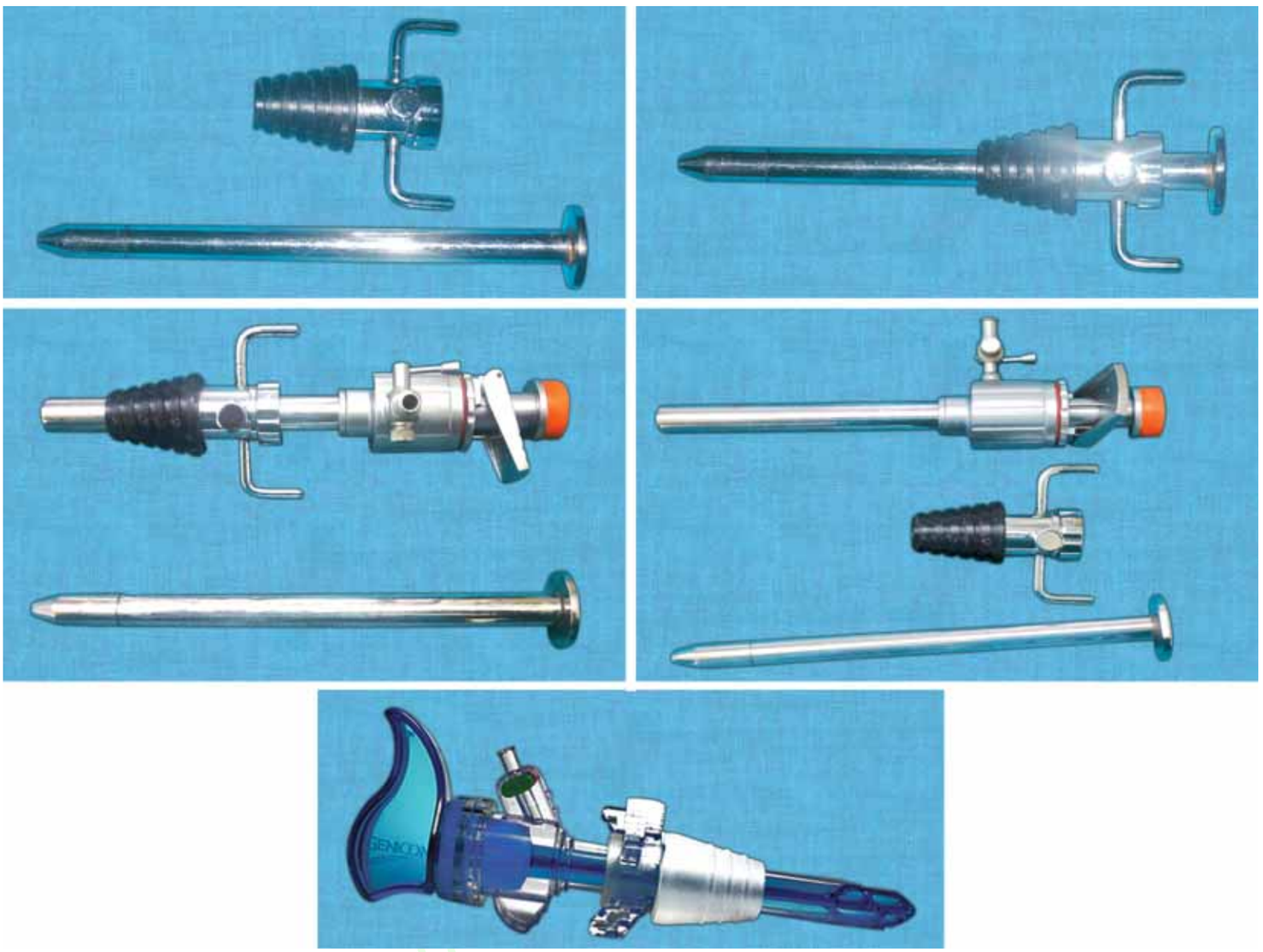


Fig. 18-62: Hasson's cannula used for open method to get pneumoperitoneum and to achieve primary port insertion during laparoscopic surgery.

Hasson's cannula technique (Open access for primary port – Harry Hasson, Chicago 1974)
Periumbilical vertical/horizontal incision → With retraction, rectus sheath is identified → Two 2 zero vicryl stay sutures are placed in the rectus sheath on either side of the planned vertical incision → Rectus sheath/fascia is incised vertically using 15/11 no blade → Extraperitoneal tissues are dissected using haemostat → Peritoneum is held with haemostat or forceps and opened using 15 no blade or scissor → Blunt finger dissection is done under the peritoneum circumferentially to release any adhesions → Hasson's cannula is placed into the peritoneal cavity and 2 zero vicryl sutures is wrapped around the cannula hub to secure it in place firmly → The camera with telescope is passed through the Hasson's cannula to confirm that cannula tip is inside the peritoneal cavity → CO_2 pneumoperitoneum is created

Contraindications
Previous prosthetic mesh; previous surgery with dense adhesions.

Problems and Complications
Bowel injury
Vessel injury – very rare.
Difficulty in keeping cannula in place.
Repeated gas leak.

Special trocar and cannulas are used while using endo GI staplers, morcellator and laparoscopic ultrasound. Radiolucent disposable trocars are available in situation where obstruction of the vision needs to be avoided like intraoperative cholangiogram.

Valve design: In *trumpet valve*, outer knob is pressed fully to release the block to allow passage of the instrument. It may damage insulation of the instrument and is very crude to use. In *flap valve*, spring loaded device is utilized as a seal and is manually controllable. But it is difficult to control the instrument from outside while passing and removing the instruments. Tissues may get caught in the valve making its sealing ineffective and causing gas leak. In *passive valves*, valves open and close automatically with passage of instruments. In disposable type, plastic or rubber sleeves are used. Magnetic flap valve, multifunctional valve systems are also available. Integrity of valve is checked by pressing and releasing it to get a sound; if sound is rubber like it is good; if it is metallic then valve is improper.

Note:
Reusable metal cannula/port with pyramidal trocar with flap/passive valve is commonly used in laparoscopic surgical practice.

Fascial sheaths of all 10 mm and above ports should be sutured using 2 zero vicryl. Different closure techniques are available – direct vision closure; using different port closure devices; using Veress needle also. If these layers are not closed properly incidence of port site hernia is very high – 2-3% for 10 mm; 4-10% for 12 mm; > 40% for 15 mm port site **(Fig. 18-63)**.

Working Instruments

Other instruments are the working instruments which are the miniature versions of hand instruments used in open surgery. Surgical principles of using various instruments are the same as in open surgery. 5 mm sized working instruments are used. They are long (usual one is 33 cm), well insulated and articulated. Insulation should be perfect as any damage in insulation can cause electrosurgical hazards while performing laparoscopic surgery.

Hand instruments are available as reusable or disposable ones. Both have advantages and disadvantages. Disposable ones are expensive but work well every time. Reusable ones are more suited for our practice as they are cost effective. Instruments such as scissors and Maryland dissectors should be in top working condition before taking up a case for surgery. They are also available in 3 mm diameter. These are not required for performing cases in adults and all instruments of 5 mm diameter are used.

Instruments with locks are used for retraction, suturing and tissue holding. Instruments without lock are used for dissection and cutting (scissors). *Hand grip* may be ring, shank and piston types. Ring and handle may be in line (coaxial) or in an angle (radial) with the shaft. Commonly working instruments are having radial handles with an angle of 70°-90° to the shaft line.

Dissecting instruments can be curved or straight with rotating shaft. Curved Maryland dissector is commonly used. Rotating shaft allows easy dissection with lesser strain to surgeon's wrist.

Scissors must be sharp and insulated. When cautery is used in scissor blades should be opened to prevent blunting of the scissor. Straight scissor is used to cut the suture material. Straight suture cutting scissor is often noninsulated. Microscissor and hook scissors are also used. Bipolar scissor is also available.

Nontoothed, toothed graspers, curved long blade dissectors, blunt dissector, right angle dissector, short and long bowel holding forceps, Allis and Babcock's forceps and claw forceps are other instruments used.

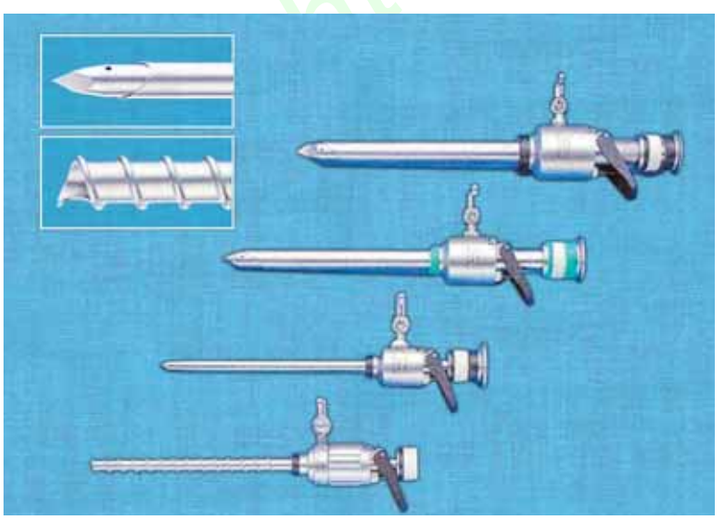


Fig. 18-63: Trocars of various sizes are available in 11 mm, 7 mm and 5.5 mm outer diameter.

Hook is an insulated instrument which is used for dissection. It is connected to monopolar cautery. Bipolar hook is also available. *Spatula* is used again for dissection, coagulation by connecting to monopolar cautery. Its shaft is insulated.

Stone holding forceps, liver retractor, hydatid trocar, needle holders, clip applicators, loop applicators, clips, endostaplers, and endosutures are other specialised instruments used. Needle holder can be 5 mm or 3 mm; can be straight or curved; can be having coaxial or radial handles.

Suction irrigation apparatus is essential to wash and clean the surgical field using warm normal saline. Two types are available – *trumpet type* where suction and irrigation is done using trumpet like action. *Toggle mode type* where suction and irrigation is done through levering bolt in the system. *Toggle mode is commonly used*. 5 mm and 10 mm apparatus are available. 5 mm is better as it does not cause sudden complete loss of pneumoperitoneum obscuring the field. Here with high flow rate of CO_2 gas pneumoperitoneum can be maintained and so image will be visible in spite of suctioning. 10 mm apparatus even though causes rapid suction and not get blocked by blood clots easily, it causes rapid loss of pneumoperitoneum leading to loss of image causing discomfort to surgeon. Few surgeons use heparinised saline for irrigation to prevent clotting and thereby preventing clot block in the suction apparatus; but it is not that essential.

Newer instruments like auto endosuturing instrument, tackers and fixation devices are available. Usually tackers and anchors are 5 mm devices. They are used in hernia repair to fix the mesh in position **(Figs 18-64 to 18-66)**.

Instruments are devised to carry cautery current to the tissue and are available in either unipolar or bipolar mode. Cautery in unipolar mode is used for coagulating bleeders and for dissection of gallbladder from its bed. Bipolar current is used to coagulate mesoappendicular vessels while doing an appendicectomy as we need to minimize lateral thermal damage.

The instruments are insulated over its entire length except the tip and the insulation needs to be checked from time to time as any damage to it can produce leakage of current at that point and inadvertent damage to surrounding structures. The instruments are available in metal or plastic handle. The handles come with or without ratchets. Instruments like the dissector have handles without ratchets allow free movements; toothed graspers are usually with ratchets **(Figs 18-67 and 18-68)**.

Needle holders are available with curved or straight tip and angled or straight handles. Using needle holder is essential for developing skills and going on to the next step in laparoscopic surgery.

Physiologic Changes due to Pneumoperitoneum

CO_2 causes hypercarbia, acidosis and hypoxia. Pneumoperitoneum exerts pressure on the IVC, decreases the venous return and so the cardiac output. It increases the arterial pressure also. It compromises the respiratory function by compressing over the diaphragm impairing the pulmonary compliance.

Respiratory changes are due to – pneumoperitoneum, head down (Trendelenburg) position, increased intra-abdominal pressure reducing cardiac output, reduced venous return (even though CVP in raised).

Raise in intra-abdominal pressure causes reduction in perfusion of spleen, mesentery, and bowel mucosa. So bowel function recovery delays and also renal blood flow.

Fig. 18-64: Atraumatic (dissector, bowel holding, Maryland forceps); traumatic forceps and scissors.

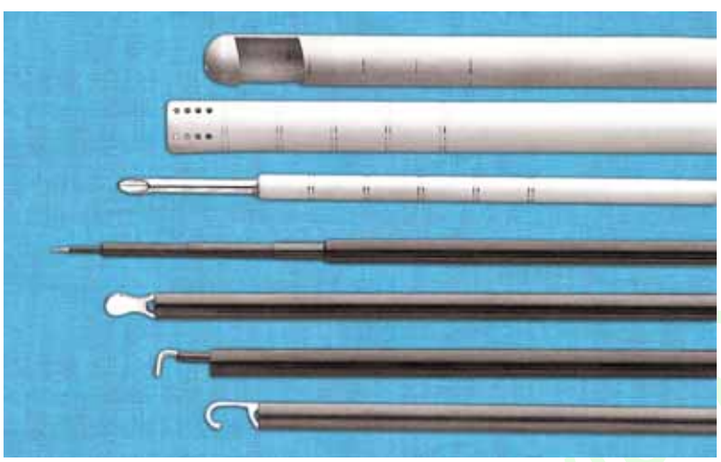


Fig. 18-65: Various needles, electrodes (spatula, hook monopolar and bipolar) and suction irrigation cannula set.

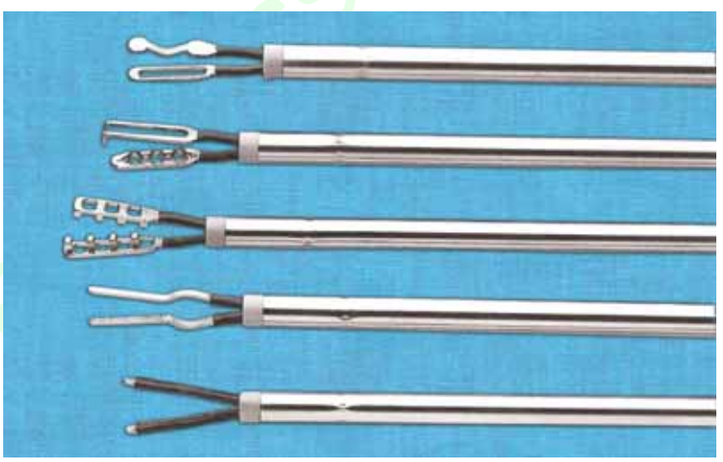


Fig. 18-66: Bipolar forceps of different types.

Fig. 18-67: Various common handles with and without ratchets in both plastic and metal handles.

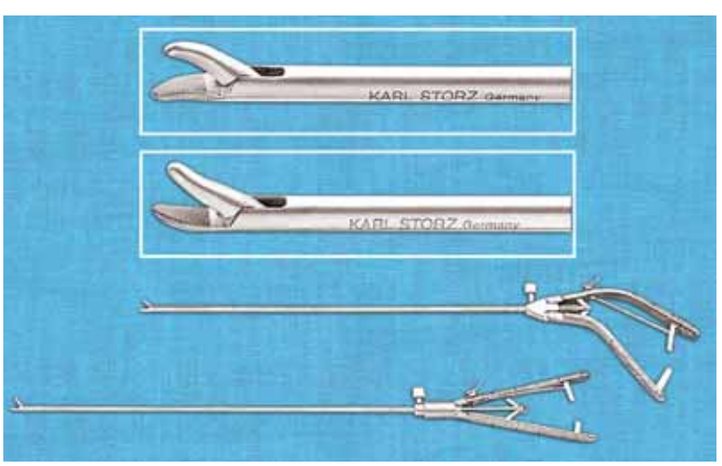


Fig. 18-68: Needle holders with curved and straight tip. Handles are either straight or angled.

Intraoperative hypothermia (for 50 liter gas flow 0.30°C reduction of body temperature) and prolonged warming using warmer is needed. Warming of insufflation gas will be helpful.

ACCESS TO THE PERITONEAL CAVITY

Access is the key for success – in laparoscopic surgery. Access for camera telescope is for primary trocar which is usually at umbilicus. Access for working trocars are called as secondary trocars which are either 10 mm or 5 mm. Secondary trocars are passed *always* under direct vision **(Fig. 18-69)**.

The first step in a laparoscopic procedure is to access the peritoneal cavity in order to establish pneumoperitoneum. It is done by one of the following two methods.

Closed Technique (Using Veress Needle)

After nasogastric suction and drainage of the urinary bladder, a stab incision is made at the umbilicus, followed by the blind passing of a Veress into the abdominal cavity. *Umbilical incision* may be horizontal supra/infraumbilical or superior crease/inferior crease umbilical or transumbilical vertical/horizontal depending on the surgeon's preference and type of surgery being done. *Supraumbilical incision* is 5 cm above the umbilicus 10 mm horizontal and is used in laparoscopic approach for oesophageal hiatus. *Infraumbilical incision* is 3-5 cm below the umbilicus and is used for pelvic approaches. *Superior umbilical crease incision* is called as crying incision which is used for cholecystectomy. *Inferior umbilical crease incision* is called as smiling incision which is commonly used access incision. Infection rate and bleeding is less common in inferior crease incision. *Transumbilical transverse or vertical incision* is also used. Position of the needle within the peritoneal cavity can be confirmed by aspiration through a water filled syringe and by the water drop test. Once the surgeon is comfortable that the needle is in the peritoneal cavity, pneumoperitoneum is established and trocars are inserted. Flow rate used for initial creation of pneumoperitoneum in 1 liter/minute (maximum 2.5 L/min). Quadro manometry in the insufflator machine is used to check this. Preset pressure should not be more than 18 mm. Usual pressure created is 12 mm. Peritoneal cavity is distended slowly not rapidly. Rapid creation of pneumoperitoneum may compress IVC causing decreased cardiac input. 200 ml of CO_2 once enters the peritoneal cavity causes obliteration of liver dullness which is sure sign of proper positioning of the Veress needle and creation of the pneumoperitoneum (Percussion over the abdomen will be resonant).

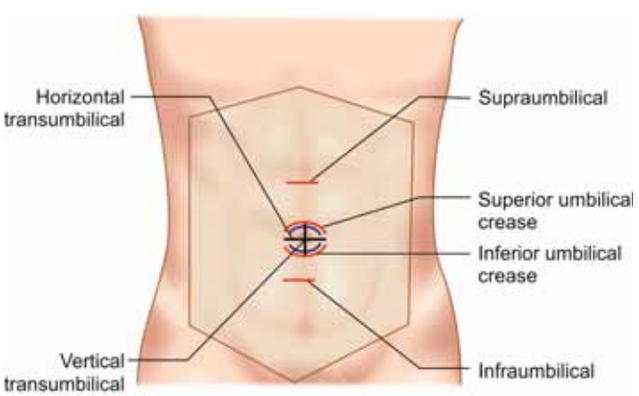


Fig. 18-69: Different incisions used to place laparoscopic primary port depending on the type of surgery patient is undergoing.

Quantity of gas needed to create adequate pneumoperitoneum so as to show pressure of 12 mm is 1.5 liters to 6 liters. Need is less in males and young. It is more in females (multipara) and elderly due to lax abdomen. Size of the abdomen, sex, pregnancy, age and adequate abdominal wall relaxations are the deciding factors.

Open Technique

1. Hasson's open method

After making the umbilical skin incision, the anterior abdominal fascia is incised and the peritoneum is identified under direct vision which is opened carefully using scissor or no 11 blade. Any adhesions prior to insertion of the first trocar is appreciated and released with blunt dissection. The fascia closed around the trocar can be sutured to prevent gas leak which is more common in open method than closed method. The wedge-shaped Hasson trocar can be used to establish a seal in order to allow and maintain the pneumoperitoneum.

2. Scandinavian technique

Here small incision is made directly into the scar tissue of the umbilicus and this is dilated using blunt conical tip trocar and cannula to enter into the peritoneal cavity.

3. *Direct layer by layer dissection* method with subumbilical crease incision

Here after making subumbilical incision, using deep retractors layer by layer dissection is done; rectus sheath is incised horizontally at the junction of the rectus and umbilical fold; peritoneum is adherent to umbilical fold and so can directly enter the peritoneal cavity. Blunt tipped instrument is passed through which 10 mm cannula is passed. Blunt instrument is removed. Cannula is connected to CO_2 insufflator **(Figs 18-70 to 18-75)**.

CO_2 is commonly used to create pneumoperitoneum as --
- It is readily available
- It is cheaper
- It suppresses the combustion
- It is easily absorbed by tissues
- It has a high diffusion coefficient
- It is quickly released via respiration

Other gases used are:
Air, nitrous oxide, helium, argon.
Pneumoperitoneum is created up to a pressure of 15 mmHg which distends the abdominal cavity adequately to have proper visualisation of the abdominal contents.

Fig. 18-70: CO_2 insufflator used for laparoscopic surgery to create and to monitor pneumoperitoneum.

Fig. 18-71: Light source, camera panel and CO_2 insufflator used for laparoscopy.

Fig. 18-72: Laparoscopic monitor. Good monitor is essential; flat/medical monitors will give clear images.

Note:
Stomach and bladder should be empty prior to trocar insertion.

Gas leak – Gas leak may be from the trocar wound site or from the faulty valve of the trocar. Carefully if observed, sound of leaking gas can be appreciated. If saline is poured at the suspected site air bubbles can be seen. To confirm whether leak is from valve or wound, all instruments including telescope are removed from the ports. Respective trocars of the cannulas are partially passed again. If leak stops then it is due to leak from one of the valves of the cannulas. Suspected cannula trocar is kept and other trocars are removed which will maintain the pneumoperitoneum. Once it is confirmed particular port cannula should be changed. If even after placing trocars of all cannulas in place gas leak continues that means it is from wound site. That particular trocar wound is identified and deep nonabsorbable temporary stitches are placed to prevent leak. Often Allis' forceps is placed to that particular wound edge. Often 10 mm to 5 mm reducers are used to pass 5 mm instruments. As reducers are valveless, if rubber cap on the reducer is damaged, leak can occur. Cap should be changed immediately.

Fig. 18-73: Laparoscopic set trolley used during procedure.

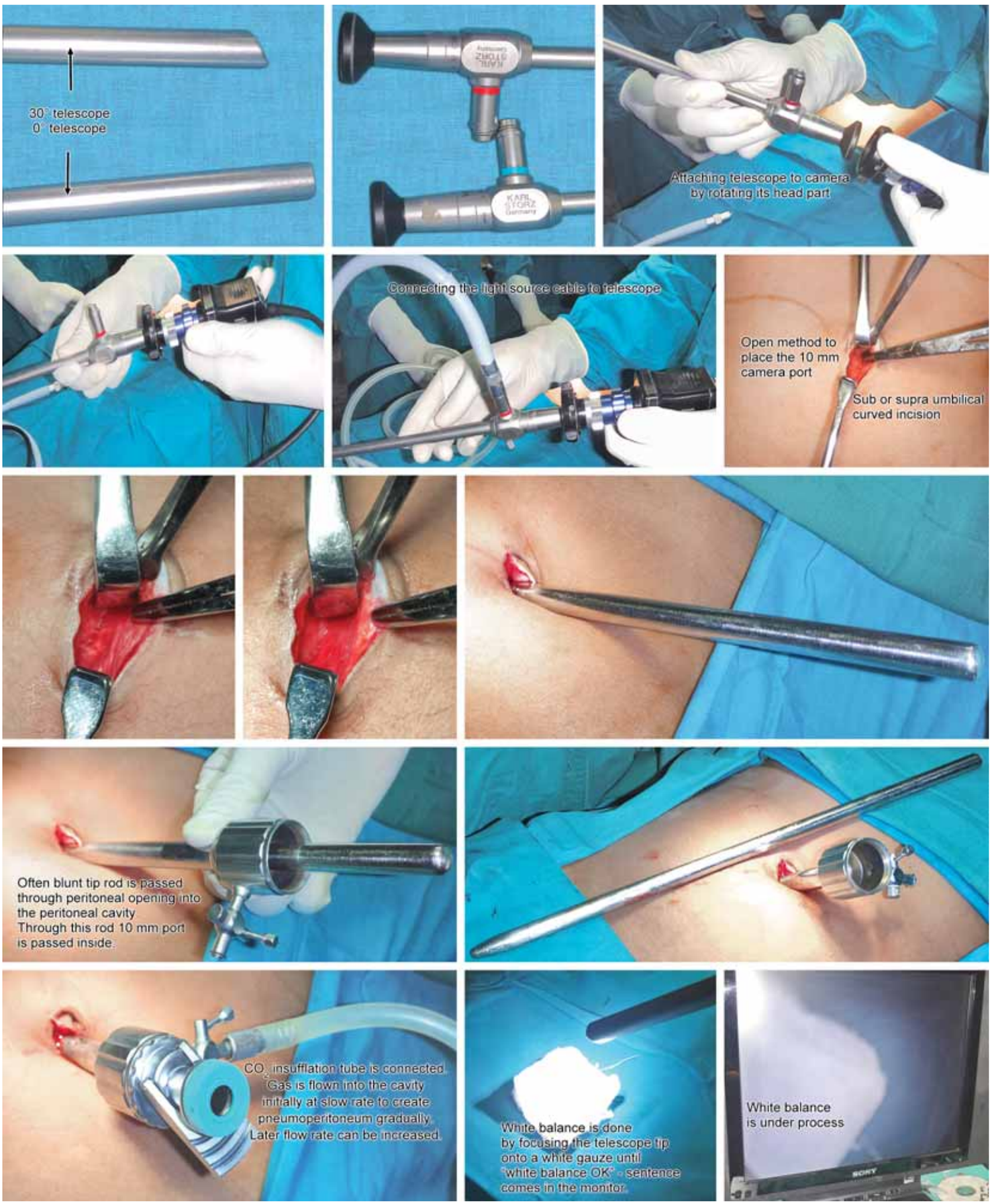
Open access for primary port is usually done through umbilical incision. But it is often *contraindicated* in previous midline scar; portal hypertension with cirrhosis as umbilical artery may be recanalised; congenital umbilical abnormalities like urachal diseases, vitellointestinal diseases.

Secondary working ports are placed on direct vision. These working ports are usually on right and left sides of the camera (primary) port. It should be at adequate distance from camera port to prevent instrument touching the telescope leading to blockage of free movements of the working instruments. Smaller diameter trocar is usually placed at surgeon's dominant hand side to allow proper wrist movements and also to avoid tremor during procedure. Initially site is pressed with finger on the abdominal wall while visualising the indentation in the monitor. Skin incision must be 1½ times larger than size of the trocar. Dermis should be cut adequately using no 11 blade stab incision. Trocar is held with the palm of the hand and thumb and index finger. Middle finger is extended along the shaft of the cannula/trocar towards the tip to achieve good control of the trocar while piercing the abdominal wall and also to prevent sudden rapid entry into the peritoneal cavity. Trocar is pierced with rotating screwing movements, (not by pushing) at 90° to skin; once it reaches the peritoneal surface it is angled 45° obliquely while entering the peritoneal cavity. Entire procedure should be done under vision in monitor.

Other Approaches to Access Peritoneal Cavity

Approach Using Visiport

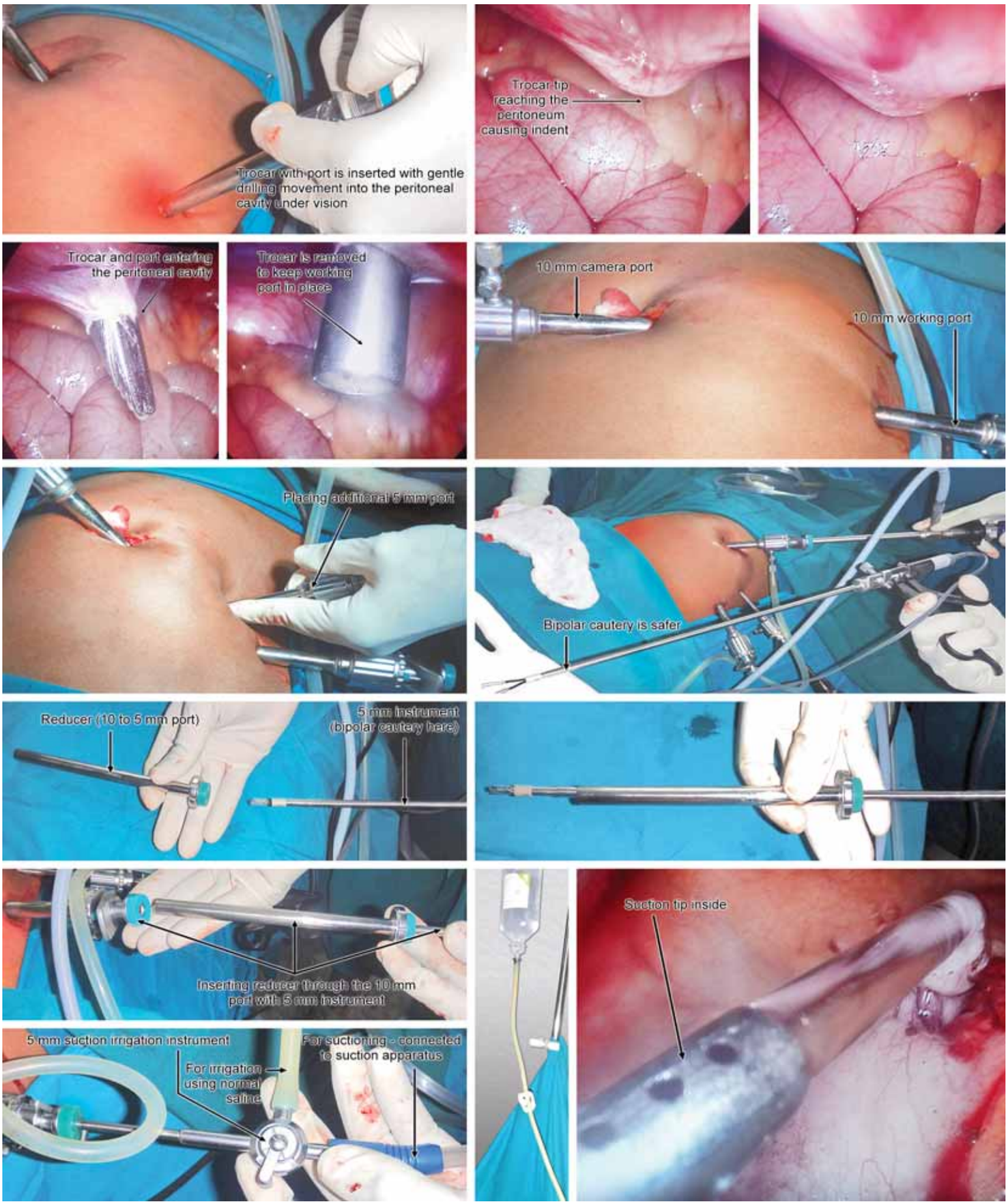
Access can be done under direct vision *using visiport* wherein telescope is passed through it. Tip of the visiport contains fine retractile blade which on firing makes small fine incisions in the tissue allowing movement of the port under vision towards the peritoneal cavity. It is very useful in accessing the peritoneal cavity with previous surgery and also in obese patient **(Fig. 18-76)**.


30° telescope
0° telescope
Attaching telescope to camera by rotating its head part
Connecting the light source cable to telescope
Open method to place the 10 mm camera port
Sub or supra umbilical curved incision
Often blunt tip rod is passed through peritoneal opening into the peritoneal cavity
Through this rod 10 mm port is passed inside
CO_2 insufflation tube is connected
Gas is flown into the cavity initially at slow rate to create pneumoperitoneum gradually
Later flow rate can be increased
White balance is done by focusing the telescope tip onto a white gauze until "white balance OK" - sentence comes in the monitor
White balance is under process

Figs 18-74(1)

White Balancing....
Distended abdomen after pneumoperitoneum; on percussion resonant note all over will be evident
Inside hot water filled flask sterile gauze should be kept to safeguard telescope tip
Hot saline filled sterile flask
Telescope is warmed by dipping it inside hot saline flask so that image inside peritoneal cavity will be clear by preventing tip getting fogged.
Entering and visualisation of peritoneal cavity. Liver, gallbladder, spleen, entire cavity should be inspected
PRESSURE mmHg
ACTUAL
SET
VOLUME Ltr.
TEMP.
ERROR
START
HEATER
FLOW Ltr / Min
Inset
Telescope is focused on the site where additional ports are placed; site is pressed with finger to visualise an indent inside
10 mm skin incision to place working port
Holding the 10 mm trocar with port to insert into peritoneal cavity

Figs 18-74(2)


Trocar with port is inserted with gentle drilling movement into the peritoneal cavity under vision
Trocar tip reaching the peritoneum causing indent
Trocar and port entering the peritoneal cavity
Trocar is removed to keep working port in place
10 mm camera port
10 mm working port
Placing additional 5 mm port
Bipolar cautery is safer
Reducer (10 to 5 mm port)
5 mm instrument (bipolar cautery here)
Inserting reducer through the 10 mm port with 5 mm instrument
5 mm suction irrigation instrument
For irrigation using normal saline
For suctioning - connected to suction apparatus
Suction tip inside

Figs 18-74(3)

Figs 18-74(1 to 3): Laparoscopic access technique – steps.

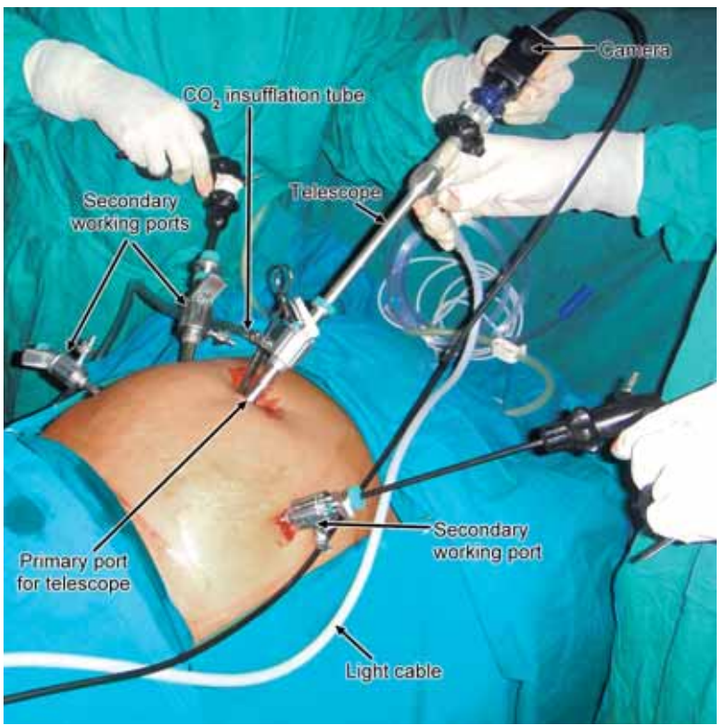


Fig. 18-75: After completion of placing primary and secondary ports, ready for needed surgical technique.

Left Palmer Point Approach

In abdomen with previous surgeries especially for incisional hernia and adhesiolysis, *left Palmer point* (left subcostal point) is used as direct method to access the peritoneal cavity.

COMPLICATIONS IN LAPAROSCOPY

Complications of Access

The rate of complication associated with Veress needle or trocar insertion is approximately 0.3%. They are - injuries to major retroperitoneal vessels and to bowel (0.2%), which are associated with significant morbidity and mortality; abdominal wall hematoma (2%); wound infection (1.2%); fascial dehiscence and herniation (port site/umbilical – 1.5%). Open technique leads to less frequent wound complications in laparoscopic surgery. Though major vascular injuries and bowel injuries with trocar placement are quite rare, use of the open technique may decrease the incidence of these dangerous complications **(Fig. 18-77)**.

Physiologic Complications of Pneumoperitoneum

Pneumoperitoneum causes several local and systemic effects, as reviewed by *Hackam* and *Rotstein.* The majority of these effects are beneficial for patient recovery, such as an observed decrease in postoperative pain and metabolic stress response, as measured by serum glucose and insulin levels and the hepatic catabolic response, measured by functional hepatic nitrogen clearance.

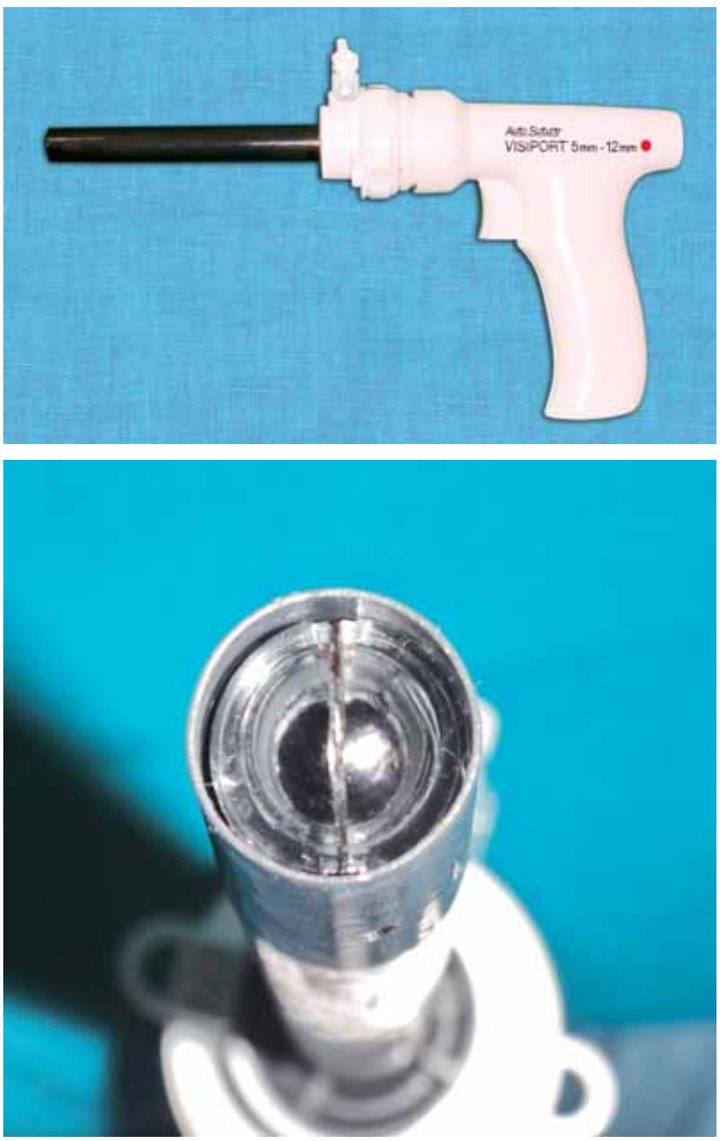


Fig. 18-76: Visiport can be used to pass primary port.

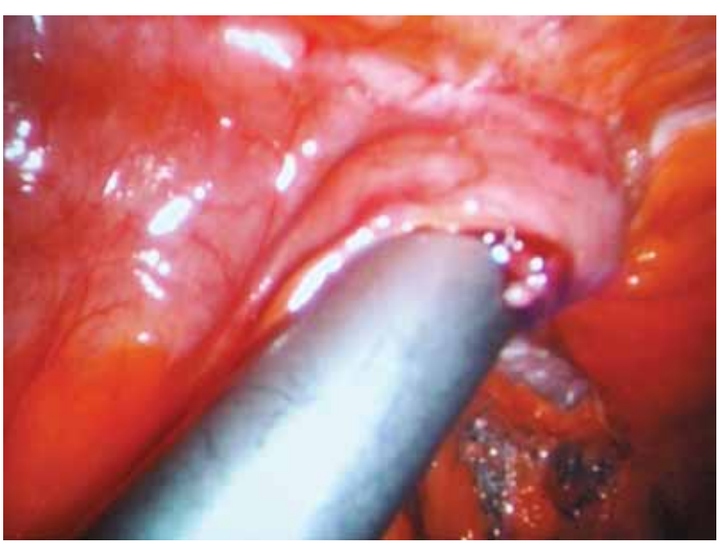


Fig. 18-77: Primary port which has passed through small bowel which was adherent abdominal wall due to previous surgery.

Physiologic Complications of Laparoscopic Surgery

- Carbon dioxide pneumoperitoneum causes respiratory acidosis from absorption of the gas. Subcutaneous emphysema, pneumothorax, pneumomediastinum and pneumopericardium are other problems.
- Deep venous thrombosis (DVT - with 40% having calf DVT and 15% having axial vein DVT).
- Cardiac output decreases by up to 30% during laparoscopic surgery, due to a decrease in stroke volume. Pneumoperitoneum also causes an increase in systemic vascular resistance. As a result, mean arterial pressure remains unchanged or increases up to 16%. Patients with marginal cardiac performance may warrant invasive cardiac monitoring to assure they tolerate pneumoperitoneum. This is partly due to intravascular volume status, and could be ameliorated by preloading patients with isotonic fluid and achieving pneumoperitoneum in the supine position rather than the reverse-Trendelenburg position. Treating these patients with clonidine blunted the increase in mean arterial pressure, systemic vascular resistance and the release of catecholamines. Cardiac arrhythmias (more common if halothane is used) are most common cardiac complication.

Complications of laparoscopic surgery	*Relative contraindications*
• CO_2 narcosis and hypoxia. • Sepsis—subphrenic abscess, pelvic abscess, septicaemia. • IVC compression. • Bleeding. • Leak from the site, e.g. bile leak. • Organ injury during insertion of ports, e.g. major vessels, bowel, mesentery, liver. • Subcutaneous emphysema and pneumomediastinum. • Gas emboli, though is rare but fatal. • Gastric content aspiration. • Hypothermia. • Postoperative shoulder pain due to irritation of diaphragm. • Hyperabduction of arm can cause stretching of the brachial plexus and neuropraxia. • Trendelenburg position can cause common peritoneal nerve injury. • Cardiac dysfunction due to decreased venous return. • Injury to the abdominal wall vessels and nerves. • Cautery burn to abdominal structures. • Abdominal wall hernias – port site hernias. • Wound infection. • Mortality—0.5%.	• Patients with compromised cardiac status. • Peritonitis. • Previous abdominal surgeries. • Bleeding disorders. • Morbid obesity. • Third trimester pregnancy. • Portal hypertension, cirrhosis. • Raised intracranial pressure. • Glaucoma. • Peritoneo-jugular, ventriculo peritoneal shunts. **Limitations** Lack of tactile sensation; tissue feel is absent. Only eye-hand coordination is the method.

- *Gas embolism* – It can occur (but very rare) by direct entry of CO_2 through inadvertent injury by Veress needle or trocar; when small gas bubbles enter the injured vein; absorption of large quantity of gas into the portal system which forms bubbles that get trapped in the portal system as well as in the pulmonary circulation at a later period. Smaller bubbles block pulmonary circulation; larger one causes gas lock in IVC and right atrium (may cause sudden death). On table patient develops tachycardia, hypotension, arrhythmias, convulsions, metallic/*mill wheel* murmur (heard through precordial or oesophageal stethoscope). Foaming of blood in CVP catheter, precordial Doppler (detects passage of even 2 ml of gas), oesophageal Doppler (detects even 0.5 ml of gas). $P_{ET}CO_2$ raises in *capnometry* which is the most valuable non-invasive method to detect gas embolism. 20% of such patients during recovery may show blindness. Once on table gas embolism is diagnosed, immediately pneumoperitoneum is stopped and gas is released; patient is kept in steep head down and left up position; hyperventilation; CVP catheter gas aspirations are done. Nitrous oxide should be stopped.

DIAGNOSTIC LAPAROSCOPY

With the availability of diagnostic modalities like helical CT and MRI scans the role of laparoscope in diagnosing occult abdominal pathologies has greatly reduced. Most often the laparoscope is used as confirmatory investigation before the pre-planned procedure such as appendicectomy or adhesiolysis for subacute intestinal obstruction. The other area where the laparoscope is helpful is to ascertain the anatomical origin of masses in the right iliac fossa in women of reproductive age where there is suspicion of tubo-ovarian pathology. Even abdominal tuberculosis can be now diagnosed with ancillary investigations such as PCR for tubercular DNA. Laparoscopy is now a precursor to appendicectomy or adhesiolysis in case of chronic vague abdominal pain where other investigations have not yielded a diagnosis **(Figs 18-78 to 18-80)**.

Preparation

- It is done always under general anaesthesia. It can be done under local anaesthesia also but it is cumbersome and painful to the patient. Other preparations are same as for open method.
- Pressure bandages are applied to both legs to improve the venous return and to decrease the stasis.
- Head end of the table is lowered to have easier insertion of Veress needle and scope.
- Ryle's tube and Foley's catheter are essential before insertion of the trocars.
- Pneumoperitoneum is created using Veress needle through umbilical incision. Access can be achieved by open method through an umbilical incision.

Procedure

Peritoneal access is gained by either open or closed method. Before proceeding to place accessory ports attention is given to the suspected pathology. Placement of working port is generally guided by the proposed site of the pathology and also the planned procedure. Lower abdominal pathology demands ports placed on either side of the rectus muscle at or just below the umbilicus. If pathology is anticipated or seen in stomach, liver, spleen on preliminary screening then the ports should be placed above the

Fig. 18-78: Laparoscopic set showing trolley, telescope and monitor instruments.

umbilical level in suitable position. Bowel should be inspected along its entire length by alternately moving the working instruments on the bowel and both sides should be inspected for pathology. The method of inspection is similar to that of exploratory laparotomy. Laparoscopy gives great advantage when inspecting the diaphragm and the pelvic structures. The procedure is converted to a definitive procedure when the pathology is identified. Routinely the procedure culminates in an appendicectomy even when no other obvious pathology is evident as it prevents diagnostic difficulties at later date **(Figs 18-81 to 18-83)**.

Note

- Instruments should be checked prior to procedure for proper functioning.
- Cardiac, respiratory fitness should be assessed.
- Position, preparation is a must.
- Adequate pneumoperitoneum should be created; gas leak should be prevented or tackled effectively.
- Telescope should be warmed before insertion to prevent fogging.
- Tip of light cable is very hot and should not touch drapes or patients' skin. It may cause deep burn injury.
- Camera operator should hold the camera firm and strong to have good view of surgical site.
- Telescope tip can be cleared by obscuring blood by touching her tip to omentum or abdominal wall or solid organ like liver. Otherwise it should be removed and cleaned with savlon and warm saline. Tip of telescope should never be touched to the bowel as it may injure the bowel.
- Insufflation gas inlet can be changed to working port instead to camera port to prevent undue fogging.

LAPAROSCOPIC ULTRASOUND

Fukuda in 1981 used laparoscopic ultrasound. Transducer in ultrasound is made up of piezoelectric cells. USG flexible probes are used which are 7 cm in length and 12 mm in diameter. Two monitors are required; one for laparoscope other for ultrasound. Now single monitor is available where both laparoscope and ultrasound images are seen which allows better hand-eye coordination.

Laparoscopic USG probes are sterilized by glutaraldehyde or through ethylene oxide.

Laparoscopic USG is useful in assessing the liver tumours, biliary tree, hepatic nodal status, pancreas, lymph nodes in different areas of the abdomen, spleen, kidneys and adrenals. Laparoscopic ultrasound is very useful in assessing the solid organs, its use is not very much in assessing the small bowel and colon because of the gas in the bowel. It is used to identify the lesions accurately with its size, vasculature; to stage the disease; to assess the resectability of tumour; to identify the vessels and its relations to the organs like hepatic veins in liver resection.

Laparoscopic USG can be used in different therapeutic purposes in liver like radiofrequency ablation and deroofing of the liver cyst. Laparoscopic USG is very useful in identifying biliary stones and is better than intraoperative cholangiogram. Endocrine pancreatic tumours are well identified by laparoscopic USG. Identification of pancreatic duct during pancreaticojejunostomy is better with laparoscopic USG. Laparoscopic guided biopsy is even though done, but it is controversial. Laparoscopic FNAC is a good diagnostic tool. 3D ultrasound is now available with better clarity of images **(Fig. 18-84)**.

3 D LAPAROSCOPY

3 D laparoscopy is now available with more clarity and 3 dimensional look. 3 D camera available at present is heavy (1 Kg). It is often difficult for cameraman to hold it and negotiate. Suturing and image quality is good in this but it is costly.

There is marked and significant improvement in operative time with a stereoscopic 3 D laparoscopic view of the operative field. As procedure is performed with identical mechanical instrumentation like in 2 D laparoscopic instruments the difference attributable is only to the changes in depth perception obtained with the 3 D laparoscope. This skill obtained with this finally will be beneficial in advanced procedures like laparoscopic radical prostatectomy, laparoscopic pyeloplasty, or other complex reconstructive procedures. One of the biggest challenges in laparoscopic surgical training is adaptation to a 2 D flat view of the surgical field. 3 D laparoscopic visual systems have been developed to augment laparoscopic skills. Suturing skill will be much more precise and accurate and also will be faster.

SINGLE INCISION LAPAROSCOPIC SURGERY

Single incision laparoscopic surgegy (SILS) is an advanced minimally invasive surgical procedure wherein surgeon operated exclusively through a single umbilical entry port. It is also called as single port access surgery (SPA), one port umbilical surgery (OPUS), and single-port incisionless conventional equipment-utilising surgery (SPICES), natural orifice transumbilical surgery (NOTUS).

It is used in cholecystectomy, appendicectomy, gynaecologic procedures, hernia surgery and other selected procedures.

It needs general anaesthesia, specialised umbilical large trocars which accommodates working instruments also, flexible laparoscope, rotatable instruments, articulating handles, harmonic scalpel.

Here through a large 2 .5 cm umbilical vertical incision dissection is done by open method to reach peritoneal cavity. Through this is passed a specialised port where one can pass 10 mm telescope and two 5 mm instruments for laparoscopic work. Instruments are angled and flexible to meet the ergonomic principles to certain extent. Dissection of gallbladder is done in similar fashion like four port technique.

Fig. 18-79: Different instruments used for diagnostic laparoscopy.

Specimen is easily retrieved through umbilical port as it is wider enough. If difficulty arises any time one can add additional ports as required.

SILS is now used in appendicectomy, ovarian cyst excision, selected cases in hernia and other procedures also.

Advantages

- There is no visible scar like a traditional multiport.
- Faster recovery time, early return to work.
- Cosmetically better **(Fig. 18-85)**.

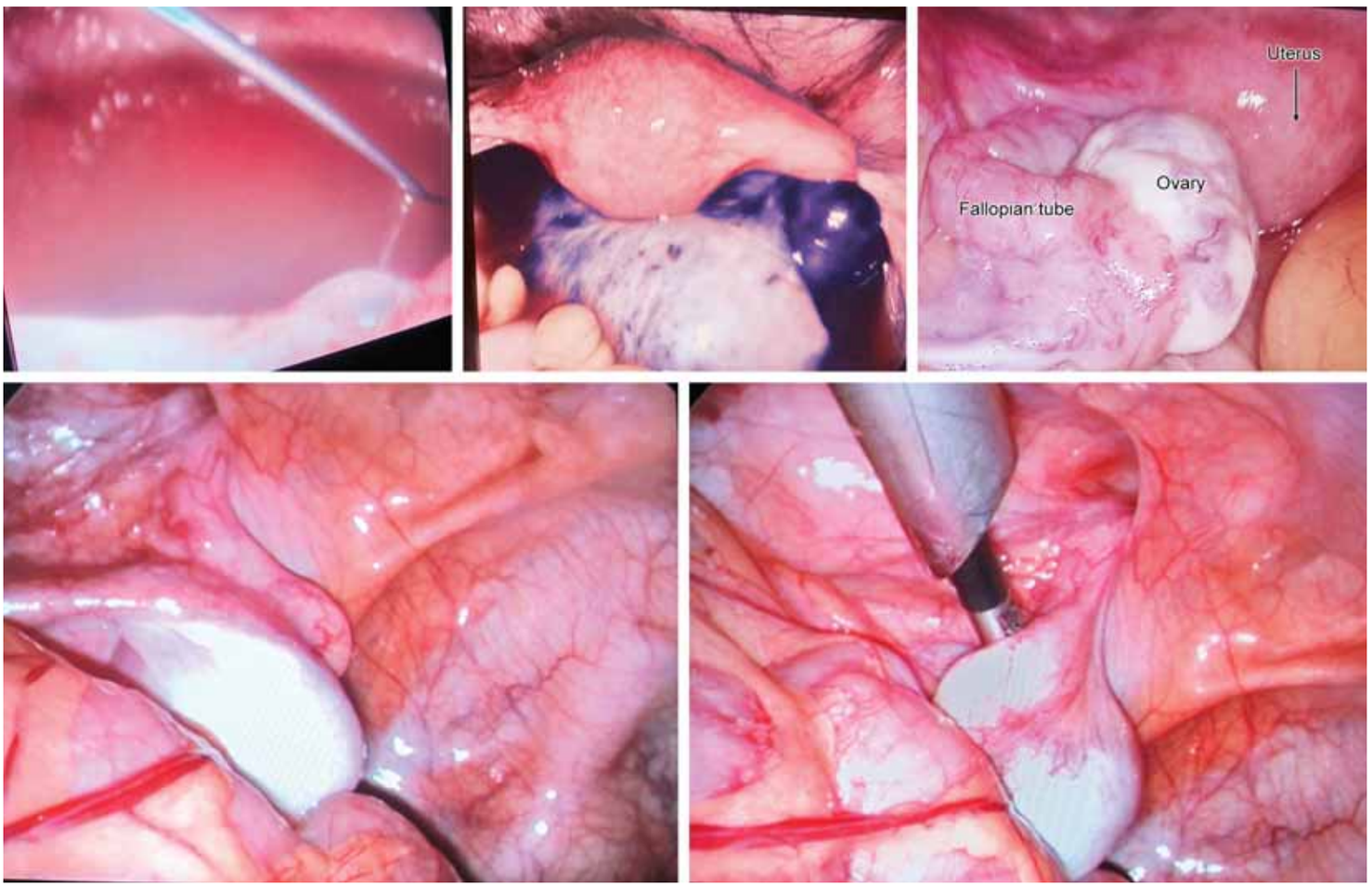


Fig. 18-80: Diagnostic laparoscopic view in ascites (tuberculosis); twisted ovarian cyst, ovary and Fallopian tube; undescended testis with inguinal hernial opening at internal ring.

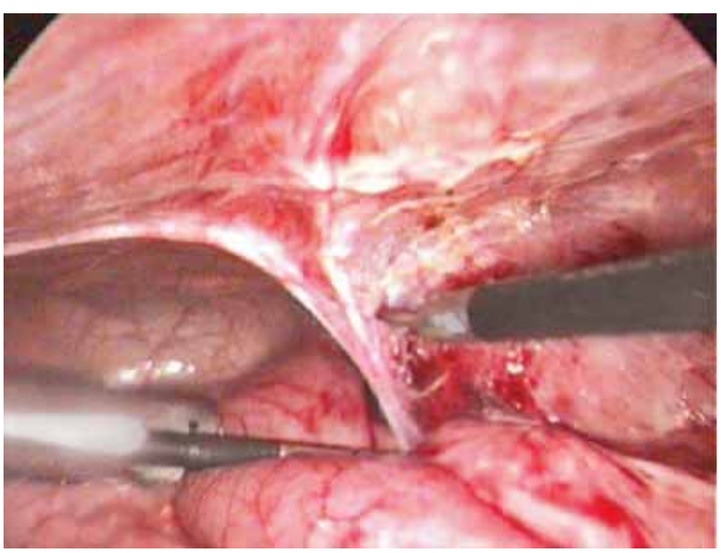


Fig. 18-81: Adhesiolysis.

Disadvantages

- Expensive trocars and instruments.
- Skilled work, learning curve.
- Dissection against normal surgical ergonomics.

Complications

- Umbilical wound pain, infection.
- Umbilical hernia.
- Time consuming because of limited visibility.
- During learning curve complications of cholecystectomy or other procedures and conversion rate may be more.

GASLESS LAPAROSCOPY (LAPAROLIFT)

Dan Kruschinski is the *Preceptor of Gasless Lift-Laparoscopy* since 1991 with an ongoing process of establishing excellent vision with new abdominal lift devices to ensure a cost-effective laparoscopic start-up system.

It is forward retraction of the anterior abdominal wall so as to create the effective working cavity inside the peritoneum to facilitate the dissection. It may be useful for pelvic and lower abdominal surgeries (APR/ovarian surgeries), appendicectomy, etc.

Advantages

Complications of CO_2 pneumoperitoneum are not present. It can be done under regional anaesthesia. It provides appropriateness, equity, accessibility, availability, affordability to the rural people wherein cost is also a main factor. In developing countries 80% rural

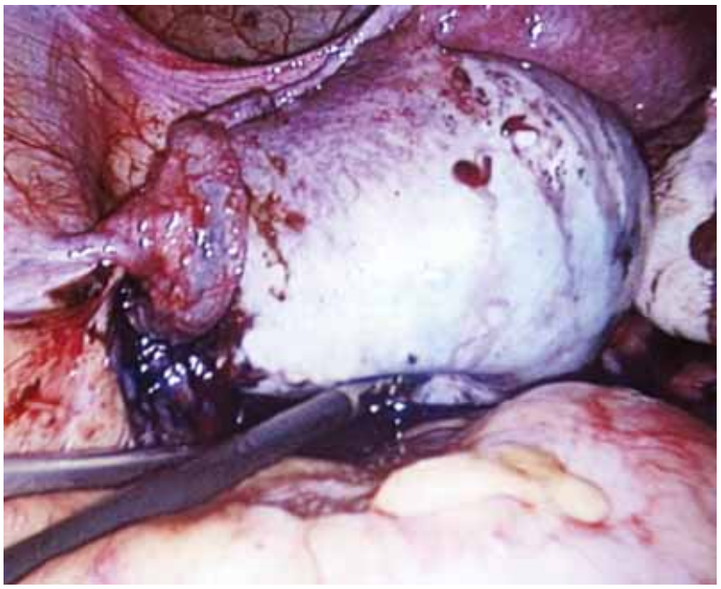


Fig. 18-82: Laparoscopic view of twisted ovarian cyst.

Fig. 18-83: Laparoscopic procedure in progress showing camera, telescope, ports, working instruments.

population is provided by 20% of surgeons. Laparolift will be useful to these patients considering their need (as they need to return their work earlier) and economy. Valveless trocars can be used. Suction usage can be unlimited. Conventional instruments can be used when need arises. During induction of anaesthesia increased ventilator pressure is not needed. It shows less infection rate; equally cosmetic; less postoperative pain; early faster recovery; shoulder pain will not be present; safer and precise.

Disadvantages

Movement of the viscera during inspiration causes difficulty in targeting the proper dissection unlike in dissection with pneumoperitoneum which is motionless. Technique even though is used in many places, is less popular due to difficulties in developing adequate lift.

HAEMOSTASIS IN LAPAROSCOPIC AND OPEN PROCEDURES

As there is no direct access to the bleeders, it is often difficult to control the bleeding during haemostasis. Often difficulty in controlling the bleeding becomes an indication for conversion into open at least during learning curve period. It is better to have an idea about different haemostasis methods during laparoscopy. Proper ergonomics and triangulations are very important in laparoscopy. One should able

Fig. 18-84: 3 D laparoscopy camera and monitor. Present 3 D camera is heavy weight – nearly one kilogram in weight.

Fig. 18-85: Single incision laparoscopic surgery (SILS) for cholecystectomy/appendicectomy and also for other procedures.

to grasp and coagulate the bleeding the tissue properly. Meantime blood from bleeding point if spills over the laparoscope tip, it will blur the image and situation becomes panic as bleeding point/area is not visualised. Surgeon should console the cameraman and ask him to stay steadily on the site of bleeding until it is well controlled. While achieving haemostasis, it is also important not to injure the adjacent structures either with clip or energy source. In cholecystectomy with cystic artery bleed, clips may be applied in a hurry to control bleeding over the common bile duct partially injuring it; cautery when used, especially monopolar cautery may cause lateral thermal damage to closely existing common bile duct wall which eventually leading into necrosis of its wall causing disastrous bile leak.

Laparoscopic haemostasis may be achieved by different means.

a. **Mechanical devices** – Clips, lineal stapling devices, pretied suture loops (endoloop/loop done in theatre table as extracorporeal knot which is pushed towards the site as ligature), intracorporeal ligature placement, transfixation suturing intracorporeally.
b. **Energy sources** – Electrocautery, ligasure, laser, ultrasonic dissection (Harmonic), cavitron ultrasonic surgical aspirator (CUSA).

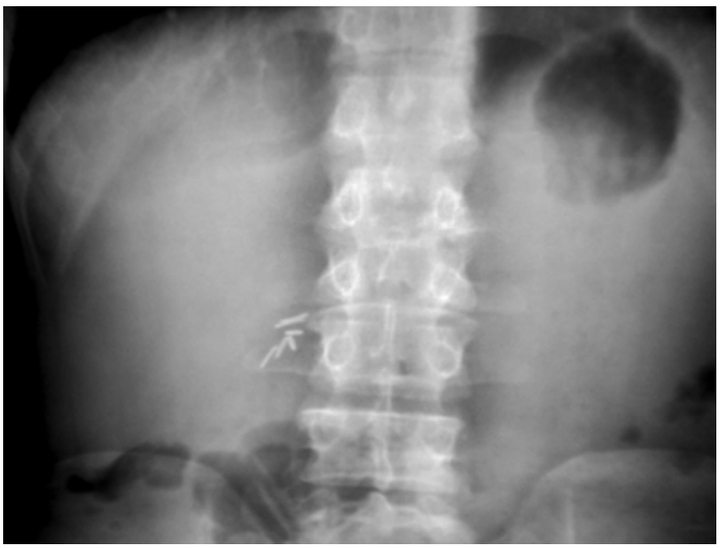


Fig. 18-86: Plain X-ray abdomen showing clips of laparoscopic cholecystectomy.

Mechanical Devices

Mechanical Clips

They are made up of titanium inert, least reactive clips available which are applied through 10 mm clip applicator. Clips are available in 7mm (medium), 9 mm (medium large) and 11 mm (large) size. Medium size is usually used. Size usage is decided as needed by the surgeons. Same clip applicator can be adjusted for different size clip placement by adjusting the applicator gap at the end. Reusable clip applicator is commonly used even though preloaded clip applicator is available. Preloaded disposable clip applicator contains 20 clips in a row which can be applied consecutively, one after other which makes surgery faster. Absorbable clips are available mainly to apply onto the continuous suture intraperitoneally to hold it at the beginning and at the end. Usually two clips are applied proximally close to each other. Third distal clip is applied at 3-5 mm gap. Tissue is cut between proximal two clips and distal clip. While applying the clip, both ends of the clip should encroach the tissue/duct/vessel completely and clip should be applied under vision with confirmation that it is not entangling any other tissues and ends are clearly seen before compressing the clip firmly. While cutting the tissue, gap should be kept distal to proximal two clips to prevent slipping of the clip. At least 5 mm of tissue should be present freely proximal to proximal clips to prevent clip migration (example – while applying clips in cystic duct). Clip applicator is usually straight but angled one is also available. Even though it is of practice that application of ligature along with or after applying the clip; it will loosen the clip due to tissue distortion. In such situation suture ligature should be finished first and then clips should be applied at needed place **(Figs 18-86 to 18-88)**.

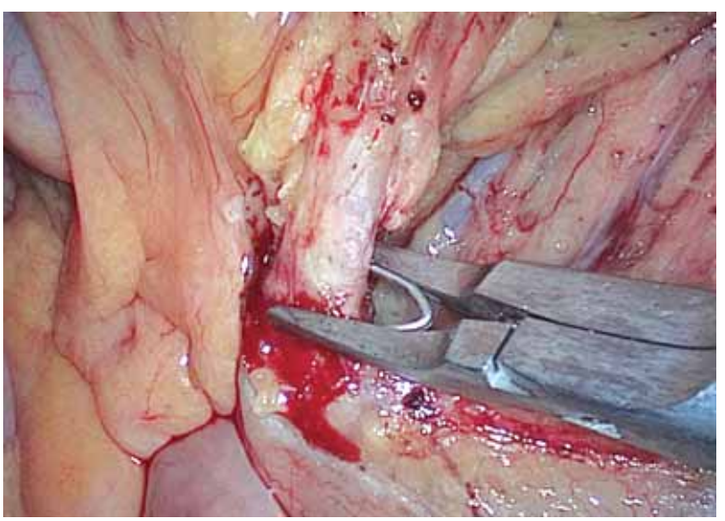


Fig. 18-87: Applying clip for a vessel in the abdominal surgery.

Lineal Stapling Devices

Lineal stapling devices are very useful to deal with splenic, renal, inferior mesenteric vessels in respective laparoscopic surgeries. Different sizes are available – 2.5 mm vascular; 3.5 mm intestinal; 4.5 mm intestinal/colonic **(Fig. 18-89).**

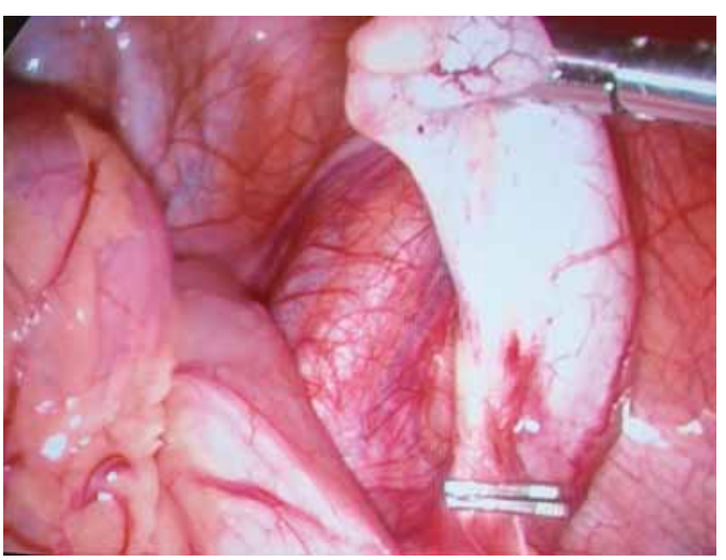
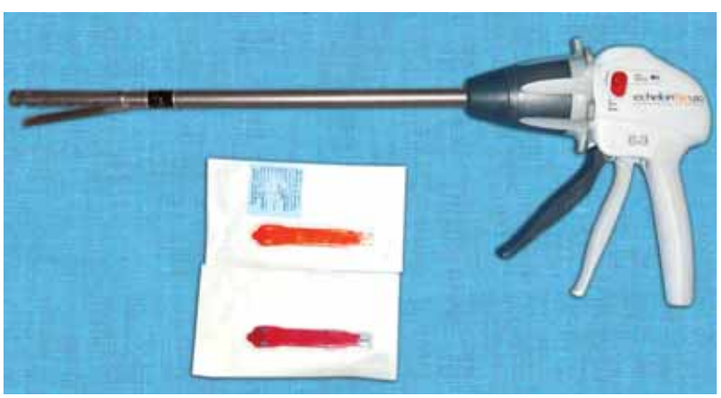
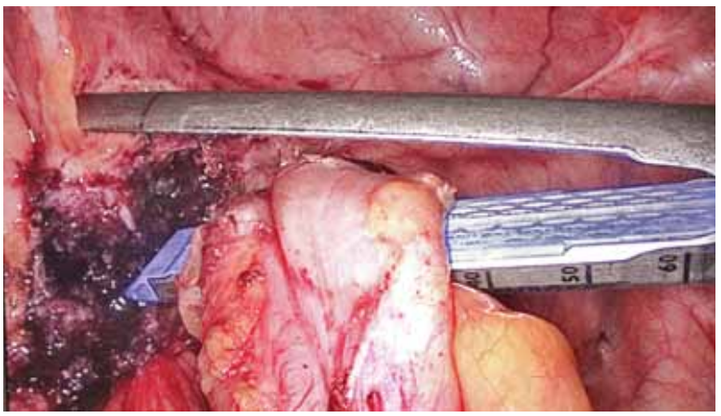
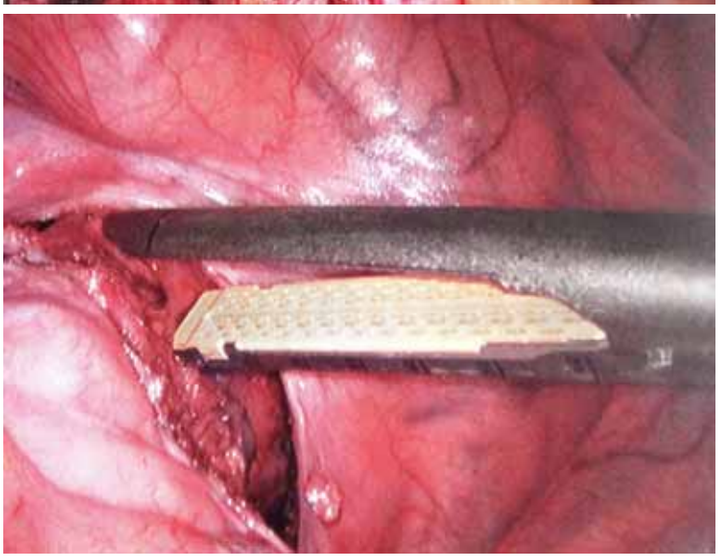


Fig. 18-88: Clip applied for appendicectomy.



Figs 18-89(1)

Figs 18-89(2)

Figs 18-89(1 and 2): Endostapler device with cartridges for stapling the bowel during resection.

Pretied Loops

Pretied loops are available as manufacturing which are made up of chromic catgut. It is mainly used in appendicectomy. Same loop can also be used in passing ligature around a specified bleeder. Bleeder is held using a Maryland instrument through a working port; pretied loop is passed through another 10 mm working port through a reducer. Instrument which was holding the bleeder is once released and passed through the loop and held again (if additional working port is there bleeder can be held using another grasper little proximally) to allow the loop to encircle the bleeder/bleeding tissue and loop is tied firmly by releasing and tightening the control shaft proximally outside. Often Roeder's knot can be made outside using vicryl suture keeping its proximal length long which is looped in the same way and knot is pushed into the site using a knot pusher or a Maryland instrument **(Fig. 18-90)**.

Extracorporeal Ligature

Extracorporeal ligature can be made and is pushed through 10 mm working port through a reducer into the tissue. Here initially long suture material is passed through 10 mm port into tissue and is encircled properly and other end is brought out through the same working port

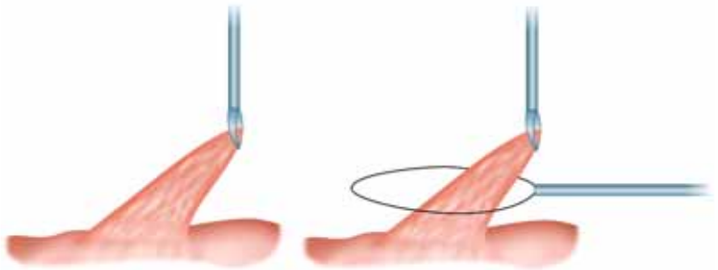


Fig. 18-90: Endoloop is often used to pass a ligature. It may be prettied endoloop (chromic catgut) or endoloop is made using Roeder's knot with vicryl.

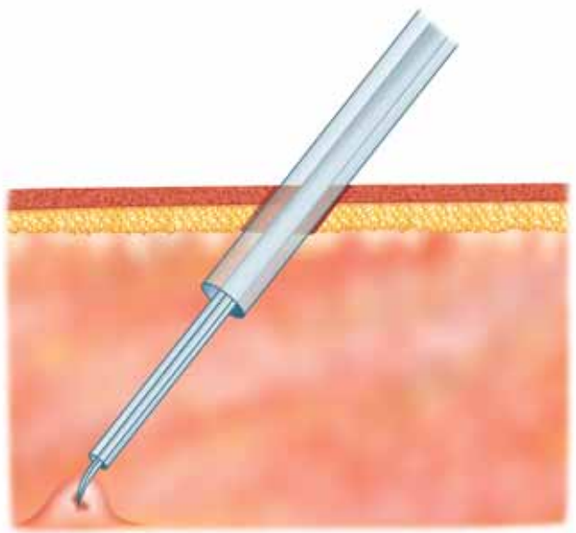


Fig. 18-91: Bleeder is held using a Maryland which can be later fulgurated using cautery.

through reducer outside to make both ends of the suture material is outside. Knot is tied outside the port which is pushed across the reducer into the looped tissue to form a firm strong knot **(Fig. 18-91)**.

Intracorporeal Suture

Intracorporeal suture is done using intracorporeal knotting technique. It needs a proper training. It is essential for all advanced laparoscopic surgical procedure.

Energy Sources

Diathermy (Electrosurgery)

Electrosurgical units (ESU) used in operating rooms convert standard electrical frequencies from the wall outlet, which are 50 to 60 Hz, to much higher frequencies, 500,000 to 3,000,000 Hz. This is important to minimize nerve and muscle stimulation, which occurs at electrical currents below 10,000 Hz. High frequency (3 lakh to 6 lakh Hz) current, is allowed to pass through the tissue to create conduction heat achieving haemostasis. *In monopolar type*, current flows from generator to patient through active electrode and returns back through the return electrode to the generator. It is *pulsed wave, low frequency and high voltage* current for *coagulation cautery*. It is *continuous wave, high frequency and low voltage in cutting* type of monopolar cautery. Active electrode passes through a fine probe to the needed tissue area; whereas return electrode is with 22 square inches of surface area flat plate placed under muscular surface with gel conductive coating. Active electrode contacts in less area than return electrode. Current gets concentrated in less area in active electrode to achieve needed effects. Effects may be coagulation or cutting. Coagulation is achieved by protein denaturation and coagulation necrosis. Cutting is due to rapid focal tissue heating causing tissue disintegration without any coagulation necrosis. So cutting cannot cause coagulation. Coagulation at the tip of probe can cause cutting but with more charring. *In laparoscopy mainly coagulation monopolar cautery is used*. Coagulation in hook or spatula can cause cutting by proper holding and positioning the instrument while creating the contact with tissues. Cutting cautery has got limited role. Pulsed coagulation in blend mode is better. During laparoscopic usage of monopolar cautery, one should be careful as instrument which has cautery cable attached is visible only at its distal 10%. During usage, one should always confirm that proximally insulation is visible. Instrument should have proper insulation without any damage otherwise severe burns of the abdominal wall at port site or damage to adjacent tissues or bowel perforation, injury to great vessels can occur. Often it may be life threatening. Direct coupling and capacitance coupling can occur. Lateral thermal damage is equally dangerous. Lateral thermal injury can occur up to 8 mm of tissues beyond; in pedicle coagulation thermal injury and vessel spasm can occur at the base of that particular pedicle **(Figs 18-92 and 18-93)**.

In bipolar cautery active and return electrodes are separated by few mm passing through the hand probe, not through the body. So conduction (earthing) plate is not needed in bipolar. Bipolar reduces the adjacent tissue damage. It has got less lateral thermal heat. Bipolar can be used only for coagulation but not cutting. Bipolar is very important in laparoscopic surgery as it reduces inadvertent vital structure injury **(Figs 18-94 and 18-95)**.

Problems and Complications of Cautery

Injury to bowel due to heat, direct or lateral, may be unnoticed or not obvious which may later be able to cause full thickness ischaemic necrosis and perforation with peritonitis. This can occur often as late as 10 days also.

Direct injury into the major vessel and vital structure through cautery can occur while instrument touches these structures and cautery got on inadvertently by assistant or scrub nurse or surgeon himself. Ideal is to disconnect the cable from the instrument when not in use.

Fig. 18-92: Monopolar hook is commonly used in dissecting the peritoneum, creating the plane, dissecting the gallbladder from its bed. Bipolar hook is also available. It is biflanged.

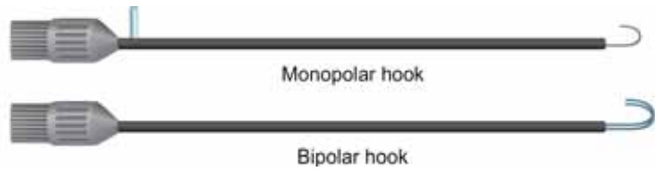


Fig. 18-93: Monopolar is used for dissection as well as dissection. Bipolar is mainly used for coagulation; but dissection is also possible.

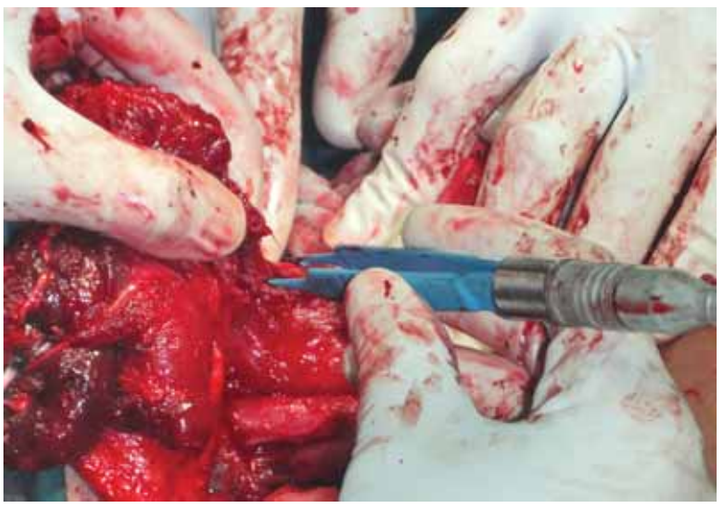


Fig. 18-94: Bipolar cautery in use. Here active and return electrodes are very close by.

Insulation failure due to damage to the insulation and damaged part may be in direct contact with bowel. Prior checking the instrument for its insulation and function is essential always **(Fig. 18-96)**.

Direct coupling can occur when instrument which is connected to cautery (e.g. Maryland) touches instrument in the port which is not insulated like laparoscope which is passed through a plastic cannula as plastic port cannula prevents passage of current into return electrode. Current is directed into different tissues which get fulgurated as injury **(Fig. 18-97)**.

Capacitive coupling injury can occur if cautery is activated before the instrument tip makes contact with the tissue with a metal cannula and plastic sleeve which prevents return current to reach return electrode across body causing bowel injury. Capacitor is two conductors separated by an insulator. Electrosurgical device is one conductor; metal cannula is another conductor; with insulator sleeve.

If return electrode is inadequate (inadequate surface area in plating) then return current will pass through other surface metals causing severe surface burns.

If bowel injury occurs and suspected it is better to convert into open to identify proper site of heat injury which needs excision with adequate margin and proper re-suturing using interrupted silk or vicryl sutures.

Ultrasonic Dissector

The *Harmonic scalpel* is a high frequency ultrasonic transducer. The active titanium blade vibrates at 55,000 cycles per second. Electric power is applied into a device which contains piezoelectric crystal to create high frequency vibration waves. From this crystal vibration is carried to a rod to instrument tip to move its long axis. Induction of mechanical vibration at cellular level using high frequency waves more than 55,000 Hz leads into friction and shear injury leading to needed effects. When applied to tissue it causes protein denaturation and coagulum formation at lower temperature (up to 80° C). It seals and cuts the tissues including vessels up to 2 -5 mm. There is no risk of electric burn or lateral thermal injury. Charring is less here compared to electrocautery and so less smoke in comparison. Field is clean and bloodless.

Hand instruments are available in 10 mm and 5 mm size in harmonic scalpel. 5 mm harmonic probe is commonly used now even though initially only 10 mm probes were available. It can be used as a grasper, coagulator, dissector and cutting instrument so that exchange of many instruments is minimised leading to faster, cleaner and better surgery. Hand instrument contains an ultrasonically activated blade which can be rotated as sharp/round/flat edges. Non-activated pad opposes this active blade to hold the tissue to create friction and shearing. Power level setting is needed in the instrument to create appropriate action. Level 1 – coagulation only; level 5 – cutting only; median power of 2-3 is usually used; usually rounded blade is used. Device is very useful in many dissections like mesoappendix in appendicectomy, cystic artery and Calot's dissection in cholecystectomy. Prior using the instrument activation is essential each time **(Fig. 18-98)**.

Harmonic ace is a modified 5 mm harmonic probe with more transection speed and haemostasis and vessel sealing capacity with

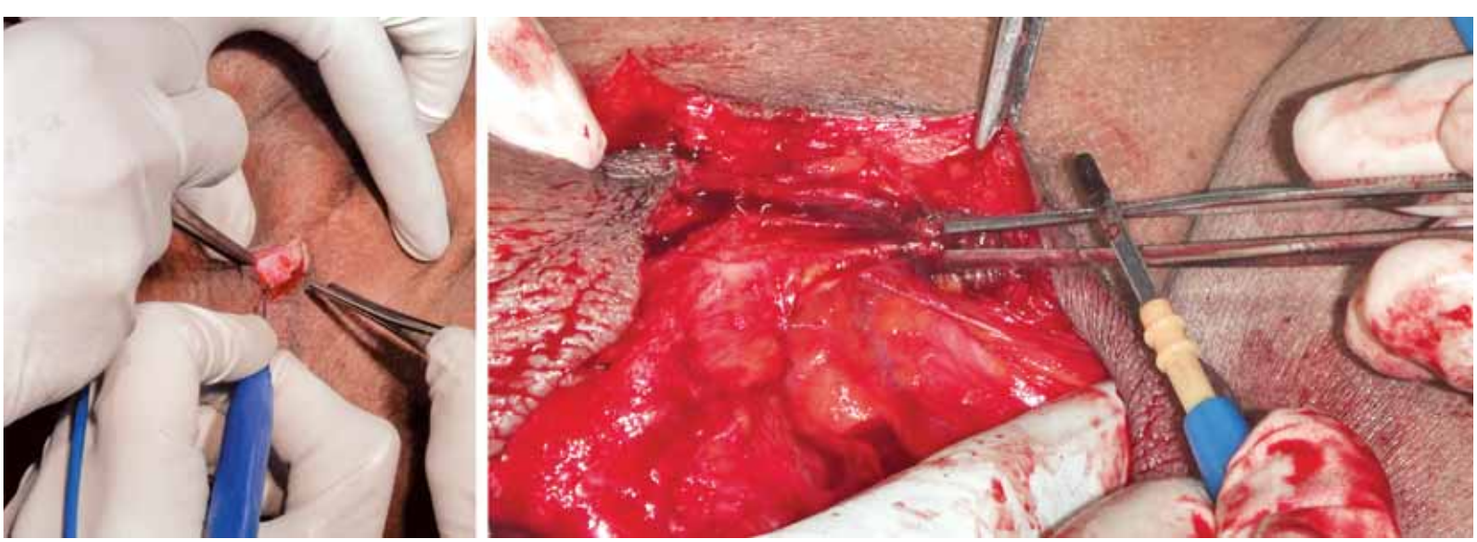


Fig. 18-95: Monopolar cautery used for haemostasis by coagulation current and for cutting by cutting current.

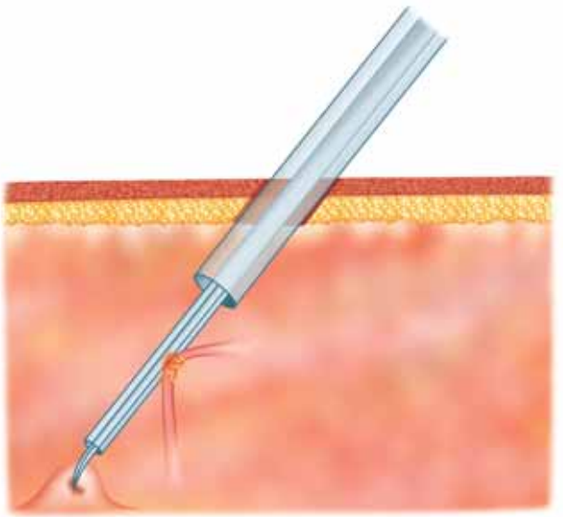


Fig. 18-96: Insulation failure causing direct diathermy injury to adjacent bowel through the 5 mm working instrument.

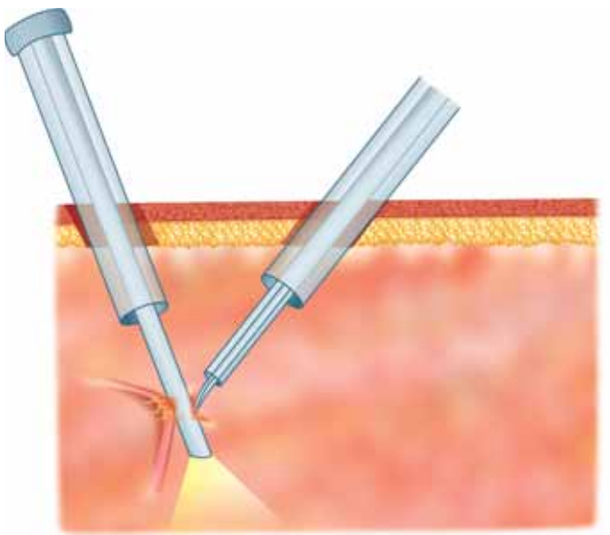


Fig. 18-97: Direct coupling.

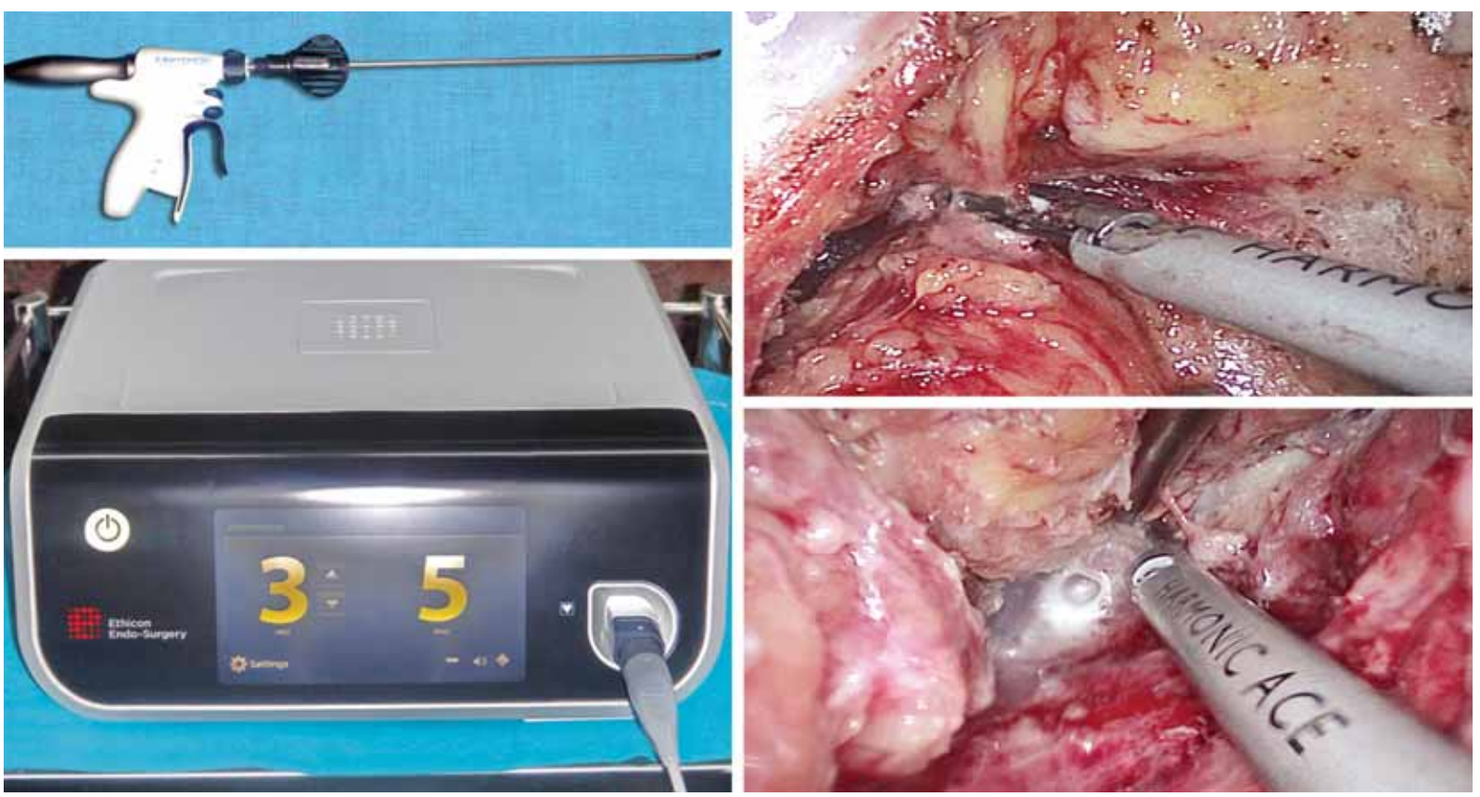


Fig. 18-98: Harmonic scalpel with its use.

additional hand activating system. 5 mm blade is available as a hook, straight and curved electrodes. Versatile curved blade is commonly used. As compared to the other devices listed, the Harmonic Scalpel is FDA approved to seal vessels up to 5 mm.

Precaution – Harmonic scalpel is very safe instrument; but integrity of instrument should be touched at the active blade; its sheathing (Teflon pad) should be adequate. While operating tip should not touch other instruments or metallic parts as tip may blast by short circuiting.

Ligasure (Valleylab)

This bipolar electrosurgical device delivers high current, low voltage along with pressure from the jaws to tissue. It can seal vessels up to 7 mm in size. This differs from the high voltage, low current energy used in standard monopolar and bipolar cautery. The system monitors the energy expended while denaturing the collagen and elastin within the vessels walls. During the cooling phase of the cycle, cross-linking reoccurs creating a new seal. The instrument

is available in 5 or 10 mm sizes. Tissue sensing technology in the Ligasure makes use of a computer algorithm to adjust the current and voltage based on real-time measures of tissue impedance. This results in a constant delivery of voltage over a broad range of tissue types. Grounding pad is not needed. Power comes from electrosurgical generator. Through hand set it reaches the blade. Sealing capacity is more here. It has got the highest burst pressure, low thermal spread, fast sealing time, and low smoke production. But smoke production is more than harmonic scalpel and instrument is not as fine as harmonic. Tissue is held with blades and is locked in handle. Foot switch is pressed to activate ligaseal. Generator gives an audible tone at the completion of cooling period. After that there is a blade in the jaw which moves to cut the tissue through a system in the handle. After that blades are unlocked. Lateral thermal spread is only up to 1.5 mm adjacent tissues. Open seal instruments are also available for haemorrhoidectomy, thyroidectomy, open GI surgeries. It is useful to seal safely uterine, splenic, inferior mesenteric arteries **(Fig. 18-99)**.

Problems – It cannot be used for dissection; takes more time; after repeated use it becomes sticky, opening the jaw after sealing often becomes difficult and forcible opening results in tissue tear and bleeding.

LAPAROSCOPIC TISSUE APPROXIMATION

Laparoscopic suturing is discussed in chapter 3. Other methods of tissue apposition are briefed here.

Laparoscopic suturing – Coaxial handled needle holder is better piston handled for intracorporeal suturing and knotting. Needle holder is held in dominant hand; supporting grasper (5 mm atraumatic, without ratchet) is held with non-dominant hand. Length of the suture material is 10 cm for first suture bite and knot with 2 cm for additional each needed suture. Lengthy suture material creates problem in manipulation inside the peritoneal cavity. Usually 2 zero vicryl is used. Needle often needs some bending (straightening) to allow it to pass through the reducer of 10 mm port; otherwise it can be pierced directly across the abdominal wall into the peritoneal cavity under direct vision. 3 zero vicryl is used to suture in pyeloplasty or in bile duct suturing. Triangulation and proper ergonomics are very important for proper endosuturing. Two instruments should meet at 60° angulation. Additional trocars should be placed to create triangulation to prevent sword fighting and crowding. 30° angled camera is better. Zoom in is done while taking bite; zoom out is done while knotting. 3 D laparoscope may be much more useful.

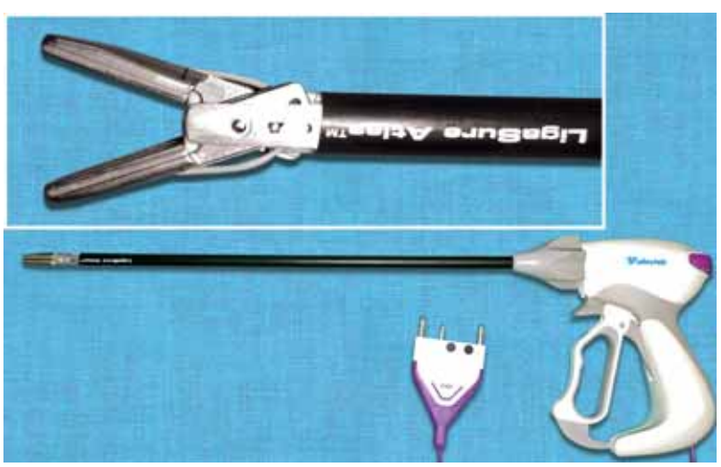


Fig. 18-99: Ligasure instrument.

Needle is passed into the peritoneal cavity through 10 mm port across reducer. Thread 1 cm away from the needle is held in a grasper or Maryland or needle holder which is already passed across the reducer; needle is pulled into the reducer sleeve; reducer is passed across the port into the peritoneal cavity; needle is released into the place under vision. Needle can be directly punctured separately across the abdominal wall under direct vision in thin individual and children. Needle is also can be passed across the 5 mm port wound after removing the 5 mm port temporarily through a 5 mm instrument needle holder or Maryland in which suture material of the needle is held 1 cm away from needle. Holding the needle at proper site in the needle holder, needle bite taking across tissue, putting a tight proper knot is an art in intracorporeal suturing. Learning curve, dedication and concentration is needed to this technique. Eye-hand coordination is important. Creation of C loop and passing the opposite instrument and pulling the end thread is initial technique to create first knot. Similarly further 2 knots are placed. Roeder's knot, extracorporeal knot creations are all other knotting techniques used.

Endostaplers are used in resection of bowel, gastrojejunostomy, anterior resection, stapling of vessels in splenectomy, nephrectomy, etc.

Autosuture endostitch devices are available wherein suturing and knotting is done easily with this.

LAPAROSCOPIC PORT SITE CLOSURE

Port site is closed by different methods. Fascial plane at any port site more than 5 mm size should be closed using 2 zero vicryl. Different methods are available with different instruments. Direct closure is also possible. Curved stout eyed port closure needle with a stout handle is often used wherein suture material is passed into its eye which is pierced across the both edges of the fascia and later tied. Fine long straight specialised port closure needle is also available which is pierced across the fascia and peritoneum into the cavity under laparoscopic vision; when its fine jaws are opened vicryl suture material which is passed across the port is grasped and pulled out; similarly it is repeated on other side and later knot is placed **(Fig. 18-100)**.

Skin is sutured with absorbable subcuticular suture (monocryl) or clips or interrupted monofilament sutures or cyanocrylate glueing **(Fig. 18-101)**.

STERILISATION/DISINFECTION OF LAPAROSCOPIC INSTRUMENTS

Laparoscopic Instruments are having complex design, delicate, increase bioburden in crevices, difficult to clean. They are used in complex laparoscopic procedures. It is difficult to clean, sterilise or maintain these instruments.

Sterilisation is a process that destroys all forms of microbial life (including spores) absolutely by physical/chemical methods; steam under pressure (autoclave), dry heat, ETO, Gas plasma;

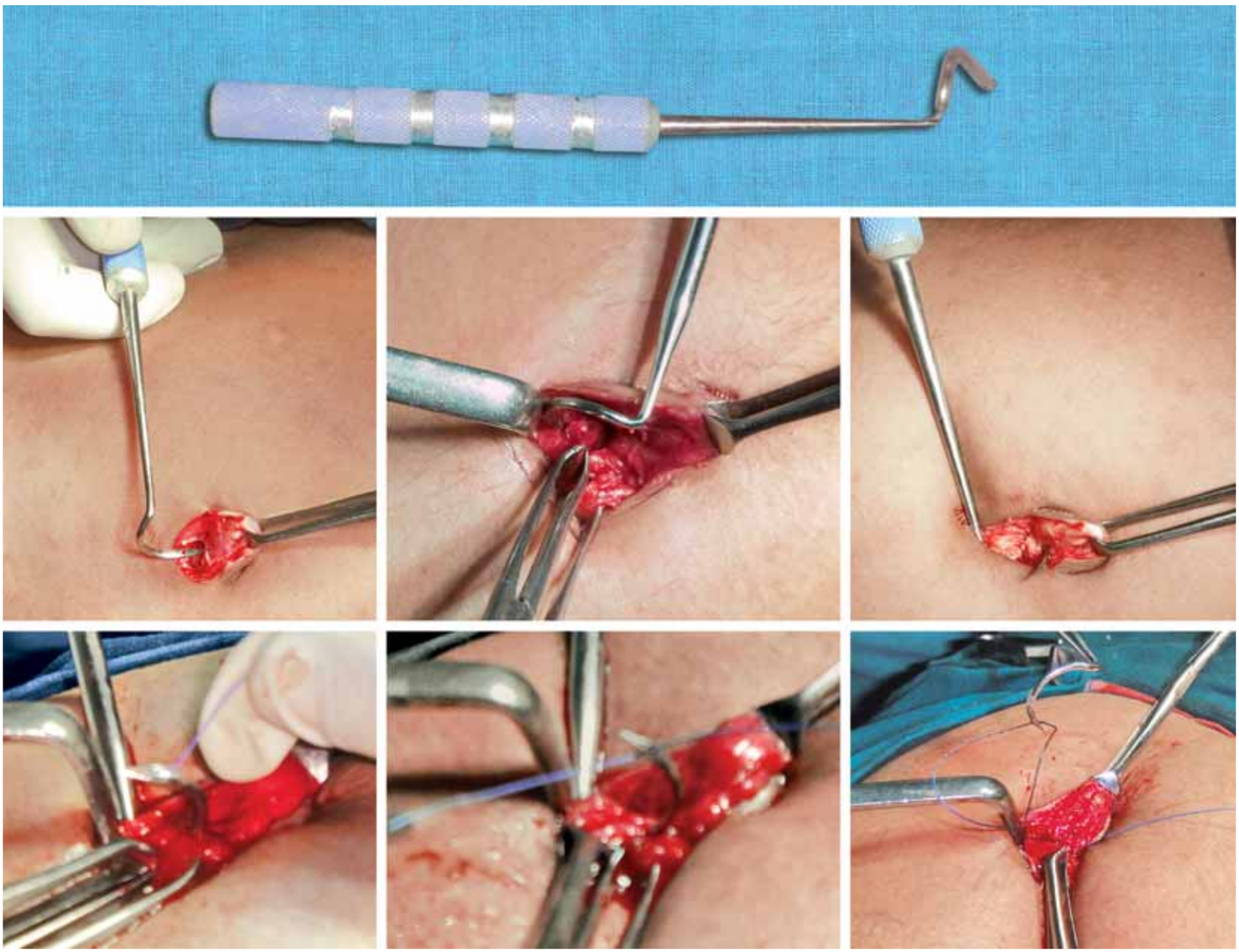


Fig. 18-100: One of the methods of port closure technique.

Fig. 18-101: Cyanocrylate glueing to close the skin.

liquid chemicals. Some disinfectants on prolonged exposure can destroy spores.

Disinfection is a process that destroys many or all pathogenic bacteria but not their spores; used on inanimate objects; use of liquid chemicals (Disinfectants).

Splauding Classification of Objects and Level of Sterilisation

Critical	*Semicritical*	*Non-critical*
Entry or penetration into sterile tissue, cavity or bloodstream	Entry to mucous membrane or non-intact skin	Entry to intact skin Noncritical patient care Noncritical environmental surfaces
Surgical instruments, Cardiac/ Urinary Catheters, Implant, USG probes	Laparoscopes, Endoscopes, respirator and anaesthesia equipment	Bed pans, blood pressure cuffs, Furniture, bedside table, utensils
Sterility required	Objects to be free of all microorganisms but not spores.	Objects to be clean

DISINFECTION

Disinfection may be -

High Level Disinfection (HLD)

At same concentration as chemical sterilants, but shorter exposure, the same disinfectant can kill only the microorganisms and ***not*** spores. E.g. Glutaraldehyde, OPA, per acetic acid, hydrogen peroxide.

Intermediate Level Disinfection

Can kill mycobacteria, vegetative bacteria, most viruses, most fungi but ***not*** the spores, e.g. Ethyl/isopropyl alcohol, sodium hypochlorite, iodophors, phenolic compounds.

Low Level Disinfection

Can kill most vegetative bacteria, some fungi, and some viruses within 10 minutes. Same as above and quaternary ammonium compounds.

For laparoscopic instruments high level disinfection may be sufficient. *Reasons are* – Only a limited number of organisms (usually ≤10) are introduced into the peritoneal cavity during laparoscopy; minimal damage is done to inner abdominal structures with little devitalized tissue; peritoneal cavity tolerates small numbers of spore forming bacteria; these equipments are easier to clean and disinfect; natural bioburden on rigid lumen devices is low. There are no evidence exists that high-level disinfection instead of sterilisation increases the risk for infection.

But sterilisation is proposed by many. *Reasons are* – degree of tissue damage and bacterial contamination is greater; possibility of transmitting infection by spore-forming organisms; increased bioburden due to complex design; risk of bio film formation.

Choice whether sterilisation or disinfection is needed depends on—type of instrument material; intended use and function; instrument design; compatibility with various sterilization processes.

Disinfectant/ sterilant	*Advantages*	*Disadvantages*
Glutaraldehyde	• Relatively inexpensive • Excellent materials compatibility	• Respiratory irritation from vapour • Pungent and irritating odour • Relatively slow mycobactericidal activity • Coagulates blood and fixes tissue to surfaces • Allergic contact dermatitis • Glutaraldehyde vapour monitoring
Ortho-phthalaldehyde (OPA) – 0.55%	• Fast acting high-level disinfectant • No activation or mixing is required • Odour not significant • Excellent materials compatibility claimed • Good mycobactericidal activity • 20 minutes soak time at room temperature for reprocessing	• Stains skin, mucous membranes, clothing, and environmental surfaces • Repeated exposure may result in hypersensitivity in some patients with bladder cancer • More expensive than glutaraldehyde • Eye irritation with contact • Slow sporicidal activity
Per acetic acid (Per oxygen compounds)	• Rapid sterilisation cycle time (30-45 minutes) • Low temperature (50-55°C) liquid immersion sterilisation • Environmental friendly by-products • It is bactericidal, fungicidal, virucidal, sporicidal and tuberculocidal • It is highly corrosive and corrosion inhibitor should be used in the formulation.	• Potential material incompatibility (e.g. aluminium anodized coating becomes dull) • Used for immersible instruments only • Serious eye and skin damage (concentrated solution) with contact • Point-of-use system, no sterile storage
Hydrogen peroxide	• No activation required • Removal of organic matter and organisms • No disposal issues • No odour or irritation issues • Does not coagulate blood or fix tissues to surfaces • Inactivates *Cryptosporidium*	• Material compatibility concerns (brass, zinc, copper, and nickel/silver plating) both cosmetic and functional • Serious eye damage with contact
Superoxide saline	• It is hypochlorous acid derived from salt through electrolysis. It is sporicidal, mycobactericidal until there is no soiling	

Note:

- *CDC Guidelines States:* Laparoscopes, arthroscopes, and other scopes that enter normally sterile tissue should be sterilized before each use; if this is not feasible, they should receive at least high-level disinfection. Objective should be free of microorganisms.

Technique of Achieving Sterilisation/ Disinfection

Cleaning

Cleaning of instruments is the main and important initial method of all disinfection or sterilisation. Cleaning is removal of visible soil - organic/ inorganic by manual or mechanical method using soap/ detergents/ enzymatic solutions; is essential presterilisation/predisinfection procedure.

Cleaning should begin during surgery itself or immediately after finishing the surgery. Instruments should never be allowed to dry; instrument is rinsed with sterile distilled water on the sterile field itself especially channel and lumen bearing instruments. It facilitates removal of blood from joints, hinges and crevices. *Saline should not be used.*

After use, the instruments are placed gently in a basin; heavy instruments at the bottom; delicate and fibreoptic instruments on top or preferably in another container. Coils to be loosely wound. Sharp end instruments should be kept separately so that personnel handling them are not injured.

Cleaning process is done in a methodical way: Pre-cleaning→ Soaking in enzymatic detergent → Washing → Rinsing → Drying.

Precleaning is done immediately after the procedure.

The instrument is wiped with a disposable cloth dampened in an enzymatic detergent solution. Enzymatic detergent solution is aspirated through the suction/biopsy channels with alternate suctioning of fluid and air which prevents drying of organic and inorganic debris on lumen surfaces and assists in the removal of large numbers of micro-organisms and it also dislodges debris from internal lumens. Air/water channels are purged. Removable components are detached. All valves/buttons/caps are removed and soaked in enzymatic detergent solution. Instruments are transported to the cleaning area in a container (without water).

Manual cleaning: It is done using brush and detergent. It is used for fragile instruments, mechanical cleaners are not available. But instruments may get degraded/blunt; it is time consuming and causes friction and fluidics. Nylon brushes of different types and sizes are used. Ports, accessories should be cleaned with brush **(Fig. 18-102)**.

Mechanical cleaning: It is done by - Ultrasonic cleaning, washer decontaminator, washer- sterilizer. **Ultrasonic cleaner is a mechanical cleaning device** highly efficient on surfaces with crevices, locks, serrations but should be used only after the debris is removed. Solution should be changed frequently as endotoxin contamination of solution can occur. It is unsuitable for plastic as ultrasound waves are absorbed by plastic. It may produce infective aerosols. Instruments of dissimilar metals should not be used together and instruments should not be overloaded.

Laparoscopic instruments require both manual and mechanical cleaning **(Figs 18-103A to C)**.

Soaking in Enzymatic Detergent

Enzymatic detergents are good to clean all debris. Single or multienzymes can be used. Formation of foam, pH of the detergents are deciding factors. Thorough washing is essential. Fast-acting enzymatic cleaning agent (ENZOL) which has mild pH and low foaming feature (contains proteolytic enzymes) which can be used in automated equipment: endoscope reprocessors, ultrasonic cleaners, and washer-sterilizers/decontaminators. Minimum 1 minute soak time is sufficient. One-step process reduces the need for mechanical cleaning which may reduce exposure to contaminated equipment. Mild pH reduces likelihood of corrosion of equipment.

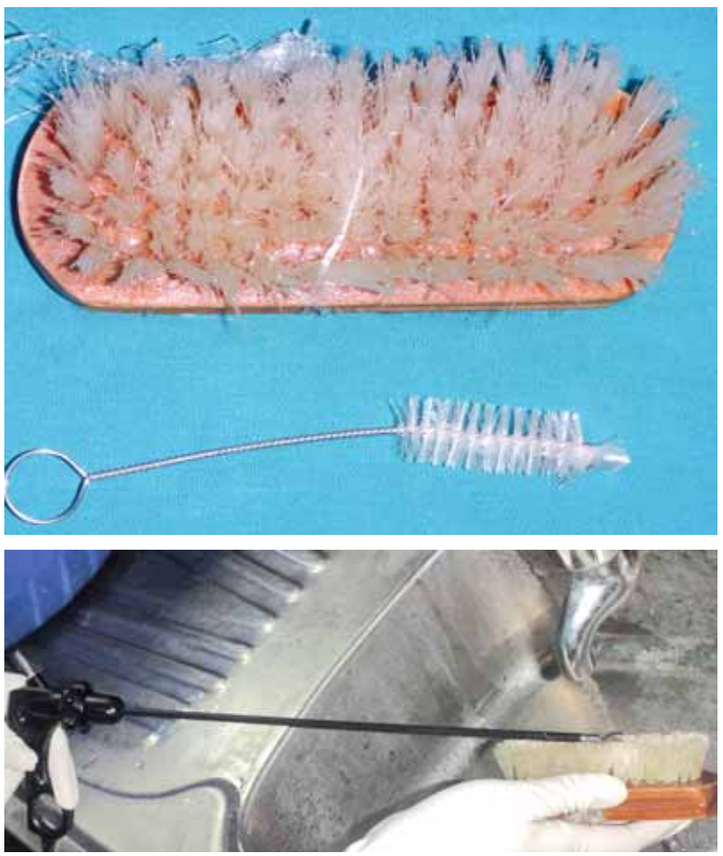


Fig. 18-102: Cleaning with brush is very important part in precleaning process.

Water Rinse

Outer surfaces of the instrument and all removable parts are rinsed with water; all channels are flushed thoroughly with water (water jet); clean running water should be used to remove all traces of detergent prior to disinfection and limit cross infection.

Drying

External/outer surfaces of the instrument is dried with a soft, lint-free disposable cloth. All internal channels are purged with air to remove rinsing water. Removing water from all channels and the exterior of the instrument prevents dilution of the biocide used for disinfection. This process can be completed using a syringe or compressed air.

Decontamination

It is removal of all visible soil, tissue, blood and foreign particle causing reduction of bioburden (microbial load and endotoxins); protects instruments against corrosion; allows safe movement of equipment and materials. It results in reduction in pathogenic bacteria from objects so as to make it safe to handle, use or discard. Cleaning reduces bioburden very significantly.

High Level Disinfection (HLD)

Disinfection clears or reduces the number of microorganisms in the instruments but bacterial spores are not completely killed even though it reduces spore numbers. Adequacy of disinfection depends

A
B
C
OPERATING INSTRUCTIONS
DO NOT OPERATE THE MACHINE WITHOUT FILLING THE TANK COMPLETELY.
DO NOT RUN THE MACHINE IF THE LIQUID TEMPERATURE HAS GONE ABOVE @ 55 °C. AS IT CAN LEAD TO FAILURE.
DO NOT PUT ANY HEAVY OBJECT ON THE BOTTOM OF THE TANK AS IT CAN DAMAGE THE TRANSDUCERS. ALWAYS USE TRAY SUPPLIED WITH THE MACHINE.
PLEASE ENSURE THAT LIQUID DOES NOT SPLASH ON CONTROLS & SWITCHES.
PLEASE ENSURE THAT THE MACHINE IS USED WITHIN 170 V AC TO 250 V AC VOLTAGE RANGE FOR LONG LIFE. OTHERWISE A C.V.T. IS RECOMMANDED. IN AREAS WITH WIDE VOLTAGE VARIATIONS.

Figs 18-103A to C: Ultrasonic cleaning device.

on number of microorganisms in the instrument; bactericidal property of the disinfectant; concentration, pH and temperature at the site; type and design of the instrument (hinges/joints). HLD reduces the bioburden significantly with bactericidal, fungicidal, virucidal and partly sporicidal features.

Disinfectants may be aldehydes; alcohols; per oxide compounds; chlorine dioxide; super-oxidised saline solutions.

Glutaraldehyde

It is noncorrosive aldehyde available as 2.4% alkaline solution. It is bactericidal, fungicidal, virucidal and only slow sporicidal agent. It is used at room temperature. HLD occurs in 45 minutes and sterilisation occurs in 10 hours. It has got 14 days maximum reuse life (Cidex). *Cidex plus* is 3.4% alkaline glutaraldehyde which has got 28 days of maximum reuse life. Entire activator (a rust inhibitor) is added to the solution to make colour of the solution green. Activated solution can be used only for 14 days. Date of activation and date of expiration should be recorded. After cleaning, with detergent, rinsing and drying, instrument is dipped in prepared glutaraldehyde solution; time is 20 minutes for high level disinfection (HLD). Hollow instruments should be dismantled and immersed. Immersion time is 10 hours for sterilisation with container being properly covered to prevent evaporation. Disinfectant should touch and soak all parts of the instrument properly. Instruments should never be placed on the top of the other. After specified time immersed instrument is removed by wearing sterile gloves and rinsed with sterile water for three times and kept in the case table. Water which is boiled for 20 minutes and filtered and cooled can also be used instead of sterile water. Final rinsing can be done using 60-90% ethyl or isopropyl alcohol **(Fig. 18-104).**

Hazards – It can cause on inhalation cough, headache, wheezing and nausea. It can cause skin redness, redness and pain in eyes. Prevention is – proper ventilation, fresh air, wearing gloves and goggles while working on glutaraldehyde. Room should have vapour extraction equipment.

Advantages are – low cost; low temperature; availability.

Disadvantages are – minimum effective concentration (MEC) of 1.5% should be regularly checked and confirmed on the prepared solution each time. Sterilisation process cannot be validated. Moisture sensitive instruments like cameras, power cords and cables cannot be sterilized. Instruments cannot be stored after sterilisation.

Alcohols

Alcohol 70% solution is bactericidal, fungicidal, virucidal and tuberculocidal also. It is fast acting but will not penetrate into organic materials and so is mainly used on clean surfaces. Camera head, cable and plug can be kept in alcohol for sterilisation. Water resistant cap should be covered to the part of the plug which needs to be protected. Ethanol and isopropanol are used.

Problems of Chemical Disinfection

Recontamination of instruments is possible as disinfectants are reusable. Both patients and theater staffs are exposed to adverse effects of the chemicals. Organic matter retained in the instrument may not be properly disinfected as disinfectant itself may get inactivated in such situation. Resistant to organisms; incompatibility of some

CIDEX
14 Days Solution
CIDEX® - Activated Glutaraldehyde Solution
ACTIVE INGREDIENTS: Contains 2.45% w/v Glutaraldehyde
CHEMICAL NAME: Pentane - 1, 5-dial
INERT INGREDIENT: Purified Water
DISPOSAL: Discard residual solution in drain or as per hospital policy.
CONTAINER DISPOSAL: Do not reuse empty container, rinse with water and dispose as per hospital policy.
INSTRUCTIONS FOR USE:
NOTE: Entire contents of the Activator vial attached to the container must be added to the Solution and mixed before this product is ready for use. Please refer IFU for Instructions for Use.
NOTE: CIDEX® Activated Glutaraldehyde Solution can be reused for up to a maximum of 14 days.
WARNINGS: THIS PRODUCT IS HAZARDOUS TO HUMAN BEINGS AND DOMESTIC ANIMALS.
DANGER: Keep out of reach of children.
CAUTION: Contains Glutaraldehyde. Harmful by inhalation and if swallowed. Irritating to respiratory system and skin. Risk of serious damage to eyes. May cause sensitization by inhalation and skin contact. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable protective clothing, gloves and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
HARMFUL: Use only in well ventilated areas [refer to the material safety data sheet (MSDS) for additional information]. Avoid release to the environment.
FOR EXTERNAL USE ONLY

Fig. 18-104: 2.45% glutaraldehyde w/v contains pentane – 1, 5 dial. Glutaraldehyde tray having activated solution.

disinfectant to instruments, corrosive nature; difficulty in determining the concentrations in reused disinfectants are the further problems.

Disinfection of Endoscopic Instruments

High level disinfection is commonly used in endoscopes/laparoscopes. Immediately after use telescopes, light source, cable, tubes are cleaned and wiped gently using 90% ethyl or isopropyl alcohol soaked cloth. Alcohol kills HIV, HBsAg viruses. All equipments are dismantled completely which are placed in a basin of water with nonabrasive soap. Instruments are washed gently using cotton cloth. Channels of the instruments are cleaned using specified brushes with circular movements to clear all organic materials. All instruments and their parts are rinsed with running water properly. Soap should be cleared completely while rinsing with water; brush may be useful while final rinsing with water to clear the retained soap. Instruments are dried with dry cloth or air dry. While cleaning lenses, it should not be touched with fingers; they are cleaned after removing the plastic covers/eyepieces using acetone or 90% alcohol; lenses should be cleaned weekly even if not in use.

Autoclave and boiling the laparoscopes is not advisable. During autoclave each instrument should be wrapped separately with clothing and kept, otherwise touching of each instrument with one another will cause damage to instruments or their insulation. Chemical sterilisation is the best. ETO, gas plasma sterilisation can also be done. After disinfection rinsing with sterile water or cooled boiled water 3 times is essential otherwise instrument may get stuck due to retained chemical. While handling the instruments sterile gloves should be used not forceps which may damage the laparoscopes. Only one telescope should be held one time; holding in groups should be avoided. *Savlon should not be used* as it will cause clouding and it will not cause HLD.

Storage of Laparoscopic Instruments

Instruments are cleaned; washed; decontaminated; dried and stored in a padded container in a cool dry place. When needed for use, stored instruments should be cleaned, sterilized or disinfected (HLD) then used.

STERILISATION

Steam Sterilisation

It kills by denaturation and coagulation of protein in the cells. Autoclave is steam under pressure. It is done with either 135°C for 5 minutes or 121°C for 15 minutes with 15 pounds pressure. There are flash and vacuum types. All instruments that are insulated, all silicone tubing, all cables and cords should be wrapped in double lined lining (double cloth wrapped).

Advantages - It is economical, fast, age old practice for sterilisation of linen and metallic instruments, very effective, and is well monitored. Nonplastic materials, instruments which will not lose their temper are autoclaved. It is ideal for reusable instruments.

Disadvantages - Sharp instruments may get blunt by autoclaving. Heat and moisture sensitive instruments (glass syringes) cannot be sterilized. Rigid endoscopes can be sterilized by porous loaded autoclaves. Instruments with narrow lumen should be sterilized using porous loaded autoclave. Endoscopes/telescopes sterilized by autoclave should not be cooled rapidly as it may cause stress damage to the instruments. It cannot be used for heat sensitive instruments and wet surfaces **(Fig. 18-105)**.

Fig. 18-105: Autoclave for sterilisation.

Ethylene Oxide Sterilisation (EO/ETO)

It kills by alkylation—Interfering with the metabolism and reproductive process of cells. Sterilisation temperature is 37-55°C; sterilization time 3-5 hrs; aeration time 12-16 hours **(Fig. 18-106)**.

Technique – Initial chamber evacuation, humidification and ethylene oxide charging phase → dwell sterilisation phase → chamber evacuation phase with aeration. It is commonly sterilized at 54.4°C for 3 hours. Heat sensitised instruments are sterilised at much lower temperature of 37.8°C for 5 hours. After sterilization, trapped or absorbed gas is removed by aeration using aeration chamber in the set. Aeration is done by continuous flow of warm air at 50–60°C for 12 hours. Personnel should take utmost care to avoid exposure toxicity.

Advantages – It is low temperature sterilization, can sterilise all kinds of instruments. It does not corrode instruments. It is suitable for all disposable instruments, insulated hand instruments and tubes used for gas, suction and irrigation. Cold or warm ETO is possible. It is material compatible, especially optics.

Disadvantages - It needs aeration and is toxic and carcinogen. Prolonged aeration periods impact instrument availability at right time for surgeries. It is costly. It causes exposure of theatre staff to toxic ethylene oxide gas. Presence of water droplets on the instruments during ethylene oxide sterilisation would form toxic chemical called ethylene glycol. Set is not mobile.

Hazards – Inhalation of ethylene oxide vapour (1000 ppm exposure) can cause pulmonary oedema and respiratory distress; damage to eyes (burns, conjunctivitis, cataract); headache, recurrent vomiting; muscle weakness; neurological manifestations (rare). Direct contact to skin can also cause similar effects by absorption but slowly. It also can cause skin irritations, redness, frostbite like burns (if contaminated shoes or gloves are used), and dermatitis.

Gas Plasma Sterilisation

It is killing of microorganisms using highly active gas ions and free radicals. It uses hydrogen peroxide and plasma which is generated by radiofrequency/ MW (Vapour phase hydrogen peroxide/VHP). It causes generation of free radicals; uses low temperature; by products are safe; aeration is not necessary; short sterilisation cycle even though vary depends on H_2O_2 concentration; good material compatibility; ready to use/store always; requires only an electrical hook up **(Fig. 18-107)**.

Advantages – It is economical; can sterilize all kinds of instruments including the heat and moisture sensitive instruments; it is fast and helps in inventory reduction; it is safe for environment, healthcare workers and patients. It does not require monitoring. It is mobile, simple for installation.

Disadvantages – It cannot sterilize cellulose materials like linen, wood, powders and liquids.

Fig. 18-106: Ethylene oxide sterilisation device.

Fig. 18-107: Gas plasma sterilisation device.

Chapter

19

Surgery of Oesophagus

SURGICAL ANATOMY

Oesophagus is a hollow muscular tube which begins at the lower edge of the cricoid cartilage (C6 vertebra) and ends at oesophagogastric junction (T12 vertebra). It is 25 cm in length. Upper end is closed by cricopharyngeus muscle which is 18 cm from upper incisors. Lower end is 40 cm from the upper incisors (Upper jaw is fixed and so is used as the landmark to measure, but not the lower jaw which is mobile). It lies anterior to vertebral column and posterior to the trachea. It lacks serosal layer but is surrounded by a layer of loose fibroareolar adventitia.

Anatomical specialities

- Lacks serosa (other structure without serosa is rectum).
- Contains 2 different types of muscles (striated and smooth at proximal 1/3 and distal 2/3, respectively)
- Contains 2 different types of epithelium.
- Segmental blood supply.
- Only part of GIT which shows *very thinly scattered* Meissner's plexus.
- Longitudinal arrangement of veins and lymphatics.

It is lined by non-keratinising stratified squamous epithelium throughout the length except the last 3 cm (OG junction) which is lined by columnar epithelium. Submucosa of the oesophagus is thick and strongest part.

Mucosa → basement membrane → lamina propria → muscularis mucosa (causes wrinkling/folding of mucosa) → submucosa containing mucous secreting glands with thin Meissner's plexus of nerves → two layers of muscles inner thick circular and outer thin longitudinal muscles (in between two layers lies the Auerbach's myenteric nerve plexus) → outermost loose adventitial coverings (no serosa; no mesentery). Endoscopic ultrasound is very useful tool to identify and evaluate different layers of the oesophagus. During anastomosis bites from submucosa and lamina propria should be adequate. Transection of the oesophagus at hiatal level causes retraction of the proximal cut end into the posterior mediastinum due to contraction of the longitudinal layer as it is fixed superiorly.

Muscles are striated in proximal 1/3rd of oesophagus; smooth muscles in distal 1/3rd and mixture of two in middle 1/3rd. This is mainly observed in circular muscle fibres.

Parts

1. ***Cervical oesophagus:*** It extends from cricopharyngeus which is the horizontal part of inferior constrictor muscle. Upper oblique part is called as thyropharyngeus. Gap between the two is called as *Killian's dehiscence* which is a *site of occurrence of pharyngeal pouch*. Cricopharyngeus originates from thyroid and cricoid cartilages. Cervical oesophagus is related to trachea and recurrent laryngeal nerve. It is 6 cm in length extends from C6 to T1. It projects towards left of trachea and so left side is easier to approach oesophagus than right. Its end is 15 cm from upper incisor extends from hypopharynx to level of sternal notch. *Laimer's triangle* is formed with base above by cricopharyngeus and on either side divergent longitudinal oesophageal muscles. Laimer's triangle lies in the posterior part of the oesophagus midline **(Fig. 19-1)**.
2. ***Thoracic oesophagus:*** It lies initially towards the right side. It extends from T1 to T11 vertebrae. It is located in superior and posterior

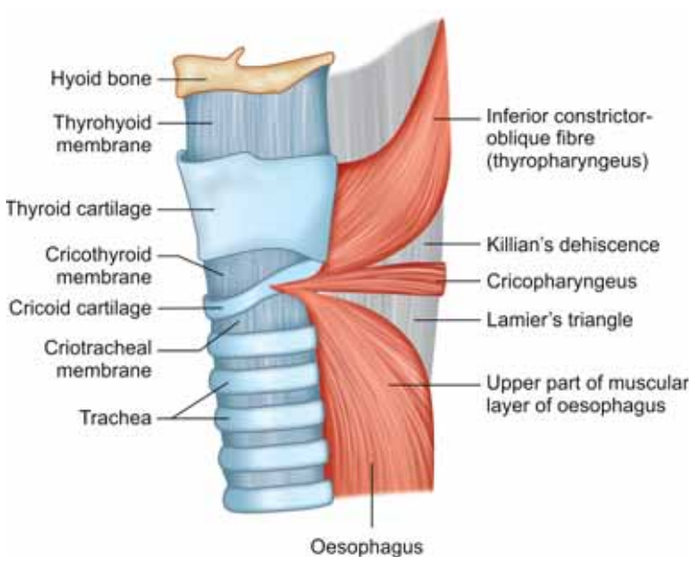


Fig. 19-1: *Killian's dehiscence* which is a *site of occurrence of pharyngeal pouch. Laimer's triangle* is formed with base above by cricopharyngeus and on either side divergent longitudinal oesophageal muscles. Laimer's triangle lies in the posterior part of the oesophagus midline.

mediastinum. In lower third it deviates towards the left and continues as abdominal oesophagus. It is related to azygos vein, thoracic duct (which crosses the oesophagus posteriorly from right to left), aorta, pleura and pericardium.

3. ***Abdominal oesophagus*** is 2.5 cm long and grooves behind the left lobe of the liver. It lies over T11 and T12 vertebral level. Oesophageal hiatus is at T10 level. Anteriorly it is related to left lobe of the liver, left vagus and oesophageal plexus; posteriorly crura of diaphragm, left inferior phrenic artery and aorta; to the right related to caudate lobe of liver; to the left to fundus of stomach. Abdominal oesophagus is more or less retroperitoneal with peritoneum covering its anterior and towards left only. In the hiatus oesophagus lies on the left/deep pillar of the right crus of the diaphragm. Angle of entry of oesophagus to stomach is called as *angle of His* which is 30° to 70°. Fundus of stomach is that part of the stomach which lies above an imaginary line drawn horizontally through angle of His. Gastro oesophageal junction is called as cardia.

***AJCC has classified oesophagus as cervical; upper thoracic; middle* thoracic; lower thoracic.**

Cervical – same as original anatomical nomenclature.

Upper thoracic oesophagus extends from level of sternal notch (thoracic inlet) to lower border of azygos vein.

Middle thoracic oesophagus extends from lower border of azygos vein to level of inferior pulmonary veins below.

Lower thoracic oesophagus extends from inferior pulmonary veins to stomach. It is older abdominal oesophagus. It includes OG junction.

Three areas of anatomic narrowing

Cervical constriction—occurs at the level of cricopharyngeal sphincter—*narrowest point of GIT*—15 cm from upper incisor—site of F/B impaction.

Bronchoaortic constriction—located at the level of T4 – 25 cm from upper incisor—site of endoscopic perforation. Here left main bronchus (T5) and arch of aorta (T4) crosses it in front. Even though it is considered anatomically as one it has got two components – aortic at T4 and bronchial at T5 level.

Diaphragmatic constriction—occurs where oesophagus traverses the diaphragm (Level of T10)—40 cm from upper incisor.

There are minor constrictions also – retrosternal between cervical and bronchoaortic constrictions; cardiac behind the pericardium; supradiaphragmatic by tortuous aorta.

In the neck it initially deviates towards the left side; then at the level of 5th thoracic vertebra it deviates towards midline; then again it deviates towards left to end as abdominal oesophagus.

Arterial supply of oesophagus

It is segmental and is supplied by inferior thyroid artery, oesophageal branches of the aorta, gastric arteries and inferior phrenic arteries. Cervical part is mainly supplied by inferior thyroid artery and partly by pharyngeal, subclavian, vertebral, common carotid, superior thyroid, and costocervical trunk. Upper part of thoracic oesophagus is supplied by mainly inferior thyroid artery (mainly right side artery) and partly by anterior oesophagotracheal branch. Middle oesophagus is supplied by superior branchial artery and branches directly from aorta. Lower thoracic oesophagus is supplied by single bronchooesophageal artery arising from aorta. Left gastric and left inferior phrenic artery also supplies abdominal oesophagus. These vessels are *small* and form a rich network in submucosa. Communicating branch between inferior phrenic artery and left gastric artery is called as *Belsey's artery* which should be preserved in Belsey Mark IV surgery **(Fig. 19-2)**.

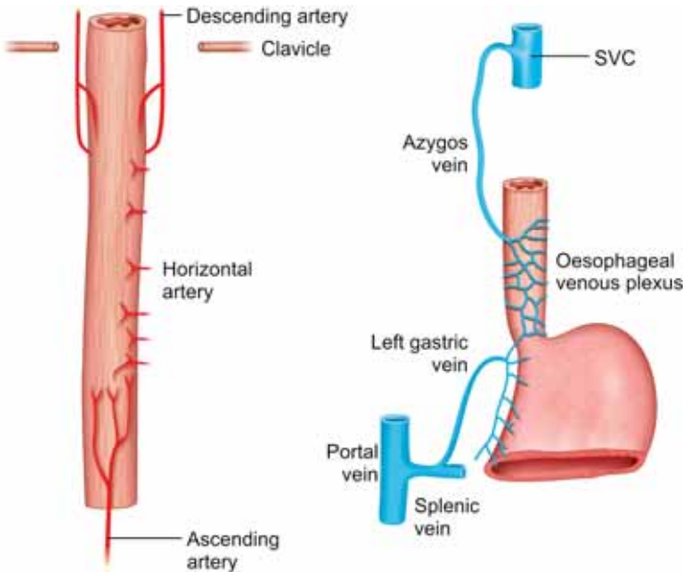


Fig. 19-2: Blood supply of the oesophagus.

Venous drainage of oesophagus

It is both longitudinal and segmental by inferior thyroid vein, brachiocephalic vein, and hemiazygos vein, azygos vein, coronary vein, bronchial, posterior intercostal, splenic vein and inferior phrenic vein. Veins are longitudinal and they lie in submucosal plane in lower third and in muscular plane above. Subepithelial longitudinal venous plexus in lamina propria → submucous intrinsic venous plexus → extrinsic venous plexus → larger veins. Venous plexus in lower oesophagus communicates with portal venous system **(Fig. 19-3)**.

Lymphatic drainage

Lymphatic arrangement in oesophagus is longitudinal and so spread of carcinoma to distant lymph nodes occurs early. Longitudinal lymphatics are 6 times more than transverse one. There are *more lymph vessels* in submucosa than blood vessels **(Fig. 19-4)**.

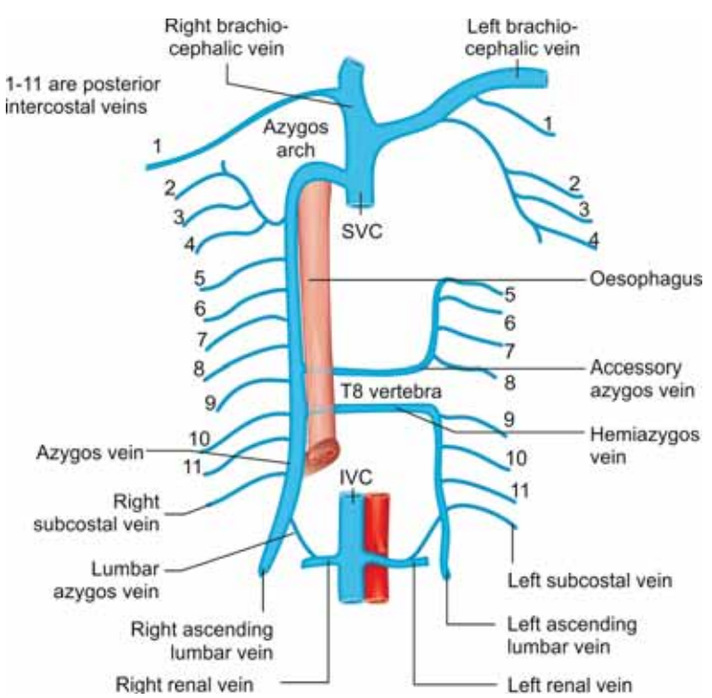


Fig. 19-3: Venous drainage of oesophagus.

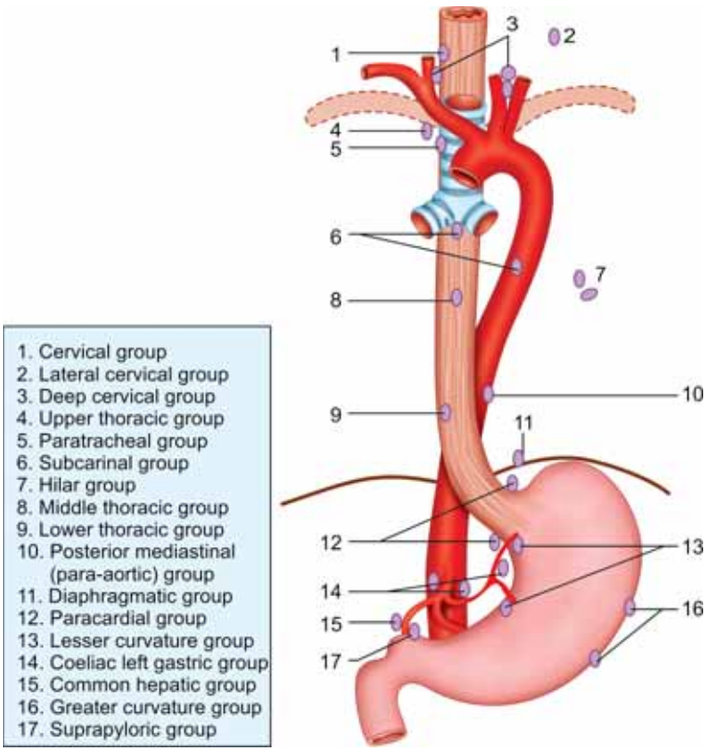


Fig. 19-4: Lymph nodes draining the oesophagus.

Lymph nodes are:

Paraoesophageal groups located in the wall of the oesophagus and are cervical, thoracic, paraoesophageal and paracardial nodes.

Perioesophageal groups located immediately adjacent to oesophageal wall. They are deep cervical, scalene, paratracheal, mediastinal, diaphragmatic, gastric and coeliac lymph nodes.

Lateral oesophageal groups receive lymph from para- and perioesophageal lymph nodes.

Upper oesophagus drains into supraclavicular nodes. Thoracic oesophagus drains into paraoesophageal and tracheobronchial nodes in thorax. Abdominal oesophagus drains into coeliac nodes.

However due to longitudinal arrangement of lymphatic plexus in the wall of oesophagus, any group of (neck/thorax/coeliac) lymph nodes can get involved in diseases at any level. In T1a only mucosa is involved by carcinoma and so metastasis is rare. In T1b submucosa is involved by tumour and so nodal metastases is up to 30-50%. AJCC has adapted different lymph node stations for oesophageal carcinoma (1-19).

Anatomical Relations of Oesophagus

Oesophagus begins at lower edge of cricoid cartilage at C6 vertebral level and ends at oesophagogastric junction at T11 vertebral level. OG junction is at the level of 7th intercostal space anteriorly. Above it lies the cricopharyngeal sphincter which is 18 cm from upper incisor. Lower oesophageal sphincter is 40 cm from upper incisor.

Relation in the neck

Oesophagus along with trachea is covered with pretracheal fascia which also encloses the thyroid gland. So anterior relations are larynx and trachea. Posteriorly buccopharyngeal fascia separates it from prevertebral space and this fascia extends laterally as carotid sheath. Recurrent laryngeal nerve lies in tracheooesophageal groove. Left RLN is closer to oesophagus than right. Thoracic duct is towards left of the oesophagus and its upper end is 4 cm above clavicle. Laterally relation from lateral to medial are – carotid sheath, inferior thyroid artery, lateral lobe of thyroid gland, recurrent laryngeal nerve **(Fig. 19-5)**.

Retropharyngeal space continues below towards posterior mediastinum and so infection can cause mediastinitis. Cervical oesophagus is closely related to trachea through *tracheal pars membranacea* and so during transhiatal dissection injury to this membranacea can cause tracheal perforation. Oesophageal perforation within the pretracheal fascia may extend into mediastinum causing mediastinitis.

Relation in the thorax

Thoracic oesophagus is related in front from above downwards are: trachea; aortic arch; right pulmonary artery; left main bronchus; pericardium and left atrium; anterior vagus; oesophageal hiatus. Posterior relations are: vertebral column; longus coli muscles; right posterior intercostal arteries; thoracic duct (crosses it from behind); right pleura; azygos, hemiazygos and accessory azygos vein; aorta; posterior vagus. Laterally – on right side are: mediastinal pleura, azygos vein, right main bronchus, root of right lung, right vagus nerve; on left side are: aortic arch, left subclavian artery, left recurrent laryngeal nerve, thoracic duct from T4 to C7, pleura, descending thoracic aorta. Arch of azygos vein (azygos arch) crosses the right main bronchus.

In thorax oesophagus descends posterior and medial to the aortic and azygos arches and left main bronchus. Right and left mediastinal pleura are on both sides. Left recurrent laryngeal nerve is lateral and

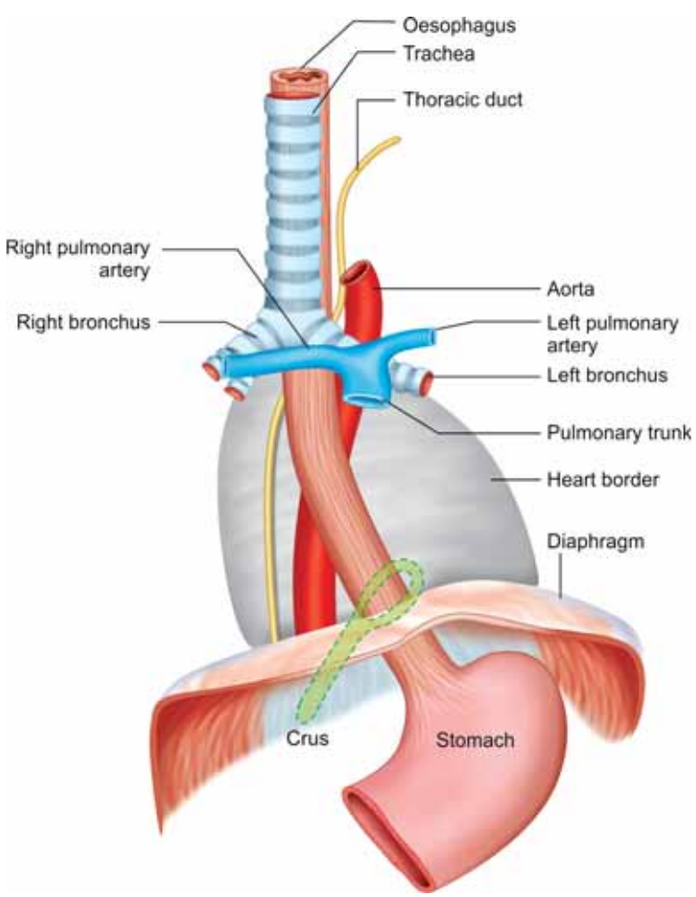


Fig. 19-5: Oesophageal relations in thorax.

thoracic duct is posteromedial. At the carinal level, oesophagus is separated from tracheal carina by subcarnial nodes, and thoracic duct crosses it from behind. Below oesophagus is behind the fibrous pericardium and right of the descending aorta. Both vagi run longitudinally on the surface of the oesophagus in front and behind (left anterior; right posterior).

Phrenooesophageal ligament or membrane is condensation of pleura, endothoracic fascia, phrenooesophageal fascia of Lamier, transversalis fascia and peritoneum into two sheaths; upper one is attached to the outer muscular layer of oesophagus; lower one into cardia extending into gastric serosa and gastrohepatic and gastrosplenic ligaments. Pleura and peritoneum maintains airtightness; other components provide strength and flexibility. Membrane is well developed in front than behind. Superficial layer is peritoneum; deeper layer is thick fibrous tissue. It provides barrier between oesophagus and thorax. When the peritoneum in front of the hiatus is stretched with downward traction, the ligament becomes obvious as a white line; division of it allows access to mediastinum **(Fig. 19-6)**.

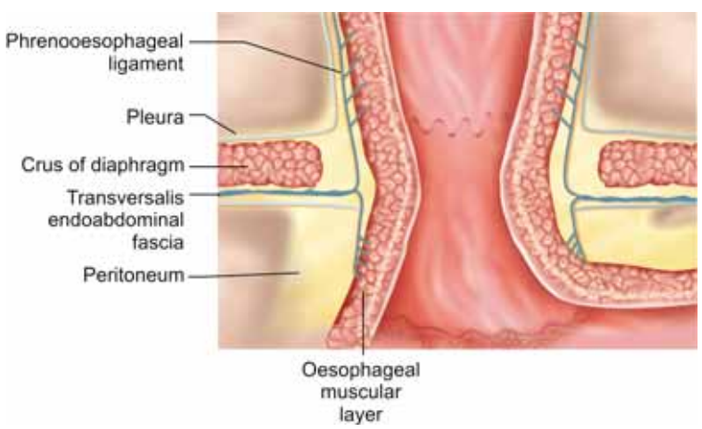


Fig. 19-6: Phrenooesophageal membrane.

Gastrohepatic ligament is the peritoneal reflections on the right side enclosing the oesophagus. It contains left gastric artery and vein, left vagus with branches and lymph nodes. Occasionally it can contain branches of right gastric artery, left hepatic artery when it is arising from left gastric artery (20%).

Gastrosplenic/gastrolienal ligament is formed by peritoneal reflections on the left side **(Fig. 19-7)**.

Relations in abdomen

Right crus of diaphragm arises from the first 3-4 lumbar vertebrae running upwards and divides into superficial and deep slings to enclose the oesophagus. Superficial right pillar of the right crus gets attached to central tendon of the diaphragm; deeper left pillar encircles the oesophagus and joins the right pillar. Left crus arises left of the upper 2-3 lumbar vertebrae, runs vertically upwards to the diaphragm without any divisions. Left crus runs left of the aorta and is actually not in direct relation to the oesophagus even though variations are common. Right crus is longer than left. Right is supplied by right phrenic nerve and left is supplied by left phrenic nerve. Median arcuate ligament is tough 2 mm wide condensed medial fibrous margins of the both right and left crura of the diaphragm. It is just proximal to the origin of coeliac artery encircling the descending aorta; but origin of coeliac artery may vary in 30% of individuals either at or above the median arcuate ligament **(Fig. 19-8)**.

Angle of His is angle between fundus of the stomach and oesophagus. Tendinous tissue binds between right and left crus

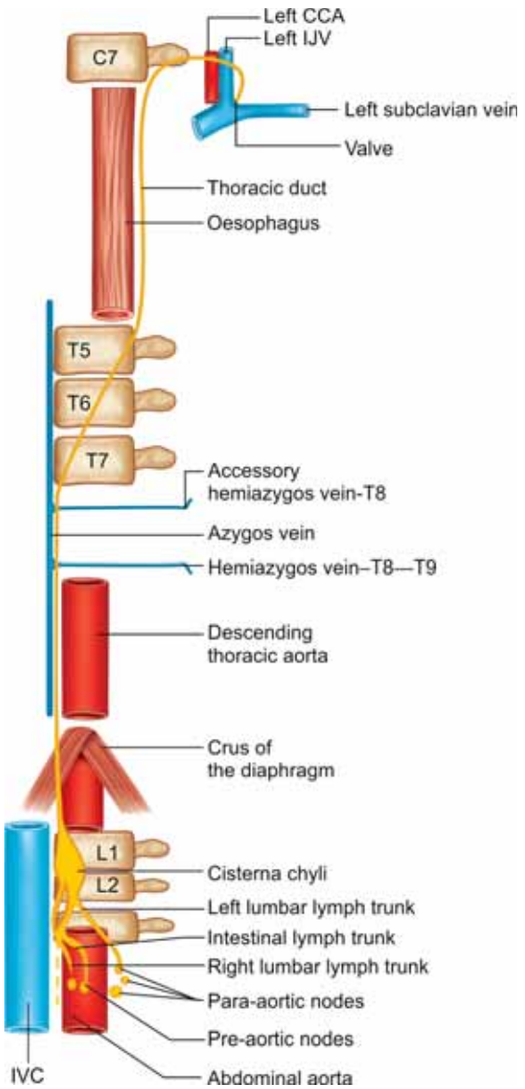


Fig. 19-7: Relations of the oesophagus.

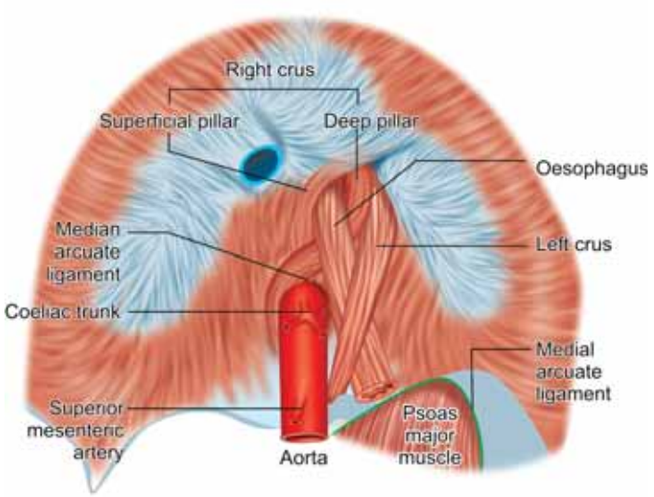


Fig. 19-8: Oesophageal hiatus — anatomy.

inferior and posterior to oesophagus to form median arcuate ligament. This tissue is important in hiatus hernia repair while placing anchoring sutures. Both pillars of the right crura have got muscular and tendinous parts. Tendinous part is more posterior than muscular part which is in front. It is important to take bites deep enough to include tendinous parts in anchorage stitches. Tendinous parts, which are posterior, are better visible through thoracotomy incision.

Antireflux mechanism is both anatomical and physiological. LOS mechanism at terminal oesophagus as a high pressure zone is physiological. Anatomical are – thickening of gastric oblique fibres; Rosette like gastric mucosal folds; angle of His; phrenooesophageal membrane and pinching action of crura.

Principles in Oesophageal Surgery

Upper half of the thoracic oesophagus is approached through right thoracotomy as aortic arch is present on left side. Lower half can be approached by right or left thoracotomy incision. Azygos vein should be double *ligated at arching of the oesophagus to reach* superior vena cava. Azygos vein enters the SVC on its posterior surface. Injury to SVC should be avoided and SVC cannot be ligated.

Left side *oesophageal triangle* (only on left side) is present on the left upper mediastinum which is formed by descending aorta, left subclavian artery and vertebral column. Floor of the triangle is mediastinal pleura under which part of oesophagus is located.

Triangle of Truesdale is formed by diaphragm below, pericardium above and in front, descending thoracic aorta behind **(Fig. 19-9)**.

Two pleura both right and left approximates behind (posterior approximation) oesophagus and aorta as mesooesophagus in the lower part of the thorax. Anterior approximation of both pleura occurs at sternal angle level.

Right pleura is very closely related to lower oesophagus up to the oesophageal hiatus. During hiatal dissection, right pleura may get torn to cause pneumothorax **(Fig. 19-10)**.

Mobilisation of distal oesophagus – Adequate exposure of the OG junction (cardia) is done. Stomach is retracted downwards and towards left using hand. Usually clean mop is used under the fingers to achieve proper grip and prevent injury to stomach. Assistant retracts the stomach. Left triangular ligament is cut by folding the left of the liver which is retracted towards right and down. Peritoneum over the phrenooesophageal ligament is held using long nontoothed dissecting forceps; using long curved scissor peritoneum and phrenooesophageal ligament is cut horizontally across the full length of the anterior aspect of the oesophagus. Ligament with peritoneum is reflected upwards to expose the cardia. Cautery can be used for dissection but should avoid injuring the bowel wall. Anterior vagus can be felt by running the index finger horizontally on the lower oesophagus with maintaining the traction on the stomach. Often anterior vagus lies very closely to oesophageal wall or often embedded in the wall. Anterior vagus is dissected along the length of the lower oesophagus. Right index finger is passed behind the oesophagus gently and loose areolar tissue is separated with blunt finger dissection to reach right of the oesophagus to create a window. A scissor cut may be needed while entering the right index finger towards right from left from behind. Posterior right vagus is little away from the oesophageal tube and usually will not come into the hooked index finger. To feel the posterior vagus index finger should be rolled with traction on the stomach. Usually posterior vagus which is thicker is dissected using finger. Often perioesophageal scarring may be present behind due to hiatal disease like reflux. In such situation sharp scissor dissection under vision is better to avoid tear in the muscle or mucosa of the oesophagus. Mobilisation further can be obtained by cutting the hiatus either anteriorly or posteriorly (*median phrenicotomy*). Care should be taken not to injure the pericardium and anterior branch of inferior phrenic vein which crosses the hiatus in front to reach IVC or hepatic vein. This vein should be ligated during phrenicotomy. But most of the time it is not necessary. Distal end of the cardia is mobilised downwards but it is limited by *gastric trinity – left gastric artery and vein (coronary vein) and coeliac branch of the posterior vagus nerve*. Dissection is done from lesser curve side of the stomach. Lesser omentum over the proximal 3 cm of lesser curve (3 cm distal to OG junction) is incised; left index finger is passed directing towards the angle of His (cardia notch) obliquely with blunt gentle careful finger dissection. Oesophageal hiatus is located at left of the midline at T10 vertebral level. Hiatus is formed by pillars of the right crus and left crus. It is obliquely placed opening 1 cm behind the central tendon of the diaphragm. Oesophageal hiatus is separated from aorta by median arcuate ligament **(Fig. 19-11)**.

Adequate exposure is important in oesophageal surgery. Proper retraction, adequate exposure and lighting, slow careful meticulous anatomical dissection is ideal. Both sharp and finger dissections are

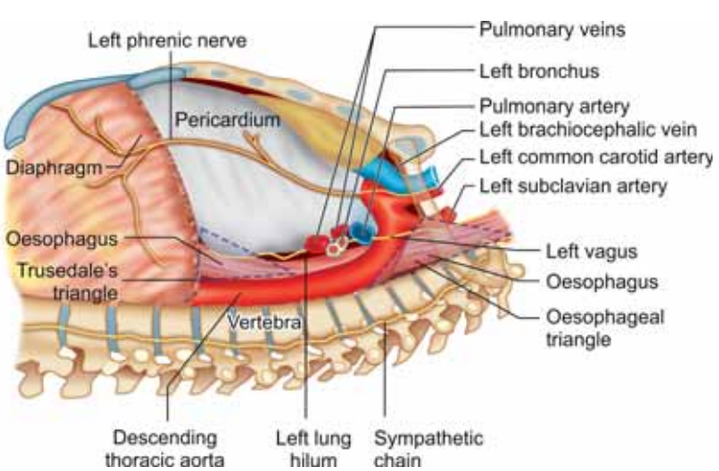


Fig. 19-9: Left side mediastinum – surgical anatomy.

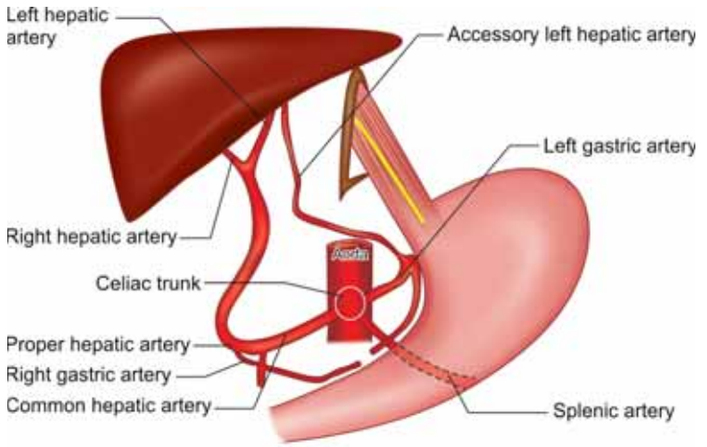


Fig. 19-10: Accessory left hepatic artery when present should be preserved. It is arising from the left gastric artery.

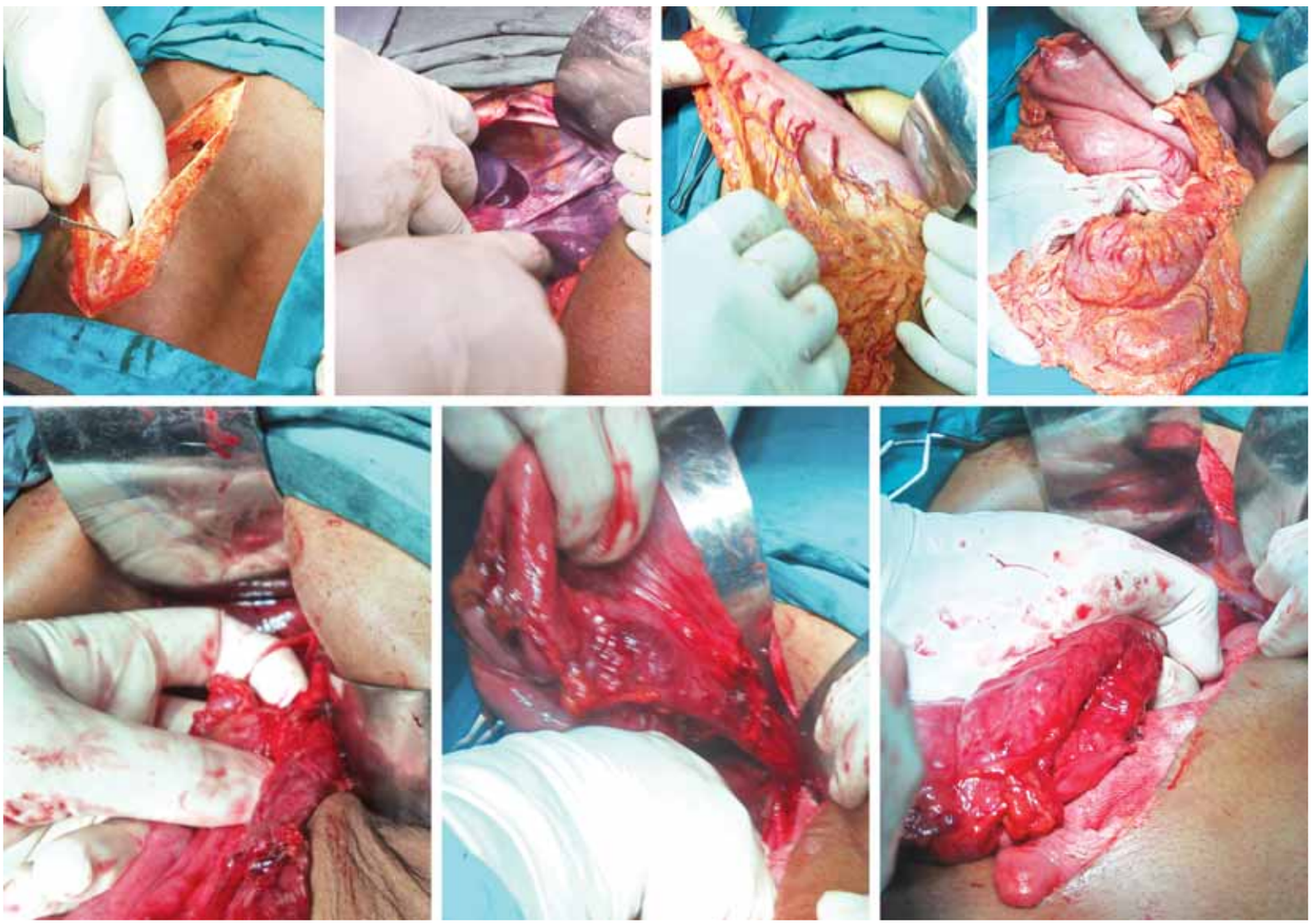


Fig. 19-11: Hiatal dissection in oesophageal surgeries.

used. Bipolar cautery or harmonic scalpel are ideal energy sources in oesophageal surgery.

Anastomosis is done using 2 or 3 zero silk interrupted sutures. Two layers are commonly used. Taking bites from mucosa is very important. Traction tear or ischaemia due to holding on the wall of the oesophagus should be avoided. Gentle firm holding is important. Often horizontal mattress (box) may be used to prevent tear at suture bite. Inner layer often sutured with 2 zero vicryl; outer layer with 2 zero silk; both should be interrupted. Adequate vascularity should be maintained at the anastomotic site. Oesophageal end anastomosis should be always as **end to side, to the side** (anterior wall) of the stomach. *End to end oesophagogastric anastomosis is not preferred* as – disparity between lumens of oesophagus and stomach; technical difficulty in performing end to end anastomosis; lesser blood supply near the proximal cut open end of the gastric pouch; there is no protection from posterior leak from the anastomotic site; postoperative reflux is more. In end to side anastomosis, better blood supply is maintained in the stoma; buttressing effect of the stomach pouch behind prevents posterior leak; technically easier; lesser chance of postoperative reflux and hence it is preferred. Even stapler anastomosis (28 mm/31 mm) should be ideally end to side of the stomach. One should avoid using unnecessary clamp on the oesophageal side; if at all gentle soft occlusion clamp can be used to avoid crushing effect and compromise the viability. *No tension and accurate apposition are essential basis in oesophageal anastomosis.* Knots of inner layer should be inside to prevent the mucosal hernia and to achieve the mucosal inversion which prevents leak. Omental wrap around the anastomosis should be placed. Before starting the anterior inner layer (3rd layer) nasogastric tube should be positioned or ideally at least before placing final stitch of inner anterior layer. But many prefer to negotiate the tube after completion of the anastomosis in view of avoiding the contamination. Anterior cut edge of oesophagus should be 1 cm lengthier than posterior edge.

Kocherisation for duodenal mobilisation; mobilisation of stomach; retaining right gastroepiploic vessels (mainly) and right gastric artery; ligating left gastric and left gastroepiploic arteries; adequate widening of the hiatus (to prevent venous congestion of pulled up stomach/colon); absolute haemostasis are main technical needs in oesophageal surgeries.

Spillage of the gastric contents should be avoided to prevent sepsis as in oesophagectomy stomach is pulled upwards into the thorax; sepsis in thorax is really risky.

Three field lymhadenectomy is often added with clearing the abdominal, thoracic and neck lymph nodes (bilateral). Here anastomosis is done in the neck. McKeown approach may be suitable here.

Feeding jejunostomy is commonly used in oesophageal resection surgeries. Few advocate passage of nasogastric tube across the stoma and fix it to the nostril securely. It acts as a stent across the stoma; keeps the stoma patent; allows nasogastric feeding also even though there is no clear cut evidence for this.

Blood should be kept ready in case there is bleeding during thoracic dissection. Intraarterial catheter is required. CVP line is better to keep always.

SURGICAL TREATMENT FOR ACHALASIA CARDIA

Heller's cardiomyotomy is done for achalasia cardia. Extended myotomy is done when there is diffuse oesophageal spasm.

In 14th April 1013 Ernest Heller, a German surgeon did first cardiomyotomy based on Gottstein's idea through abdominal approach. He did myotomies at both anterior and posterior walls. It is an extramucosal oesophagomyotomy. Later many modifications were tried on this procedure. Original Heller's myotomy was double myotomies. In 1918 Groeneveldt from Holland modified it as only anterior myotomy which was popularised by Zaaiijer (1923). Myotomy facilitates gravity induced swallowing. Incidence of reflux and oesophagitis is very high (20%) and so partial or often total Nissen's fundoplication is added to prevent reflux. Pressure of the lower oesophageal sphincter (LES) is completely reduced but not eliminated by myotomy. Relief of dysphagia occurs *immediately after* recover from anaesthesia.

Vigorous achalasia and with severe suspected metaplasia confirmed by endoscopic biopsy needs resection of the lower oesophagus and oesophagogastric anastomosis. In megaoesophagus/sigmoid oesophagus results of myotomy is not good. Hence resection is better option **(Fig. 19-12)**.

Preparation

Contrast oesophageal study, oesophagoscopy oesophageal manometry should be done. Manometry shows absence of peristalsis in lower oesophagus with incomplete relaxation of LES. Contrast CT scan is better option to see extent and dilatation. Chest X-ray to see the lungs for pneumonia, double mediastinal strip of oesophagus is also important. Barium swallow shows bird beak appearance. Fluoroscopy may be useful to see elongation, sigmoid oesophagus. Endoscopy shows dilated proximal oesophagus, closed puckered LES which will not open freely. Biopsy should be done to check mucosal changes and malignant transformation (adenocarcinoma).

Oesophagus is lavaged with normal saline on previous day and same day morning to prevent aspiration during induction of anaesthesia. Preoperative antibiotic is not necessary.

Nasogastric tube into the oesophagus is helpful especially while dissecting the lower oesophagus.

Approaches

Laparoscopy is an excellent approach for modified Heller's cardiomyotomy. *Toupet's posterior partial fundoplication* is added usually. It has become standard now. It is not useful in diffuse oesophageal spasm, vigorous achalasia and failure/recurrence.

Open thoracotomy through left sided thoracotomy approach is also better as it avoids laparotomy, retains integrity of the phrenoo-

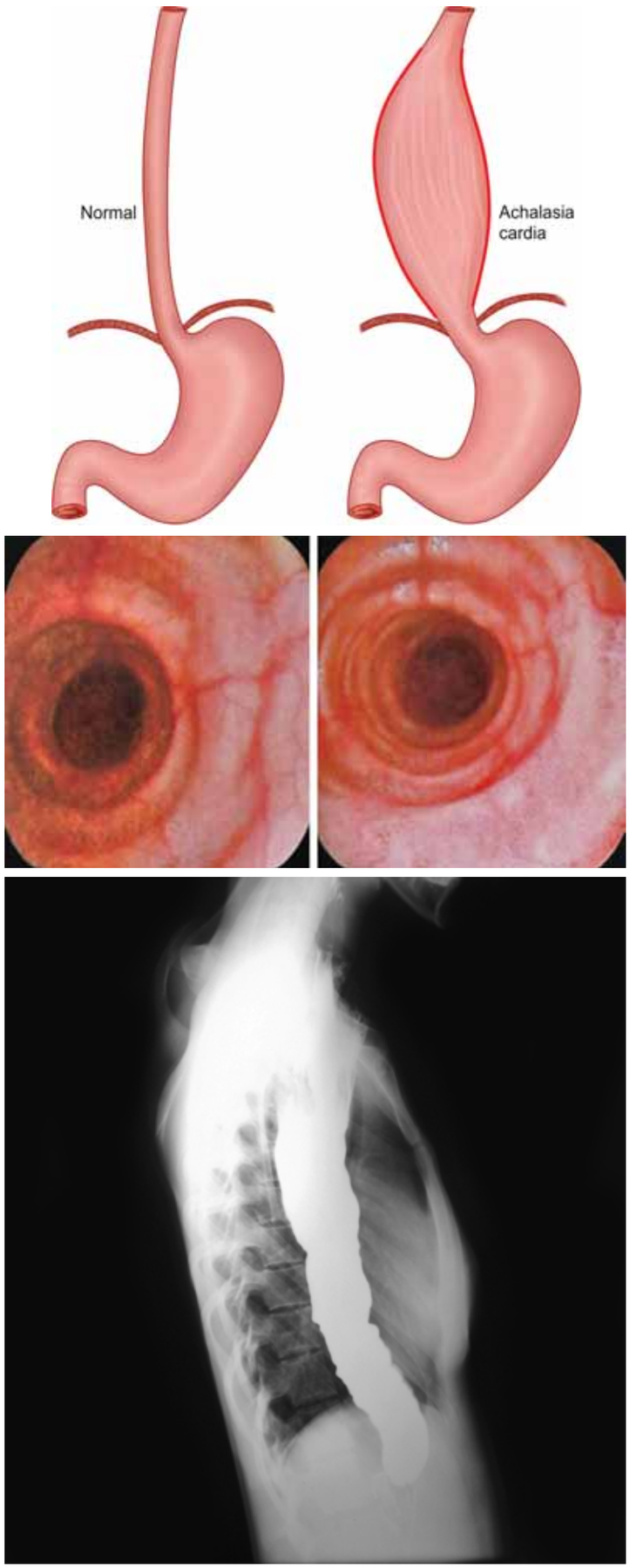


Fig. 19-12: Achalasia cardia – diagram; endoscopic view; barium study view.

esophageal ligament thereby reducing the chances of reflux. Lengthy myotomy for diffuse oesophageal spasm is possible by thoracotomy approach. Disadvantages are morbidities of thoracotomy; if unidentified mucosal leak occurs it will cause empyema which is dangerous and needs drainage. Belsey Mark IV antireflux procedure can be done safely through this approach if needed. Thoracotomy is better in obese patients or in patients where adhesions at hiatus are anticipated through abdominal approach or failed abdominal myotomy. *Thoracoscopic approach* even though is practiced is not readily accepted.

Laparotomy – open abdominal approach (described by Ellis et al in 1958) – Heller's original approach was also abdominal. It is technically easier; general surgeons are more comfortable with laparotomy approach. But reflux is more common through this approach. Toupet's partial posterior fundoplication is done in this approach. Nissen's total fundoplication is also done but it may cause dysphagia and gas bloating syndrome and is obstructive wrap which is not ideal in myotomy. Anterior partial fundoplication is also useful and is nonobstructive wrap. Respiratory complications are less here. Transabdominal is preferred in patients with compromised cardiopulmonary function and in patients who need additional abdominal procedure and in patients who have already undergone prior thoracotomy.

Thoracoscopic approach is similar to thoracotomy technique. It has not become very popular due to technical difficulties in reaching and dissecting the hiatus. Right lateral decubitus with left thorax up is the position as per left thoracotomy. 1st port is in 3rd intercostal space 2 cm anterior to the posterior axillary line. 2nd 10 mm port is in 7th intercostal space 4 cm behind the posterior axillary line used for telescope; 3rd port is in 6th intercostal space in anterior axillary line; 4th port is in 7th intercostal space in midaxillary line; 5th port is 8th intercostal space in anterior axillary line. Inferior pulmonary ligament is cut; left lung is retraced. Oesophagus is identified in the groove between aorta and pericardium. Mediastinal pleura is incised; anterior vagus is dissected and kept aside; myotomy is done by cutting both longitudinal and circular muscle layers for 8 cm proximally. Distal myotomy across OG junction onto the stomach wall for 1 cm is done. This is the most difficult part of the procedure in thoracoscopy approach. Reflux is common in this approach as fundoplication is not possible. Belsey Mark IV procedure can be done to prevent reflux; but it is technically difficult. *Right sided thoracoscopic approach* is also used for myotomy in case laparoscopy is not possible or failure of previous laparoscopy.

Technique Through Thoracotomy

Procedure is done under general anaesthesia. Double lumen endotracheal tube may be beneficial. Position of the patient is for full left thoracotomy. After cleaning and draping, skin incision is made along left 7th intercostal space just above the 8th rib. Latissimus dorsi and serratus anterior are divided. Monopolar cautery is used. Pleura is opened after cutting the intercostal muscles. *Finochietto retractor* is placed and widened adequately. Occasionally rib resection may be needed if approach is inadequate. Inferior pulmonary ligament is divided. Left lung is retracted upwards. Mediastinal pleura overlying the lower oesophagus is incised longitudinally. Oesophagus gently dissected using finger at its lower part and is encircled using Penrose or latex drain or infant feeding tube. Presence of nasogastric tube facilitates the dissection. Vagi are identified and safeguarded.

Index finger is placed under the lower oesophagus. Narrow segment and dilated proximal part can be easily seen and felt. Longitudinal incision is made over left anterolateral aspect of the oesophageal wall away and anterior to left vagus using number 15 blade gently and carefully. Cranially incision is slowly extended for 7-8 cm until myotomy is extended into dilated segment also. Myotomy above should be extended into 2 cm over the proximal dilated segment. Distal extent of incision up to oesophagogastric junction may be maximum 10 mm over the stomach. But it is sufficient to make incision around 3 mm downwards over stomach. Lengthier incision over stomach should be avoided. Stomach wall is identified by presence of transverse small veins traversing it over the mucosa deep to muscular layer. Outlook of gastric muscle differs from oesophageal musculature. Edge of the cut musculature is held using dissecting forceps and using fine scissor it is raised from the deeper mucosal plane for half the circumference. It prevents from muscle reuniting again leading into stenosis. Raising of the muscle is done on both edges. Bulging of the mucosa onto the myotomy gap is clearly evident **(Fig. 19-13)**.

Anaesthetist is asked to infuse 200 ml of methylene blue into the oesophagus from above to see any leak from the mucosa. On table oesophagoscopy (flexible) is also often done. Saline infusion from above also can be done. If there is a leak mucosa is sutured using 3 or 4 zero silk or vicryl interrupted sutures.

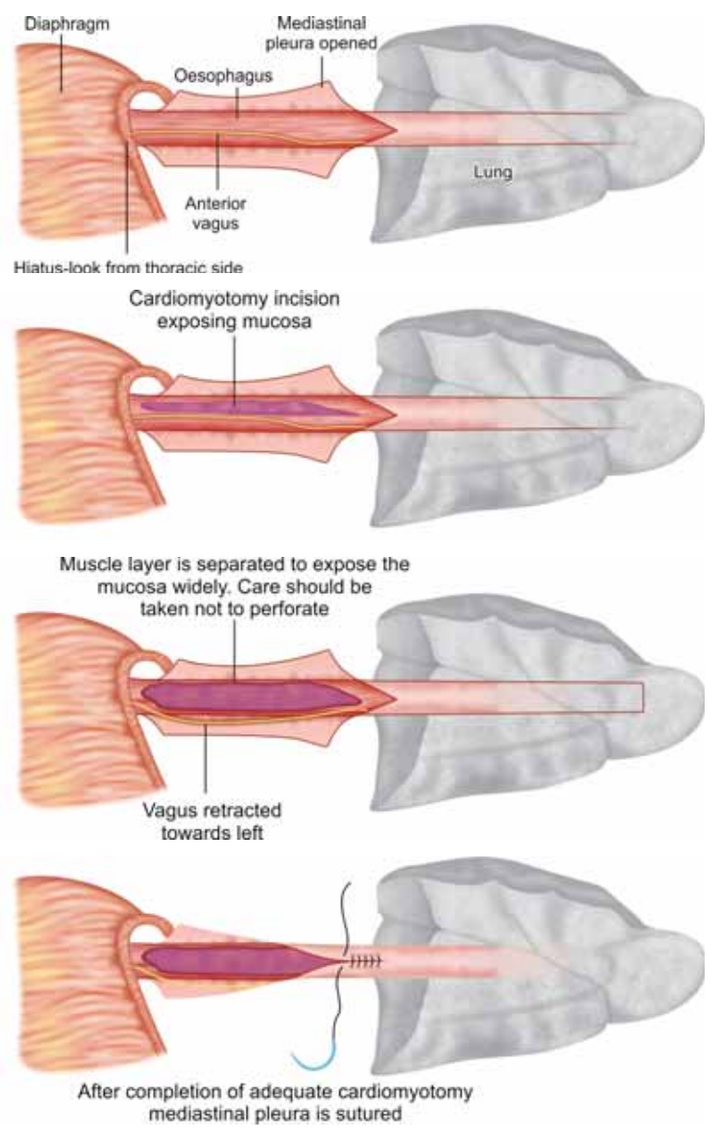

Diaphragm
Mediastinal pleura opened
Oesophagus
Lung
Anterior vagus
Hiatus-look from thoracic side
Cardiomyotomy incision exposing mucosa
Muscle layer is separated to expose the mucosa widely. Care should be taken not to perforate
Vagus retracted towards left
After completion of adequate cardiomyotomy mediastinal pleura is sutured

Fig. 19-13: Cardiomyotomy through thoracotomy (left) approach.

Extended myotomy is done in diffuse oesophageal spasm. Extension is done proximally above adequately until entire spasmodic segment is released.

Intercostal tube (30 French no.) is placed. Lung is inflated. Thoracotomy wound is closed in layers.

Postoperative Care

Intravenous fluids and nasogastric aspiration is done. Nasogastric tube can be removed in 24-48 hours. Oral liquids started in 48 hours. Chest tube is removed in 4 days once drain reduces to minimum and chest X-ray confirms lung expansion.

Postoperative endoscopy and manometry may be done if needed to confirm the efficacy of the procedure.

Complications and Problems

Respiratory infection, empyema if there is leak postoperatively.

Recurrent dysphagia after initial symptomatic response or persistent dysphagia can occur. An *incomplete myotomy* that does not adequately lower the LES pressure will cause persistent or recurrent dysphagia. Here dilatation can be tried. Otherwise laparoscopic myotomy is done. Alternatively resection of lower oesophagus with oesophagogastric anastomosis is done.

Reflux oesophagitis is one of the complications even though it is less common and less severe in thoracotomy approach compared to abdominal approach. Antireflux procedure is needed. Few undertake modified Belsey Mark IV procedure while doing initial myotomy through thoracotomy approach itself. A nonobstructive wrap is always better.

Oesophageal perforation can occur but incidence is less.

Diaphragmatic hernia is another complication which can occur.

Technique Through Abdominal Approach

Incision – Upper midline incision extending down beside the left side of the umbilicus. Xiphoid process may require to be excised. Patient is in head up (reverse Trendelenburg) position.

A self-retaining retractor is placed. Sternal self-retaining chain retractor is better if available. Left lobe is mobilised by placing surgeon's left hand over the left lobe retracting it below and towards right. Left triangular ligament is divided using cautery and scissor. Thus left lobe is mobilised and retraced by folding it inwards to expose hiatus fairly adequately. Wet mop should be placed under the retractor to avoid injury to left lobe of liver during retraction. Stomach is displaced below by downward traction by first assistant using fingers or Babcocks. Peritoneal reflection over the OG junction is lifted using long dissecting forceps and using long curved scissor it is cut horizontally to push it upwards towards hiatus. Anterior left vagus should be safeguarded, gently dissected and kept aside using smooth sling. Entire abdominal oesophagus is mobilised using right index finger with blunt dissection. Dissection facilitates separation of the abdominal oesophagus from behind away from aorta. Mobilised lower oesophagus is hooked with right index finger and long gauze or tape or infant feeding tube or Penrose drain is passed around. Phrenooesophageal membrane is divided to allow the dissection into the peritoneum. Right pleura may get injured while dividing this membrane/ligament and so care should be taken to avoid it. Oesophagus is dissected by blunt and sharp dissection further upwards across the hiatus.

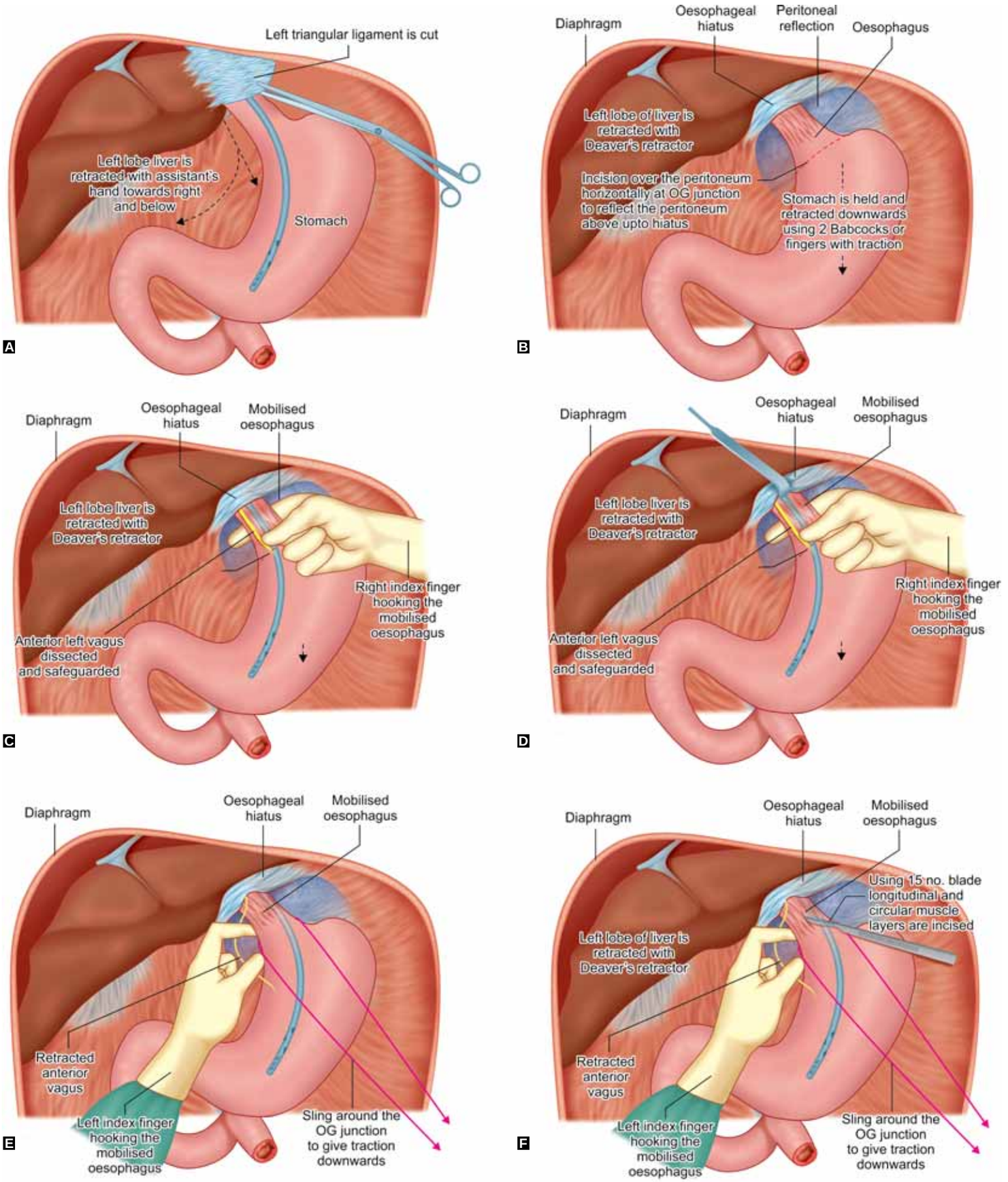
Oesophagus is held under tension by giving traction on the sling. Constriction part can be felt with this method. Using left index finger lower oesophagus is encircled; longitudinal incision is made on the anterior left lateral aspect of the oesophagus over the muscle; both longitudinal and circular muscles are cut; mucosa can be visualised. Both muscles are cut even though only circular muscle is hypertrophied and thickened due to the disease. Care should be taken not to injure it. Using right angles Mixter forceps dissection between mucosa and muscular layers is carried out upwards creating separation; separated muscle is cut using curved scissor; bipolar cautery can be used for small bleeder with care to avoid injury to mucosa. Energy sources like harmonic may be useful. Such *separation/adequate lifting/cutting of the muscle* are done sequentially with each time around 1 cm only. One should not take longer segment in a hurry as it will cause injury to mucosa by lifting of the mucosa. Cranially myotomy is done 8-10 cm. Often a metal clip is placed at this point for future identification of uppermost point of myotomy. Upper myotomy should go to the proximal 2 cm dilated segment of oesophagus. Myotomy is also done downwards over the stomach wall for less than 1 cm. It should never exceed more than 1 cm. Small veins traverse horizontally in submucosa of the stomach which are the identification markers of stomach wall. Edge of the cut musculature is held using dissecting forceps and using fine scissor it is raised from the deeper mucosal plane for half the circumference. It prevents from muscle reuniting again leading to stenosis. Raising of the muscle is done on both edges. Metal clip is also placed over the lowermost cut edge for identification. 200 ml methylene blue instillation is done to check for perforation **(Fig. 19-14)**.

It is usual to add on to Toupet's partial fundoplication along with closure of the oesophageal hiatus. Crural pillars/crura of the diaphragm behind are identified and approximated using interrupted 3-4 2 zero silk or polypropylene sutures. It should be only adequate apposition; should not be too tight; should able to pass finger through it. Gastric fundus is mobilised by dividing few gastric veins along the fundus. Cut muscle edges of the myotomy are sutured to the mobilised stomach which has wrapped from behind to complete the posterior partial fundoplication. Interrupted 3 zero polypropylene or silk sutures are used. Wound is closed without drain usually. Drain is kept if there is perforation or more bleeding **(Fig. 19-15)**.

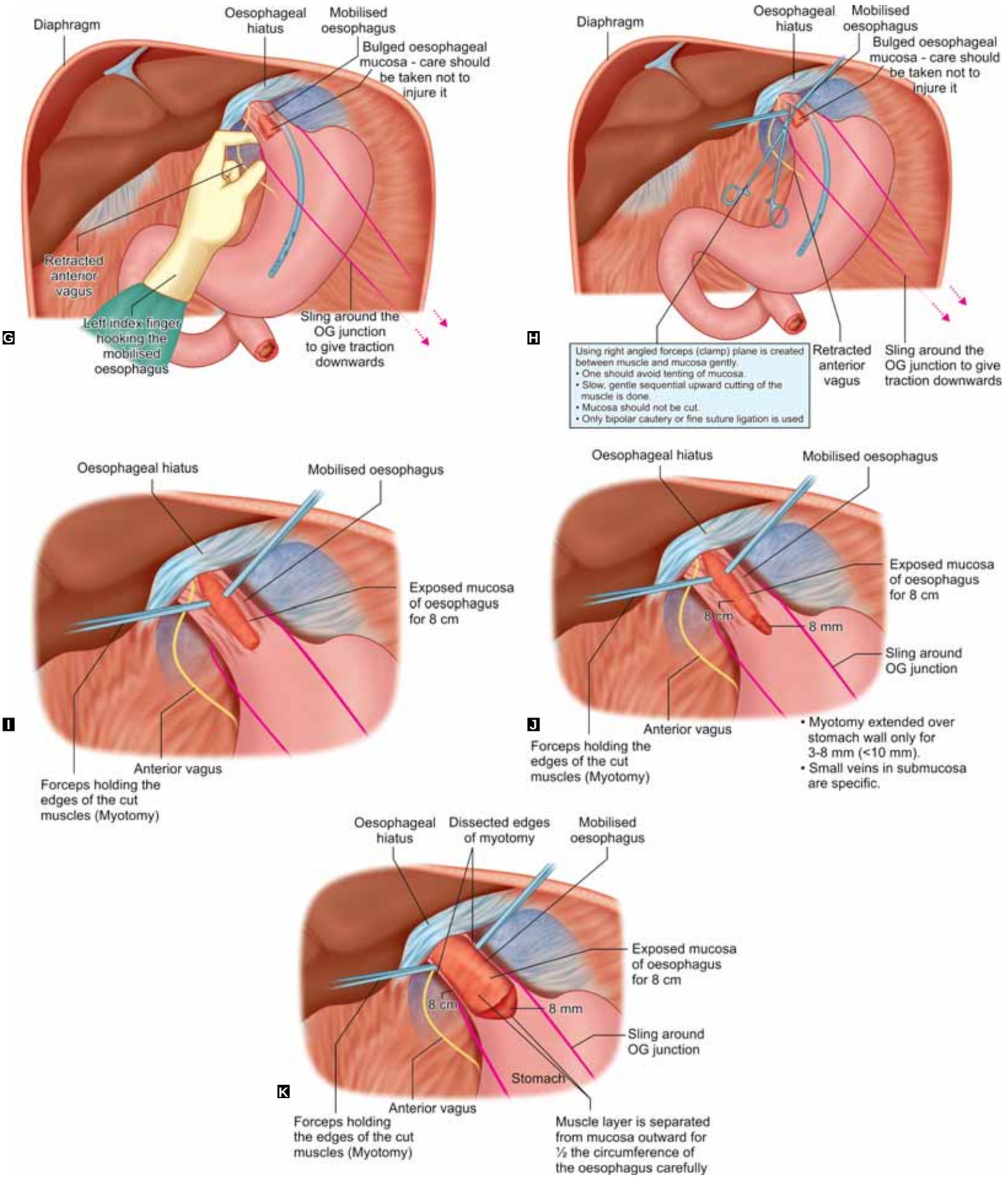
Modifications

Often *anterior partial fundoplication* (*Dor's*) is also done instead of posterior fundoplication. In anterior fundoplication, after fundal mobilisation, it is placed back in normal position. Left sided cut edge of the myotomy is sutured to the medial aspect of the fundus from below upwards for about 4 cm as 3 zero silk or polypropylene continuous seromuscular suture; last bite is taken from the left crus of the diaphragm fixing it to the hiatus. Gastric fundus flap is rotated in front towards right medially on to the right cut edge of the myotomy **(Fig. 19-16)**.

After taking the bite from the right cut edge of the myotomy wound seromuscular bites are taken from the anterior stomach wall close to greater curvature from below upwards. Again upper most suture is taken from the right crus of the diaphragm. This keeps the cut edges of the muscle in separation preventing reunion and stenosis and it also protects exposed mucosa by covering it. But incidence of reflux is more with Dor's anterior wrap than Toupet's posterior wrap. So Toupet's posterior fundoplication is preferred commonly **(Fig. 19-17)**.

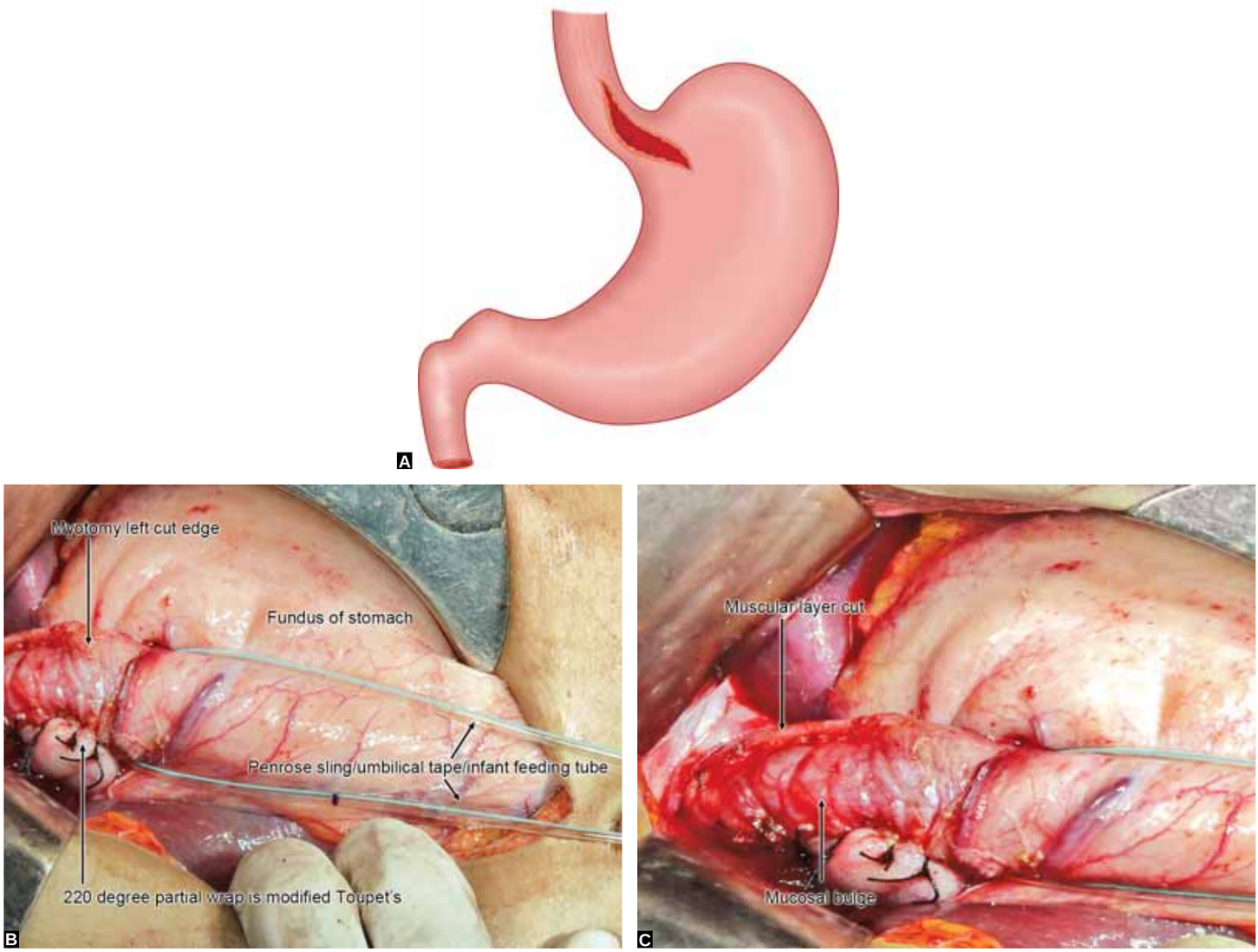

Left triangular ligament is cut
Left lobe liver is retracted with assistant's hand towards right and below
Stomach
A
Diaphragm
Oesophageal hiatus
Peritoneal reflection
Oesophagus
Left lobe of liver is retracted with Deaver's retractor
Incision over the peritoneum horizontally at OG junction to reflect the peritoneum above upto hiatus
Stomach is held and retracted downwards using 2 Babcocks or fingers with traction
B
Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Left lobe liver is retracted with Deaver's retractor
Right index finger hooking the mobilised oesophagus
Anterior left vagus dissected and safeguarded
C
Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Left lobe liver is retracted with Deaver's retractor
Right index finger hooking the mobilised oesophagus
Anterior left vagus dissected and safeguarded
D
Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Retracted anterior vagus
Left index finger hooking the mobilised oesophagus
Sling around the OG junction to give traction downwards
E
Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Using 15 no. blade longitudinal and circular muscle layers are incised
Left lobe of liver is retracted with Deaver's retractor
Retracted anterior vagus
Left index finger hooking the mobilised oesophagus
Sling around the OG junction to give traction downwards
F

Figs 19-14A to F


Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Bulged oesophageal mucosa - care should be taken not to injure it
Retracted anterior vagus
Left index finger hooking the mobilised oesophagus
Sling around the OG junction to give traction downwards
G
Diaphragm
Oesophageal hiatus
Mobilised oesophagus
Bulged oesophageal mucosa - care should be taken not to injure it
Using right angled forceps (clamp) plane is created between muscle and mucosa gently.
• One should avoid tenting of mucosa.
• Slow, gentle sequential upward cutting of the muscle is done.
• Mucosa should not be cut.
• Only bipolar cautery or fine suture ligation is used
Retracted anterior vagus
Sling around the OG junction to give traction downwards
H
Oesophageal hiatus
Mobilised oesophagus
Exposed mucosa of oesophagus for 8 cm
Anterior vagus
Forceps holding the edges of the cut muscles (Myotomy)
I
Oesophageal hiatus
Mobilised oesophagus
Exposed mucosa of oesophagus for 8 cm
8 cm
8 mm
Sling around OG junction
Anterior vagus
Forceps holding the edges of the cut muscles (Myotomy)
• Myotomy extended over stomach wall only for 3-8 mm (<10 mm).
• Small veins in submucosa are specific.
J
Oesophageal hiatus
Dissected edges of myotomy
Mobilised oesophagus
Exposed mucosa of oesophagus for 8 cm
8 cm
8 mm
Sling around OG junction
Stomach
Anterior vagus
Forceps holding the edges of the cut muscles (Myotomy)
Muscle layer is separated from mucosa outward for ½ the circumference of the oesophagus carefully
K

Figs 19-14G to K

Figs 19-14A to K: Achalasia cardia – Modified Heller's cardiomyotomy open method through abdominal approach.



Figs 19-15A to C: Heller's cardiomyotomy.

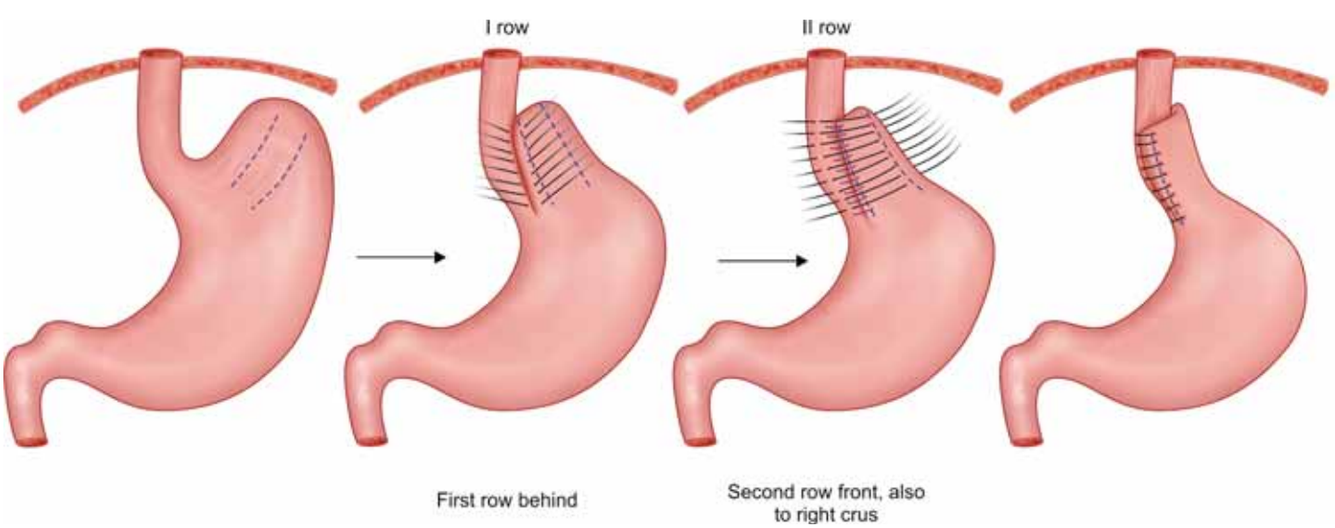
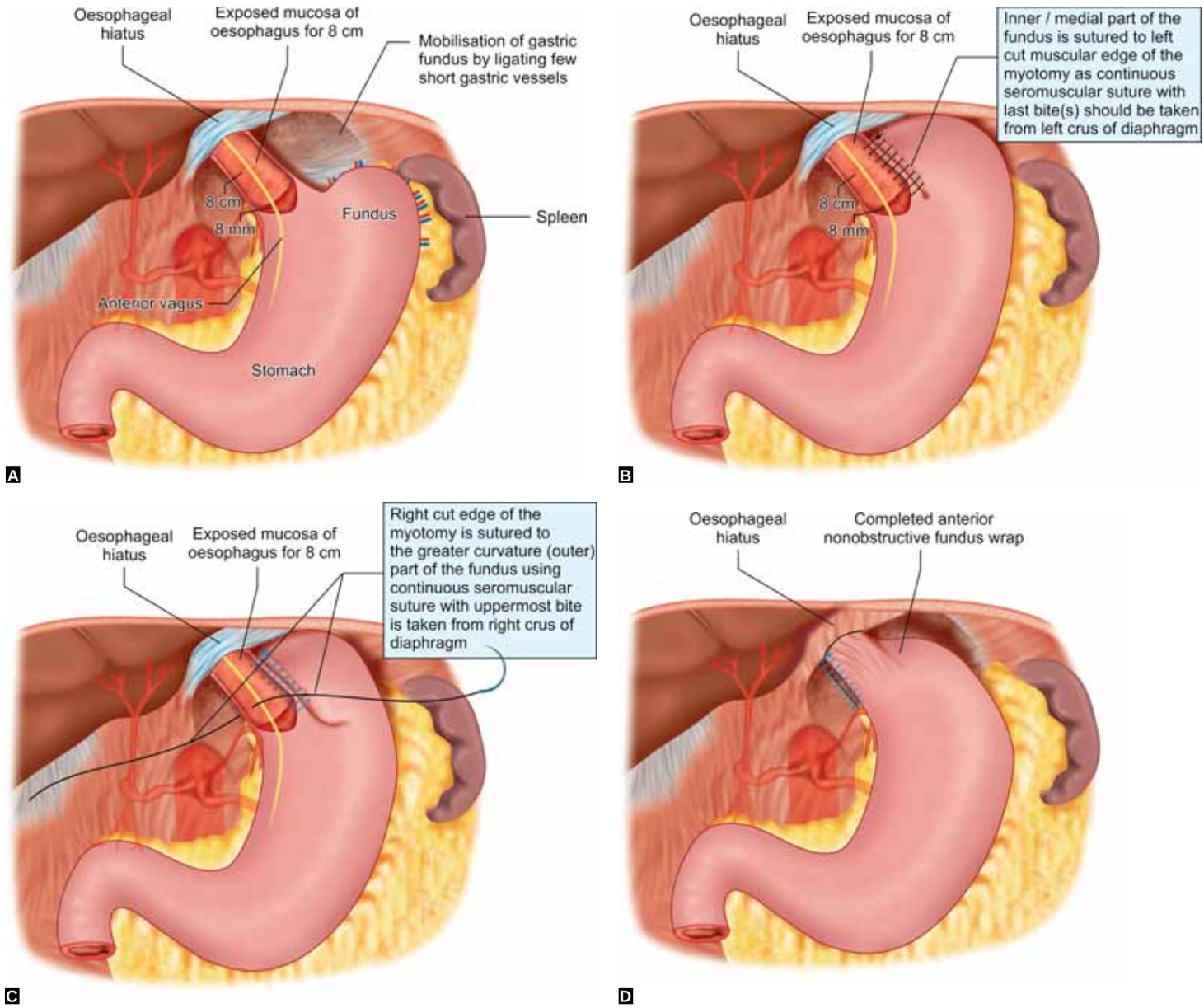


Fig. 19-16: Dor's anterior fundoplication.


Oesophageal hiatus
Exposed mucosa of oesophagus for 8 cm
Mobilisation of gastric fundus by ligating few short gastric vessels
8 cm
8 mm
Fundus
Spleen
Anterior vagus
Stomach
A
Oesophageal hiatus
Exposed mucosa of oesophagus for 8 cm
Inner / medial part of the fundus is sutured to left cut muscular edge of the myotomy as continuous seromuscular suture with last bite(s) should be taken from left crus of diaphragm
8 cm
8 mm
B
Oesophageal hiatus
Exposed mucosa of oesophagus for 8 cm
Right cut edge of the myotomy is sutured to the greater curvature (outer) part of the fundus using continuous seromuscular suture with uppermost bite is taken from right crus of diaphragm
C
Oesophageal hiatus
Completed anterior nonobstructive fundus wrap
D

Figs 19-17A to D: Anterior fundoplication (Dor's) for achalasia cardia.

Often initial myotomy is guided by passing a *balloon* which is inflated across. Anterior gastrotomy is done. Foley's catheter is inserted into the stomach and gently negotiated across the stenotic segment. Balloon is inflated slowly to stretch the muscle fibres which can be cut easily and mucosa can be identified easily. Later Foley's catheter is removed and gastrotomy is closed. Specialized balloon for the purpose is also can be used similarly **(Fig. 19-18)**.

Postoperative care

Nasogastric tube is removed in 24 hours. If there was perforation it is kept for 5 days. Drain if kept when indicated is removed in 5 days. Oral fluids started in 24 hours; later gradually semisolid and solid diet. Patient needs postoperative follow up with gastroscopy and manometry study in few months to confirm the adequacy of the cardiomyotomy.

Results and complications

Results of myotomy are very good. It is 90%.

Mucosal perforation, mediastinitis are rare complications. If there is mucosal perforation it is closed using interrupted sutures.

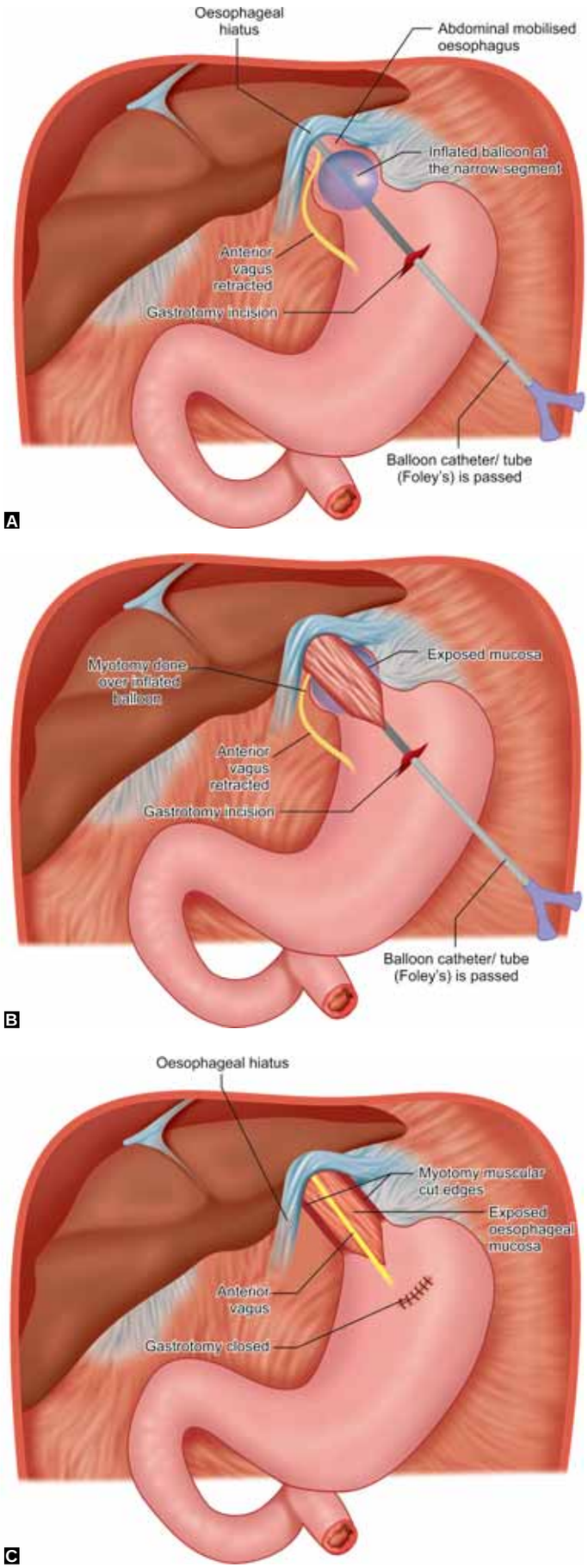
Rarely splenic injury may occur. Pleural effusion, pneumothorax or empyema are rare known complications.

Dysphagia and gas bloating syndrome is the problem, but it is less in partial fundoplication.

Laparoscopic Cardiomyotomy

Shimi and colleague (UK) in 1991 did first Heller's cardiomyotomy laparoscopically. Cuschieri described proper technique of laparoscopic cardiomyotomy.

Procedure is done under general anaesthesia. Nasogastric tube should be placed prior to surgery. Often orogastric tube is passed until procedure is over. Patient is in supine position with abducted and flexed legs with head up position 40° (reverse Trendelenburg). Surgeon stands in between legs. Camera surgeon on the right side of the patient;



Figs 19-18A to C: Cardiomyotomy balloon is often used.

assisting surgeon on the right side proximally; scrub nurse on the right side distally left of the left leg of the patient. Manometry and endoscopy needed should be kept in place to assess the completion and pressure before and after myotomy.

Supraumbilical incision in the epigastrium is made at 5 cm above the umbilicus (15 cm below the xiphoid). This 10 mm port site is used for 30° telescope with camera. Peritoneal access is done either by open method or by Veress needle. 10 mm trocar is passed. Other trocars at 5 mm left anterior axillary; 5 mm just below the xiphoid; 5 mm left midclavicular; 10 mm left midclavicular.

Left lobe of the liver is retracted through 5 mm subxiphoid port. Stomach is held with bowel holding forceps and retracted downwards and outwards by assistant through left anterior axillary 5 mm port. Gastrohepatic ligament is divided. After identifying right crus, behind the oesophagus dissection is done to create a window. Deep pillar of right crus and left crus are identified. Anteriorly phrenooesophageal ligament and peritoneum is divided transversely. Oesophagus is mobilised adequately proximally as well as at OG junction distally for 3 cm. Anterior left vagus is identified, dissected and safeguarded. Oesophagus is held with a tape or 0.62 cm width and 15 cm length Penrose drain and pulled down towards left lower abdomen. It facilitates further easy dissection.

Myotomy is done on the anterolateral surface of the oesophagus left of anterior vagus as longitudinal incision starting at cardia extending upwards for 6-8 cm. After dissecting longitudinal muscle circular muscle should be cut up to mucosa. Fine laparoscopic scissor is used. Harmonic scalpel is very useful. Monopolar cautery may injure mucosa and so better to be avoided. As bleeding is very less if at all needed bipolar is sufficient. In harmonic scalpel active blade should be kept anteriorly. Technique is splitting, elevating the longitudinal muscles and circular muscles; then to cut the circular muscle fibres as small segments sequentially up to the needed proximal length. Usual site is at 2 O'clock position left of the anterior vagus. But few advocates right of the anterior vagus at 11 O'clock position. Both are same until anterior vagus is safeguarded and adequate myotomy is done. Mucosa is whitish, smooth structure which is readily identifiable **(Fig. 19-19)**.

Adequate myotomy is important as incomplete myotomy is the common cause of failure. Myotomy should extend 3 cm proximal over the dilated proximal oesophagus. Distally it should extend across stomach only for less than 1 cm. Stomach wall is identified by its pattern of veins which is submucosal and transverse (*bridging veins*). Stomach wall is more vascular and difficult to dissect and chances of perforation are higher during this dissection. After myotomy cut edges are dissected for half the circumference of oesophagus (50%) to prevent reapproximation. Ideally gastroscopy is done. OG junction is identified by Z line and observed for patulous junction; it suggests adequate myotomy. Myotomy area is filled with normal saline and through gastroscopy air insufflation is done to confirm that there is no air leak bubble seen per abdomen over myotomy site. Often methylene blue is infused into the oesophagus to confirm leak. Manometry if kept in place just prior to surgery, pressure can be checked for adequacy and completion of myotomy by observing the drop in pressure.

Hiatal repair is done by approximating the crural pillar using nonabsorbable interrupted polypropylene sutures. Fundus of stomach is mobilised by dividing short gastric vessels using harmonic scalpel or bipolar cautery and scissor. Mobilised fundus is brought behind the OG junction round the hiatus to wrap it. *Toupet's partial posterior 220° (original Toupet is 180°; modified Toupet is 270°) fundoplication* is done. Mobilised and wrapped fundus is sutured to the right cut edge of the myotomy. This part of the wrapped fundus is

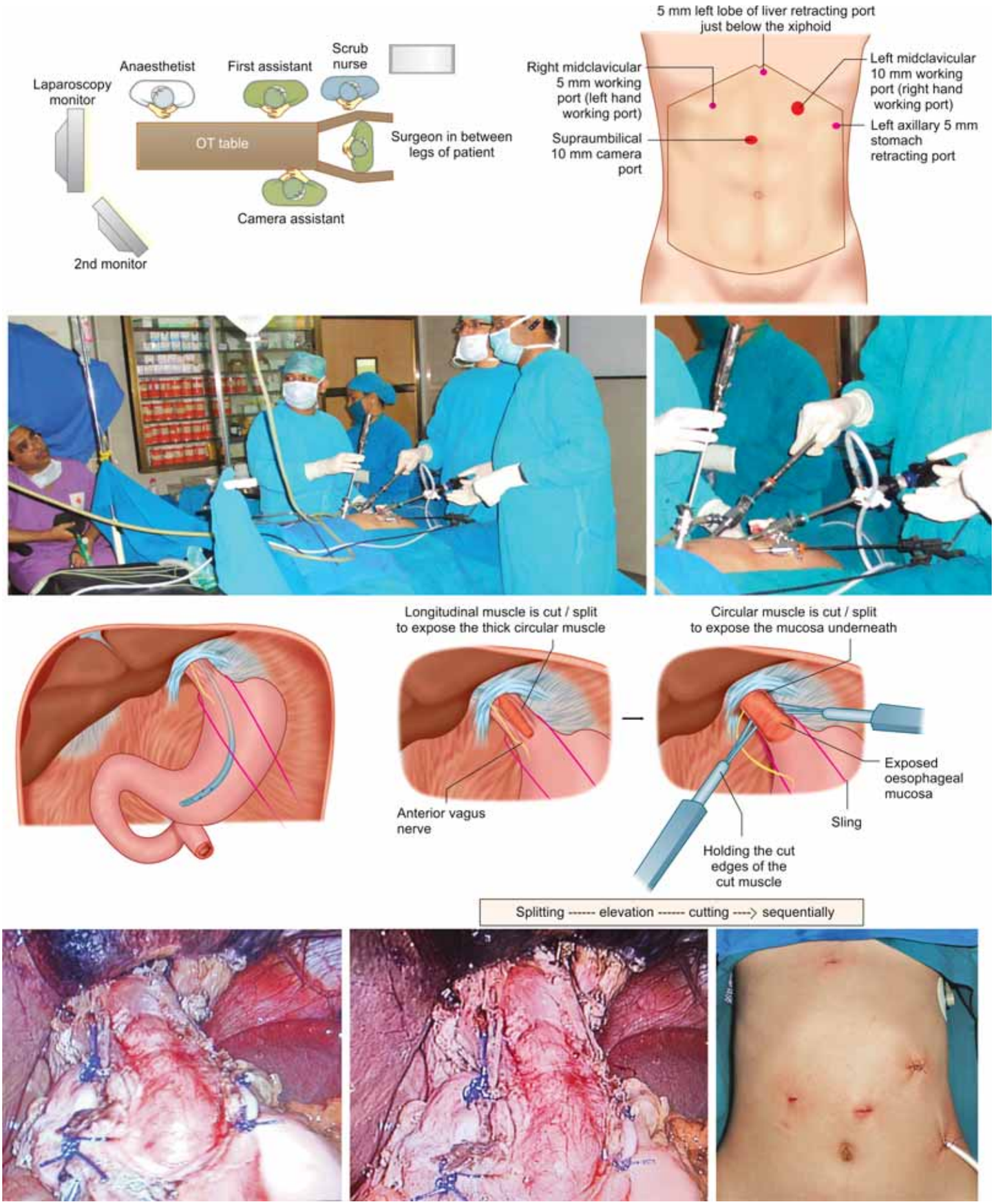

Laparoscopy monitor
Anaesthetist
First assistant
Scrub nurse
OT table
Surgeon in between legs of patient
Camera assistant
2nd monitor
5 mm left lobe of liver retracting port just below the xiphoid
Right midclavicular 5 mm working port (left hand working port)
Left midclavicular 10 mm working port (right hand working port)
Supraumbilical 10 mm camera port
Left axillary 5 mm stomach retracting port
Longitudinal muscle is cut / split to expose the thick circular muscle
Circular muscle is cut / split to expose the mucosa underneath
Anterior vagus nerve
Exposed oesophageal mucosa
Sling
Holding the cut edges of the cut muscle
Splitting ------ elevation ------ cutting ----> sequentially

Fig. 19-19: Technique of laparoscopic cardiomyotomy.

also sutured to the right crus in its upper part. Left cut edge is sutured to the left part of the mobilised fundus with interrupted sutures with its uppermost bite taken from the left crus. It prevents reflux and recurrent dysphagia by keeping the cut edges separate. *Dor's anterior partial fundoplication* is often advocated by many as it does not require posterior dissection and it covers the mucosa and may seal small injury which is unnoticed. But reflux incidence is more in anterior Dor's fundoplication. Left cut edge of the myotomy is sutured to the inner part of the fundus of the stomach with seromuscular sutures (2 zero silk/polypropylene). After that right cut edge of the myotomy is sutured on to the greater curvature (outer side) part of the stomach to pull and rollback the fundus over anterior surface of the myotomy area. Anterior fundoplication is used if there was mucosal injury (perforation) which is sutured on table; as it seals sutured site securely.

Intraoperative gastroscopy is very useful to identify the completion of the myotomy. Manometry on table is also very useful.
Robotic-assisted laparoscopic cardiomyotomy is very useful which reduces the hand tremors increasing the precision.

Postoperative care

Nasogastric tube/orogastric tube is removed after 24 hours. Oral fluids are started. Normal diet is started in 10 days. Straining is avoided for one month to prevent herniation of fundal wrap across the hiatus into the mediastinum.

Complications

Oesophageal perforation (4%) – once it is identified it should be sutured using 4 zero vicryl intracorporeal interrupted sutures. Closure is confirmed by methylene blue infusion.

Pleural injury and pneumothorax is the problem. It may occasionally need a chest tube insertion.

Postoperative dysphagia and recurrence of symptoms is usually due to incomplete myotomy (early). Late occurrence of dysphagia is due to reflux induced peptic stricture.

SURGICAL TREATMENT FOR REFLUX OESOPHAGITIS (FIG. 19-20)

Principles of antireflux surgeries

- Operation should restore the LES pressure twice the resting gastric pressure
- The adequate length of the intraabdominal oesophagus should be maintained
- Apposition of diaphragmatic crurae, reduction of hiatus hernia when present
- Repaired OG junction should relax during swallowing adequately
- Tension free fundoplication should be done.

Fundoplication

- *Nissen's posterior total fundoplication:* Here after narrowing the crus of diaphragm, mobilised *posterior part of the fundus* of the stomach is wrapped totally 360° around the area of OG junction.
  - *Rudolph Nissen* (1959) first did total fundoplication.
  - Opening the peritoneum over the oesophagus to mobilise the lower oesophagus.
  - Dissection of the diaphragmatic crura of the oesophagus.
  - Mobilisation of entire fundus by ligating short gastric vessels.
  - Vagi are preserved.

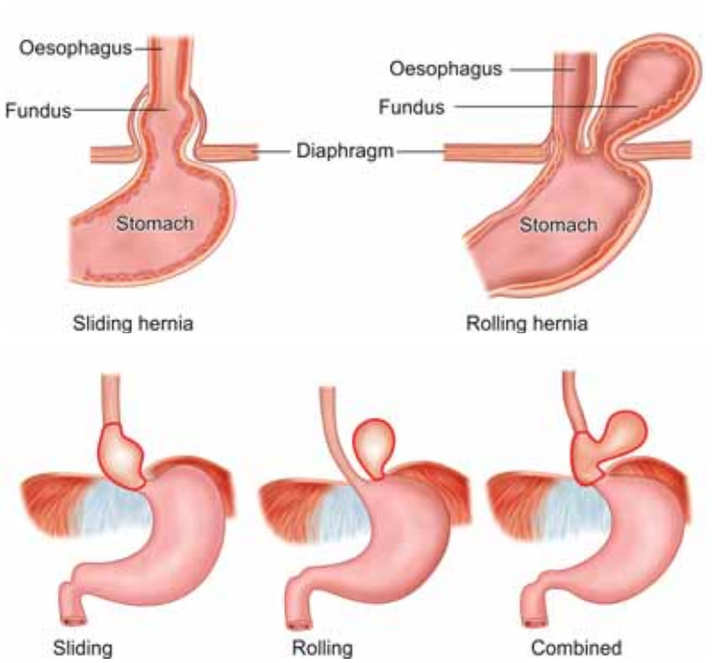


Fig. 19-20: Types of hiatus hernia – sliding, rolling, combined.

  - In Nissen's, 60 French bougie wrap is ideal; after complete mobilisation, only *posterior part of the fundus* is wrapped around after crural repair (otherwise fundoplication may displace into thorax causing paraoesophageal hernia); intraabdominal length of 2 cm oesophagus is created (not more); fundus of the stomach is known to relax in concert with oesophageal sphincter so only fundus should be used to buttress the sphincter; wrapping should be done only around sphincter of oesophagus not around the body of stomach; fundoplication should be kept in abdomen without under tension and without displacing into thorax. Nonabsorbable polypropylene sutures are used.
  - Crural repair is done using interrupted polypropylene sutures.
  - Fundoplication should prevent sphincter shortening/unfolding during gastric distension, should preserve normal swallowing ability, allow proper belching and allow vomiting whenever needed.
  - Bougie; on table and postoperative manometry to assess the pressure of new LOS; on table and postoperative gastroscopy – are commonly used in fundoplication.
  - Mortality of procedure is very less; other parts of the abdomen can be assessed and addressed like gall stones.
  - *Complications* are – *Gas bloat syndrome* (inability to belch); dysphagia; inability to vomit; slippage, proximal migration; paraoesophageal hernia, splenic injury. Floppy Nissen's fundoplication reduces the incidence of gas bloat syndrome.
  - *Laparoscopic Nissen's fundoplication* is ideal and equally successful.
  - *Transthoracic approach* is used for Nissen's fundoplication in patients who has had hiatus hernia repair earlier; who has had short oesophagus; in patients who has sliding hiatal hernia that does not reduce below the diaphragm, associated pulmonary disease, in obese, in patients who have narrow subcostal angle or barrel-shaped chest.
- *Toupet's partial 180° posterior fundoplication*: It is similar to Nissen's posterior fundoplication; it controls reflux alike Nissen's but gas bloat is very less. It is commonly done procedure now. Short

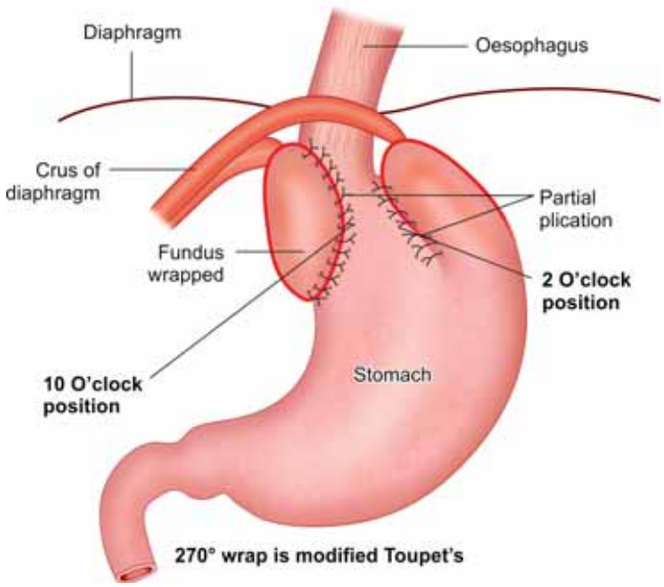


Fig. 19-21: Toupet's partial fundoplication.

gastric vessels are divided completely or partially. Modified 270° type is better placing sutures at 10 O'clock and 2 O'clock positions **(Fig. 19-21)**.

- *Dor anterior fundoplication*: Here right margin of the fundus is sutured to left margin of the oesophagus; front part of fundus is sutured to right margin of the oesophagus; 2nd row is also sutured to right crus. It is useful after Heller's cardiomyotomy if perforation of oesophagus has occurred. It will cover the sutured mucosal injury safely.
- *Rosetti Hell anterior fundoplication*: Here *anterior part of fundus* of stomach is used. Superomedial part of the fundus is brought around oesophagus to suture to anterior part of fundus. Here *short gastric vessels are not ligated* and much less fundus need to be mobilised.
- *Watson's anterolateral fundoplication*: 5 cm intraabdominal oesophagus is created with blunt transhiatal dissection. 120° anterolateral fundoplication augments the LOS function during stomach distension. Bougie insertion, division of short gastric vessels is not needed here.
- *Lind both anterior and posterior fundoplication* of 300° with 60° anteriorly uncovered area is not routinely practiced now.
- *Partial fundoplication with mesh wrap* around is also used. But complications of mesh like erosion, stricture and adhesions are so many.

Fundoplications

- Nissen's – total 360° posterior fundoplication
- Toupet's – partial 180° posterior fundal/posterolateral
- Rosette Hell – total anterior fundal
- Dor – anterior partial
- Watson's – anterolateral 120° partial
- Lind – posterior and anterior

Other Procedures

- *Hill's operation* (Dr Lucius Hill, USA, 1959):
  - Intraabdominal fixation of OG junction (cardia) into median arcuate ligament to augment the effect LOS, to enable the effective oesophageal peristalsis. Procedure is done through transabdominal approach which is assessed by intraoperative manometry. But it is technically difficult, may damage celiac plexus.
  - Oesophagogastric junction and crura of the diaphragm are dissected properly like in any other procedure in this location. Median arcuate ligament is condensed preaortic fascia arching over the anterior surface of the aorta just above the origin of coeliac artery. It joins the right crus and is attached to vertebral column also. Vertically it extends for about 3 cm along the aorta. Medial arcuate ligament is dissected off from coeliac artery and coeliac ganglion; right and left inferior phrenic arteries are also very close which should be carefully dissected. Nerve fibres of coeliac ganglion close to the ligament should be cut. In *Vasanth's method*, dissection at median arcuate ligament is done from upper margin; gently index finger is passed from above downwards underneath dense preaortic fascia to negotiate between aorta and median arcuate ligament. Inferior phrenic arteries and coeliac trunk and coeliac ganglion are there which should not be injured. Using no 1 zero polypropylene, suture bites are taken between pillars of right crus and left crus to repair the oesophageal hiatus **(Fig. 19-22)**.
  - Three suture bites are taken which are not tied but held with haemostats. Then either finger or flat instrument is placed underneath the median arcuate ligament to safeguard aorta and other structures; 1 zero polypropylene suture bites are taken; first from anterior phrenooesophageal bundle (near gastric fundus) from left towards right; next bite from lower oesophagus, posterior phrenooesophageal bundle with part of the lesser curve of the stomach; last bite is from the median arcuate ligament. Anterior phrenooesophageal bundle is left and lateral to anterior vagus at the base of the angle of His distal to oesophago fundic junction; posterior phrenooesophageal bundle is behind the OG junction towards tight right of posterior (right) vagus. Remaining two lower bites are also taken similarly. Haemostasis should be checked at this stage. Crural fibres are sutured to do hiatal repair; index finger should be able to pass through the sutured oesophageal hiatus. Then arcuate ligament repair sutures are tied to complete Hill's posterior gastropexy. Often Teflon pledgets are used into the arcuate ligament sutures but it is not mandatory. Antireflux adequacy is confirmed using saline.
- *Belsey Mark IV operation* (Ronald Belsey, Britain, 1967):
  - It is plication of oesophagus to the diaphragm through many interrupted mattress sutures so as to push the oesophagus downwards to make it intraabdominal with adequate length. It is done through left transthoracic approach. 240° fundoplication, creation of intraabdominal oesophagus, crural sling repair are the techniques. It corrects GERD and also maintains normal eructation and physiological reflux. But long hospital stay and respiratory complications are distressing problems **(Fig. 19-23)**.
  - Left posterolateral thoracotomy is done through 6th intercostal space. Oesophagus is mobilised from diaphragm to aortic arch. Left superior and inferior bronchial arteries are ligated. Direct oesophageal arteries are also ligated. Adequate mobilisation is essential. Vagi should be preserved carefully. Phrenooesophageal membrane is divided to enter into the peritoneal cavity. With the left hand fingers mobilising and retracting the OG junction and gastric fundus, with the right hand scissor dissection is done under vision. Short gastric vessels are divided. All attachments

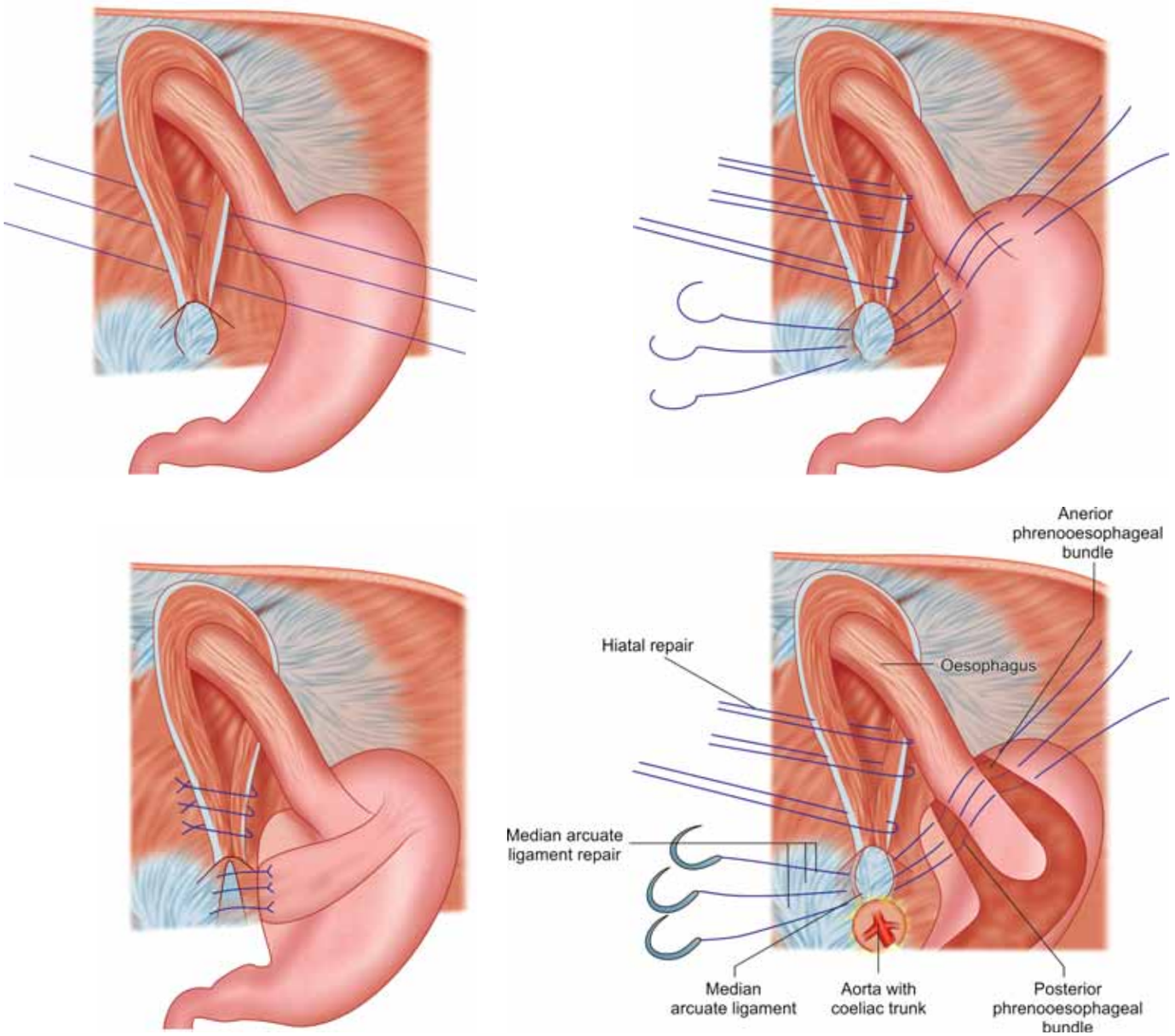


Fig. 19-22: Hill's repair of hiatus hernia.

between stomach and hiatus are divided. Fundus and abdominal oesophagus are drawn into thoracic cavity by holding with Babcock's clamps.

– Hiatal repair sutures are placed using 1 zero polypropylene sutures from below upwards. All sutures are placed (3-4) first (tied together later only after completing the fundoplication).
– Gastric fundus is plicated around the anterior 2/3rd of the lower 4 cm of oesophagus. First row of sutures are 1.5 cm above the cardia. 3 zero or 2 zero polypropylene suture material is used. Left anterolateral position of the oesophagus used for plication as view over right side is inadequate. Bite taken from the gastric fundus (seromuscular) then from the muscular wall of the oesophagus horizontally then again on to the gastric fundus adjacent to first bite with a 5 mm gap. All first row plication sutures are placed; then they are tied to pull up the fundus **(Fig. 19-24)**.
– Second row of sutures are placed 2 cm above the first row using 2 zero or 3 zero polypropylene suture or silk. From gastric fundus as seromuscular to the oesophagus as muscular then back to the gastric fundus as seromuscular with a 5 mm gap. All sutures are placed and then tied; ends are not cut but held with haemostats. Now each free ends of the suture are passed through (after passing needles to each tails) the diaphragm from abdominal side towards thoracic side. Once all ends are passed like that; knotting is done securely. Fundus with the oesophagus is pushed down into the abdominal cavity.
– Hiatal sutures which were taken earlier (previously placed) are tied now securely to complete the hiatal repair.

- *Placement of Angelchik prosthesis*: Annular silicone gel filled angelchik prosthesis with a tape on either end. After insertion around OG junction ends are tied around.

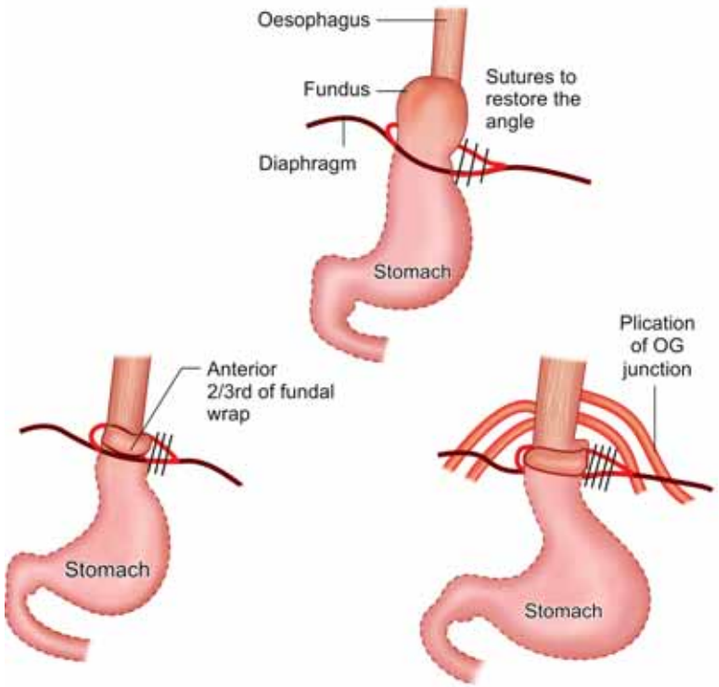
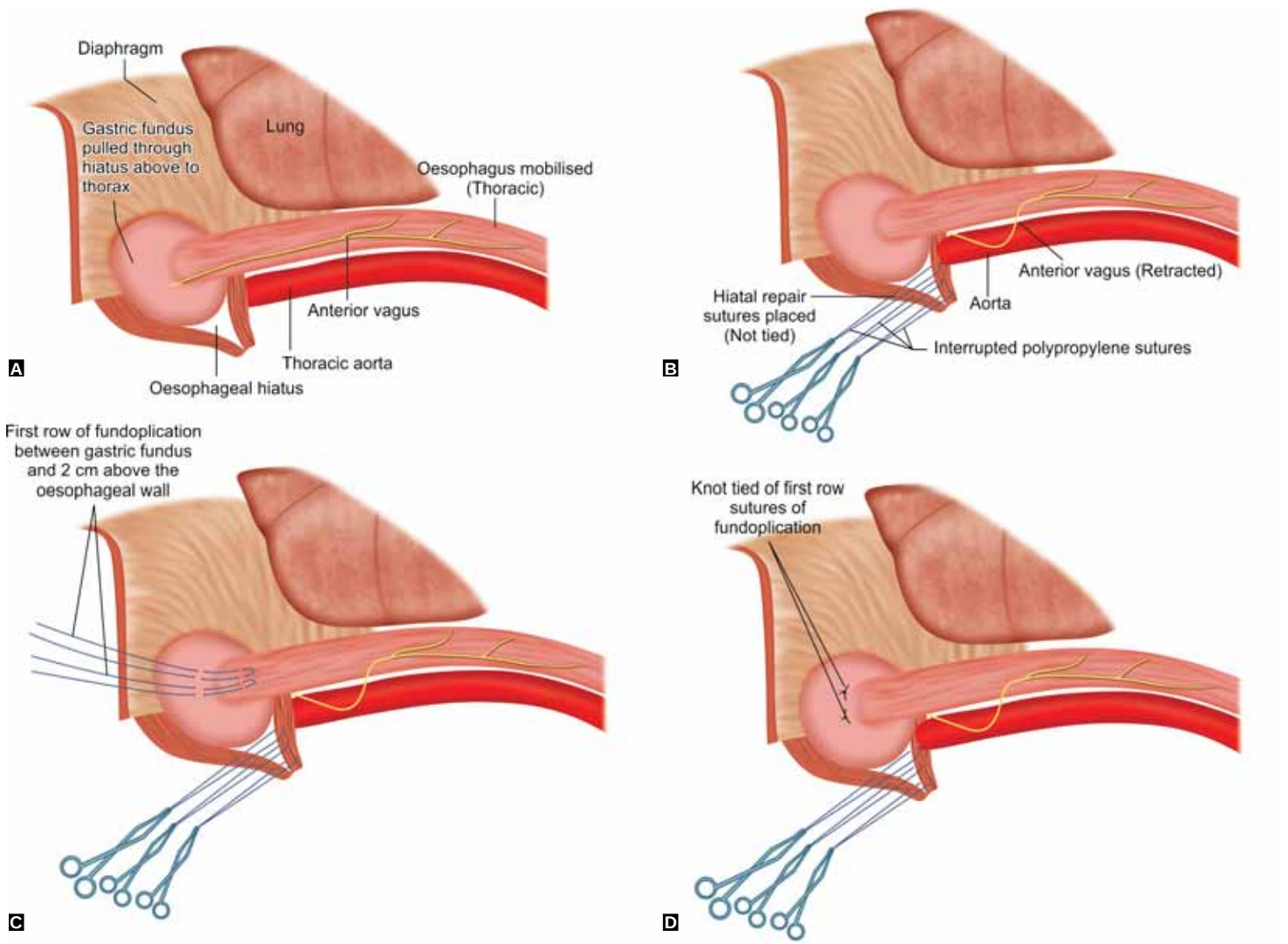
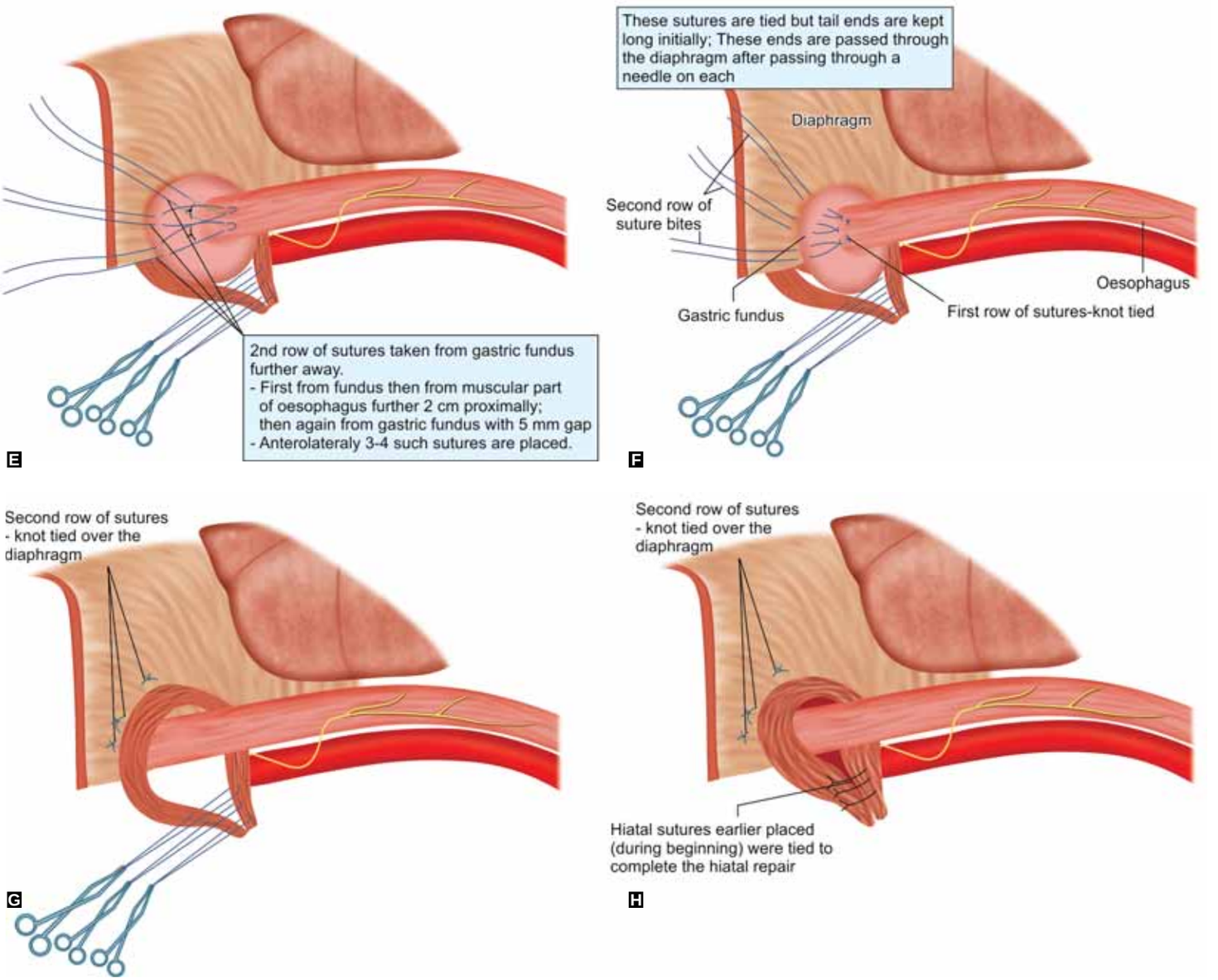


Fig. 19-23: Belsey Mark IV operation.

- *Collis' vertical gastroplasty* is done using fundus stomach. A vertical cut along the line of oesophagus is made on the fundus which is sutured to create extra length of oesophagus and new lesser curvature. It is done whenever oesophagus cannot be mobilised due to oesophageal shortening by a stricture developed as a complication of GORD. Partial fundoplication is added to this usually. Previous gastrectomy is contraindication to this **(Fig. 19-25)**.
- *Transthoracic Collis – Nissen's gastroplasty* –
  - It is used in short oesophagus with stricture and recurrence after an earlier antireflux procedure. Open mind should be also kept for need of bowel (colon) interposition in such patients. New oesophagus is created by lengthening it. Then antireflux procedure is done. Entire procedure is done through thoracotomy **(Fig. 19-26)**.
  - Double lumen endotracheal lumen tube is placed. One lung anaesthesia is given. Nasogastric tube should be passed. Lateral left side up position is used for 6th intercostal space thoracotomy. Latissimus dorsi and serratus anterior muscles are cut. Incision posteriorly should extend up to the lateral margin of the spinal muscles. Pleura is opened. Often 7th rib excision posteriorly is needed to have a better access with ligation of intercostal vessels running under 7th rib at its lower margin. If needed conversion



Figs 19-24A to D


2nd row of sutures taken from gastric fundus further away.
- First from fundus then from muscular part of oesophagus further 2 cm proximally; then again from gastric fundus with 5 mm gap
- Anterolateraly 3-4 such sutures are placed.
E
These sutures are tied but tail ends are kept long initially; These ends are passed through the diaphragm after passing through a needle on each
Diaphragm
Second row of suture bites
Oesophagus
Gastric fundus
First row of sutures-knot tied
F
Second row of sutures - knot tied over the diaphragm
G
Second row of sutures - knot tied over the diaphragm
Hiatal sutures earlier placed (during beginning) were tied to complete the hiatal repair
H

Figs 19-24E to H

Figs 19-24A to H: Technique of Belsey mark IV operation.

into thoracoabdominal by anterior extension of the thoracotomy should be done to facilitate the better dissection of the hiatus.

– Inferior pulmonary ligament and then mediastinal pleura has to be incised medial to the thoracic aorta. With blunt and sharp dissection and nasogastric tube as a guide, oesophagus with anterior vagus is encircled using sling (umbilical/Penrose drain). Proximally dissection is extended up to the inferior pulmonary vein. Lower part of the incision is extended in front along the pericardiophrenic sulcus to facilitate the hiatal dissection.
– Phrenooesophageal ligament and peritoneum is incised. Hiatus is dissected circumferentially. Hernial sac existing is identified. Hernial sac is dissected by holding the oesophagus with traction. A branch of inferior phrenic artery is ligated. Gastrohepatic ligament is incised and opened towards right with adequate traction. An accessory left hepatic artery is commonly seen in this ligament which should be ligated. Other attachments between hiatus and proximal stomach are divided using bipolar cautery or harmonic scalpel.
– Oesophageal stricture should be dilated using series of Maloney dilators. Peritoneum of the hernial sac is excised. Short gastric vessels along the greater curvature are ligated and divided or using harmonic scalpel for about 15 cm of greater curvature. Pad of fat around the OG junction is dissected and removed. 60 no. French Maloney dilator is passed across the hiatus. Lineal stapler is fired along the fundus left of the oesophagus to create a new fundus and neooesophagus of 7-8 cm (lengthened oesophagus). Stapled lines along the neooesophagus and gastric fundus are often inverted using continuous seromuscular sutures using 3 zero PDS or vicryl. Metal clip is applied at the junction of neooesophagus and stomach as a marker.
– New fundus is brought under the neooesophagus to create a wrap; it is sutured to the greater curvature with interrupted using

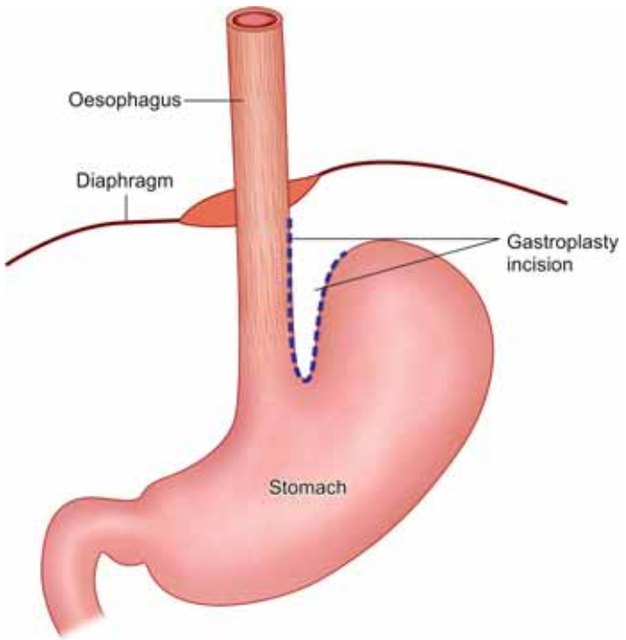


Fig. 19-25: Gastroplasty technique.

2 zero polypropylene sutures to complete the wrap. Usually 3 sutures for 3 cm length are placed. Bite also should be taken from the neooesophagus. Wrap should accommodate index finger to prove it as floppy. After that hiatal repair is done by apposing the right and left crura using interrupted polypropylene sutures. Mediastinal pleura may or may not be sutured. Intercostal tube is placed (36F). Thoracotomy wound is closed.

– Complications are – gastroplasty tube necrosis; recurrence; leak; empyema; obstruction.

- *Thal's patch procedure*: It is done for localised nondilatable stricture oesophagus. Stricture is incised full thickness longitudinally. Mobilised fundus of stomach is placed and sutured as a serosal patch technique over the defect **(Fig. 19-27)**.
- *Narbona's ligamentum teres cardiopexy* (commonly done in Spain): Ligamentum teres is mobilised from falciform ligament with its blood supply from left lobe of liver; it is detached from umbilicus and brought around the mobilised lower oesophagus with traction until LOS pressure becomes 15-20 mm Hg with manometry; flap end is sutured left of OG junction and anterior wall of stomach. It is more physiological and division of short gastric vessels is not required.
- *Boerema operation*: It is fixing OG junction in front into anterior abdominal wall. It is not practiced now.

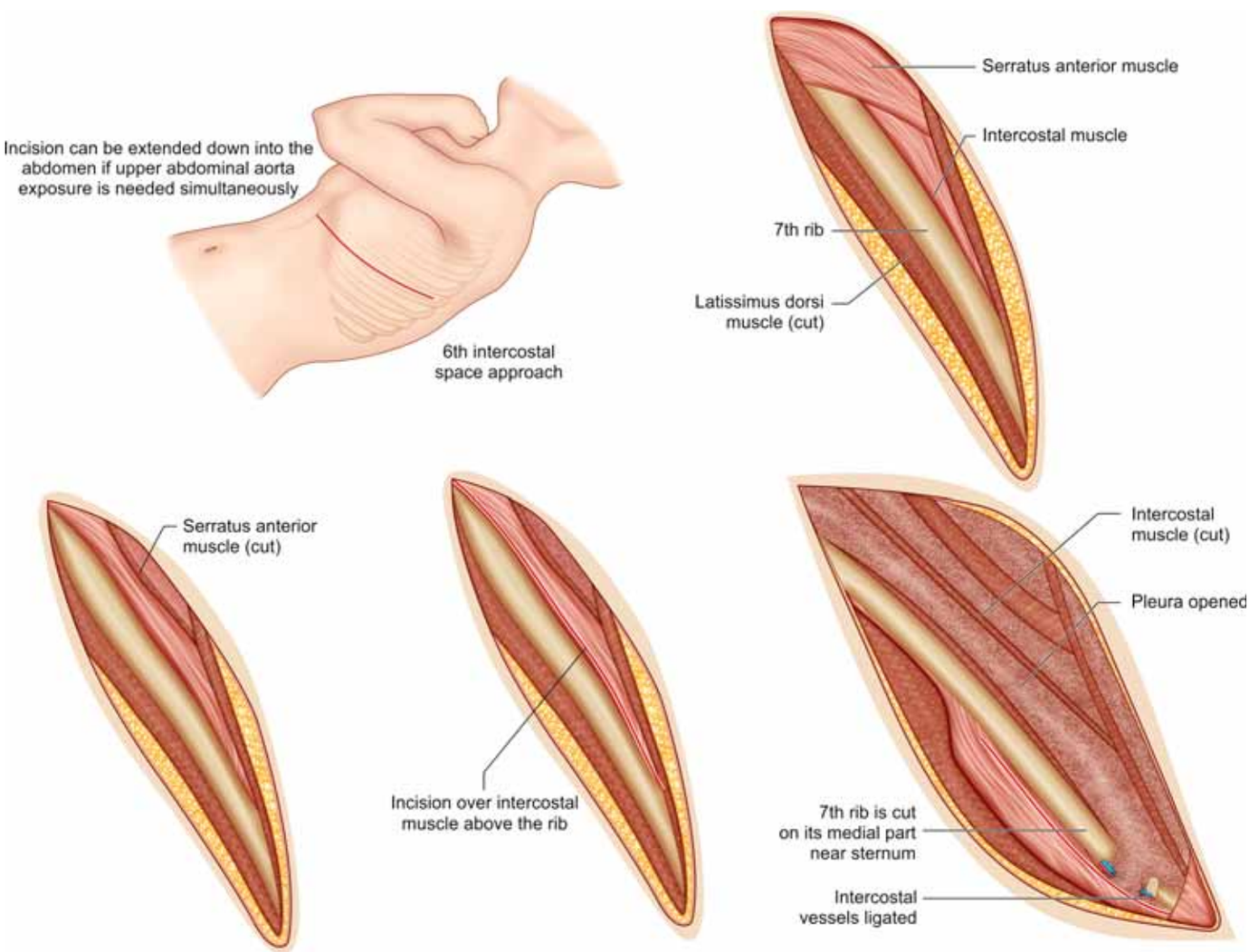

Incision can be extended down into the abdomen if upper abdominal aorta exposure is needed simultaneously
6th intercostal space approach
Serratus anterior muscle
Intercostal muscle
7th rib
Latissimus dorsi muscle (cut)
Serratus anterior muscle (cut)
Incision over intercostal muscle above the rib
Intercostal muscle (cut)
Pleura opened
7th rib is cut on its medial part near sternum
Intercostal vessels ligated

Fig. 19-26: Transthoracic Collis-Nissen's gastroplasty.

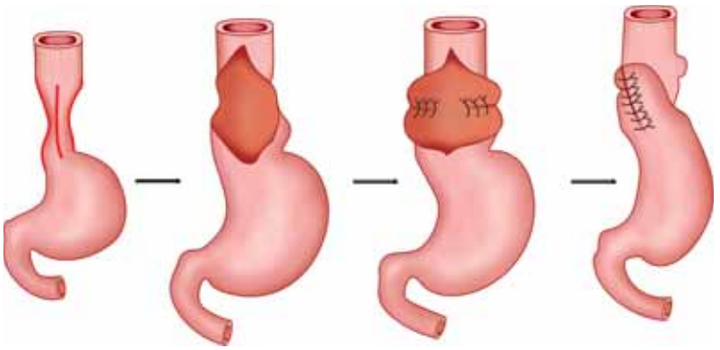


Fig. 19-27: Thal's patch.

- *Oesophagogastrectomy* is required whenever there is *failure of antireflux procedure/metaplasia* is present/*nondilatable stricture* is present. Lower end of oesophagus and proximal stomach is resected with oesophagogastric anastomosis is done through thoracoabdominal approach.
- *Transhiatal oesophagectomy* with anastomosis between cervical oesophagus and stomach in the neck is an alternate procedure which can be used in severe extensive disease and stricture.

Nissen's Fundoplication (Nissen–Rosetti)

It is done either through laparotomy/laparoscopy or through thoracotomy.

Preparation

Preoperative gastroscopy, pH studies, oesophageal manometry, contrast CT chest are needed as investigations. Nasogastric tube should be passed. Often oesophageal bougie or orogastric tube is also used as a guide for mobilisation.

Procedure

Patient is in reverse Trendelenburg position with head up (15-30°); general anaesthesia is used always. Upper midline incision from xiphoid process is done often extending left of the umbilicus below. Self retaining retractor is essential. After laparotomy, abdominal cavity is quickly explored **(Fig. 19-28)**.

Mobilisation - Stomach is held downward and left by assistant. This stretches the tissue around the oesophagus to facilitate dissection and also reduces the any hiatal hernial component. Left triangular ligament is cut to mobilise the left lobe of liver which is retracted down and towards right. Care should be taken not to injure left hepatic vein or IVC. Gastrohepatic ligament is divided. Accessory left hepatic artery may be present in the ligament which is usually saved. It is a branch of left gastric artery. It is now found that ligation of accessory hepatic artery is safer and so if needs can be ligated. Phrenooesophageal ligament and peritoneum is incised circumferentially in the hiatus to visualise the crura of diaphragm from behind. Mobilisation is done like mobilisation of the distal oesophagus described above. Blunt, peanut and sharp dissections are used. Energy sources can be used carefully. Three fingers should be passed easily, freely through post oesophageal window. Anterior and posterior vagi nerve trunks should be preserved dissected carefully and safeguarded. Penrose drain or sling is passed around the hiatus which is used as traction for further dissection.

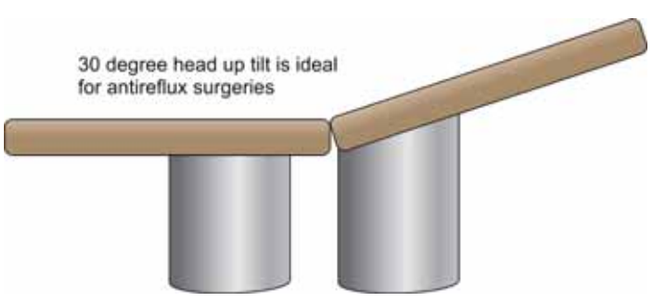


Fig. 19-28: Operation table position in fundal wrap procedure with patient is in reverse Trendelenburg position with head up (15-30°).

Gastrophrenic ligament is identified and divided. Short gastric vessels are divided from the fundus to mobilise it adequately to create a wrap. Short gastric vessels are short, thin walled and stout. Tear of these vessels cause torrential haemorrhage. Often tear may extend into the splenic capsule creating further damage. Traction over the spleen should be gentle and minimal to prevent this; vessels should be ligated using 3 zero silk or vicryl and divided with bipolar cautery. Harmonic energy source is better. Sling over the hiatus is used for continuous traction over the fundus. Two Babcock clamps are passed underneath the oesophagus from right towards left to hold the mobilised fundus; fundus is brought underneath and the front of oesophagus. Babcock clamps are relaxed to check any tension on the mobilised fundus. Mobilised fundus should stay there comfortably without any tendency to return back to its original position. If it is not so, further mobilisation of fundus is needed.

Hiatal repair is a must to prevent fundoplication to slip into the thoracic cavity (mediastinum). Distal slippage of wrap does not occur as gastric trinity prevents that. Using zero polypropylene sutures, deep bites are taken from peritoneum right crus including tendinous portion then of left crus and peritoneum over it. From below upwards 3 interrupted sutures are placed. Sutures are tied sequentially from below upwards. It should not be too tight or too loose. Index finger should be able to pass through the repair and oesophagus comfortably **(Fig. 19-29)**.

Fundoplication - Adequate mobilisation of the hiatus, distal oesophagus (6-8 cm) and fundus is essential. *Wrap* can be done with vagi within or outside. Vagi are kept outside the wrap often. But many advocate wrap with keeping both vagi in position. Often *posterior vagus is kept outside the wrap and anterior vagus is within* the wrap. It does not make any difference until wrap is loose, free (*Floppy*) and suturing bites should not pass through the vagi. No. 2 zero polypropylene interrupted sutures are placed between wrapped part of the fundus through oesophageal muscle wall to the left part of the mobilised fundus to complete 360° plication. First three sutures each at 0.5-1.0 cm apart are placed from below upwards; then sutures are tied. First bite should be from mobilised fundus of the right of oesophagus of patient; through the lesser curve; then from the fundus at left of the oesophagus. Thickness of bite should be around 5 mm; but should not enter the lumen. Interrupted sutures are placed at 1 cm gap. Maximum 3 cm wrap is created not more than that. After completion of the wrap, two fingers should able to pass under the wrap to confirm that fundoplication is not too tight. Suture is also often placed from the wrapped fundus to the hiatal wall (right crus) to stabilise the fundoplication; but it is not necessary **(Figs 19-30 to 19-32)**.

Single suture 360° wrap with Teflon pledget buttress is also often done. Even though many advocate mesh usage for hiatal repair it is not advisable as mesh erosion into the oesophagus is threatening and dangerous.

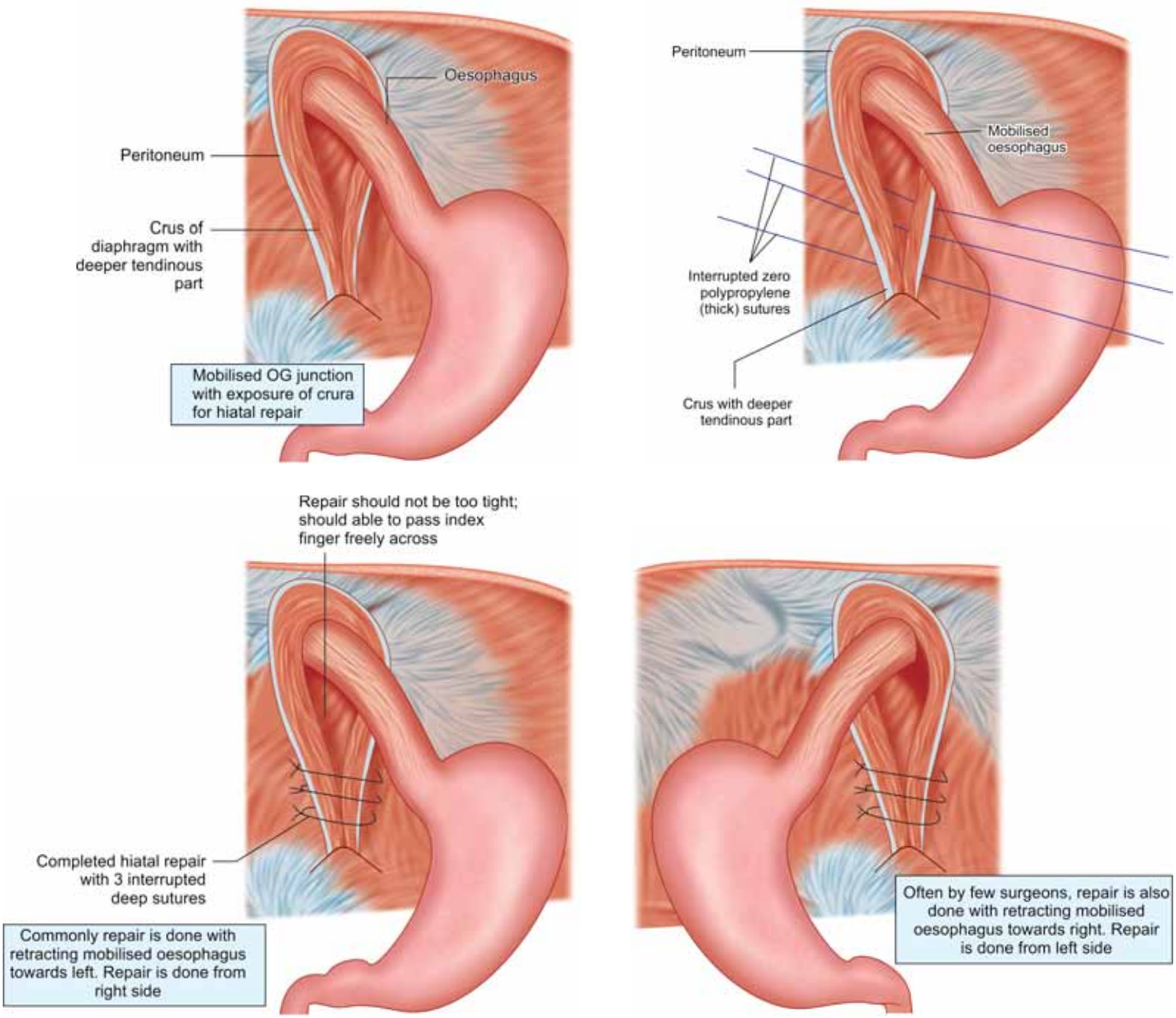

Oesophagus
Peritoneum
Crus of diaphragm with deeper tendinous part
Mobilised OG junction with exposure of crura for hiatal repair
Peritoneum
Mobilised oesophagus
Interrupted zero polypropylene (thick) sutures
Crus with deeper tendinous part
Repair should not be too tight; should able to pass index finger freely across
Completed hiatal repair with 3 interrupted deep sutures
Commonly repair is done with retracting mobilised oesophagus towards left. Repair is done from right side
Often by few surgeons, repair is also done with retracting mobilised oesophagus towards right. Repair is done from left side

Fig. 19-29: Hiatal repair.

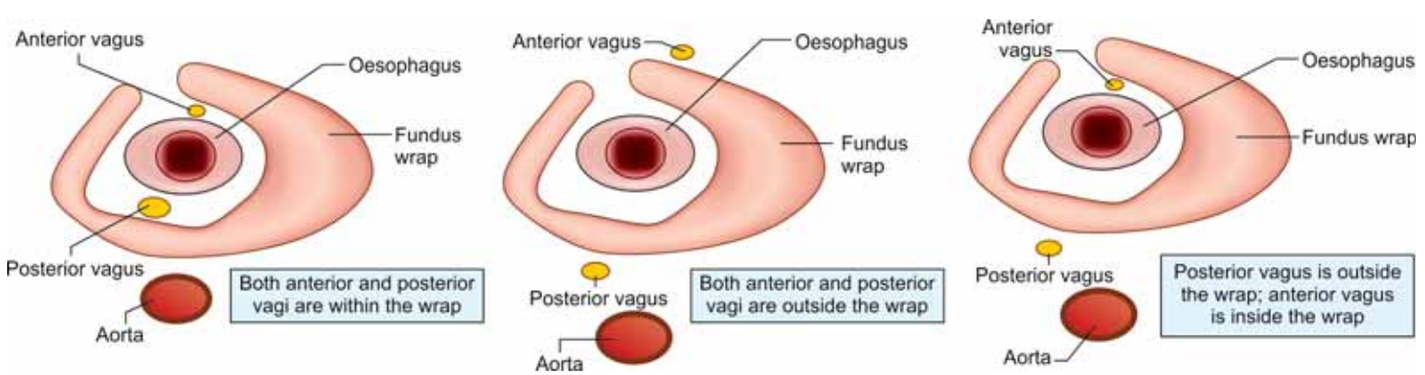


Fig. 19-30: During fundal wrap vagi are kept in different positions depending on the choice.

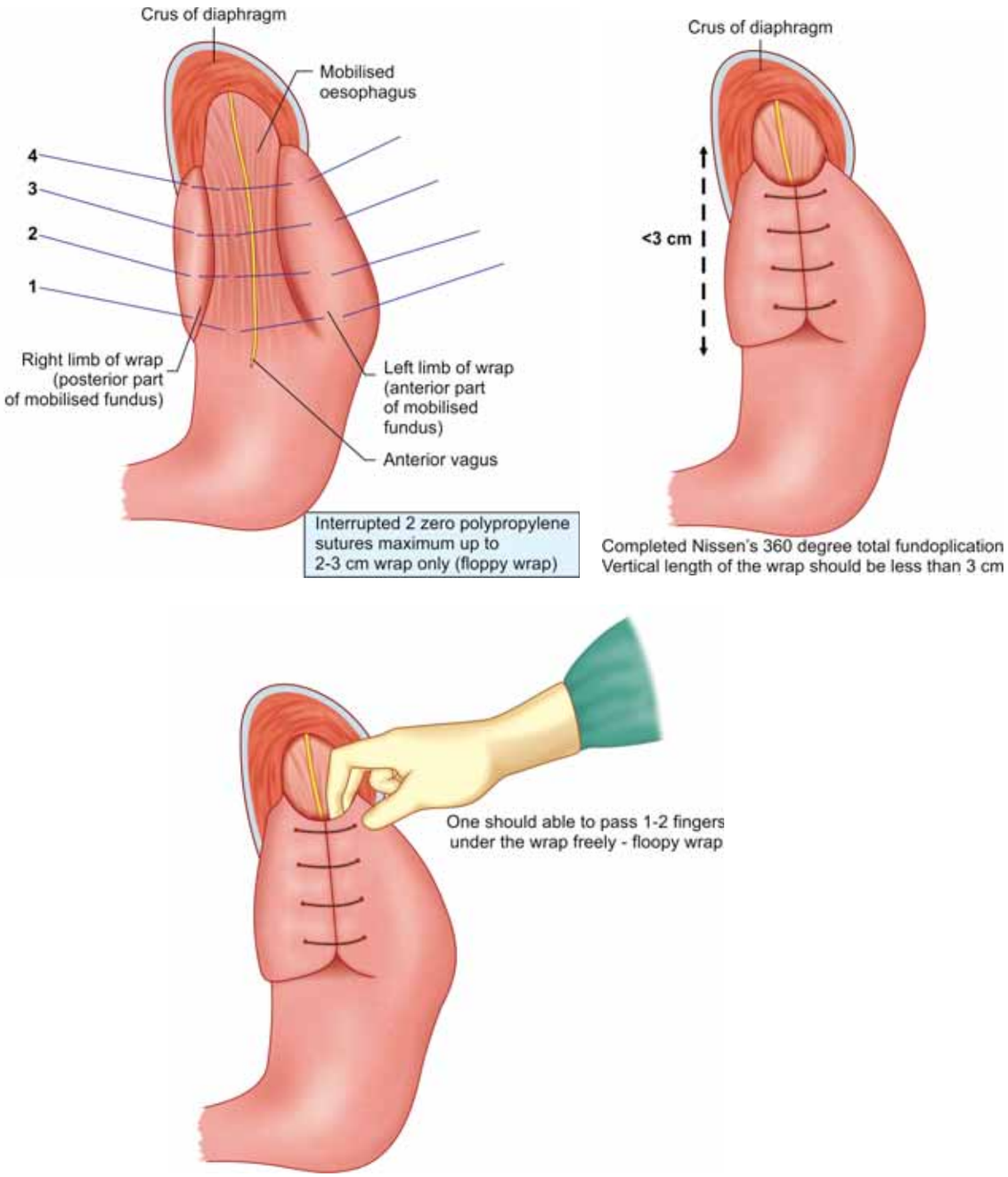

Crus of diaphragm
Mobilised oesophagus
4
3
2
1
Right limb of wrap (posterior part of mobilised fundus)
Left limb of wrap (anterior part of mobilised fundus)
Anterior vagus
Interrupted 2 zero polypropylene sutures maximum up to 2-3 cm wrap only (floppy wrap)
Crus of diaphragm
<3 cm
Completed Nissen's 360 degree total fundoplication
Vertical length of the wrap should be less than 3 cm
One should able to pass 1-2 fingers under the wrap freely - floopy wrap

Fig. 19-31: 360° wrapping of the fundus in NIssen's fundoplication.

Through nasogastric tube 400 ml of saline is infused into the stomach. Stomach is compressed with moderate pressure to trial expelling of the saline from stomach to oesophagus. If saline cannot be expelled means antireflux valve created is competent.

Postoperative care

Nasogastric tube is removed after 48 hours. Oral fluid is started. Oral contrast X-ray study is done to visualise progressively narrowing tapered OG junction which suggests the successful surgery. Absence of tapering suggests loose fundoplication.

Success rate for Nissen's fundoplication is 90%. Recurrence or failure rate is 10%.

Complications

Dysphagia is common after Nissen's fundoplication. It is usually temporary lasting for 3 weeks due to mucosal oedema. If dysphagia persists it is due to tight/wide (>3 cm width) wrap or too tight hiatal repair or missed other causes like achalasia, motility disorders. Indwelling bougie placement across the hiatus during surgery will prevent fundal wrap becoming too tight. Two fingers should be able to pass under the wrap.

Gas bloat syndrome is inability to belch causing tightness in the upper abdomen. It is due to too tight wrap. Floppy fundoplication prevents this.

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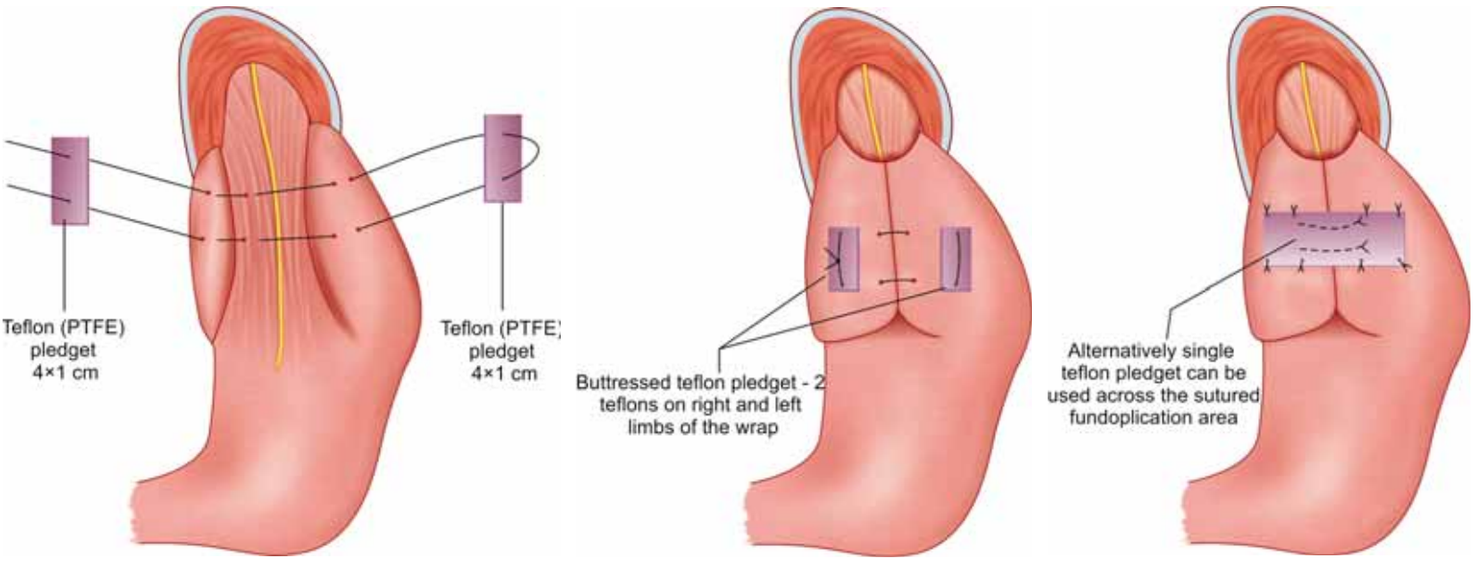


Fig. 19-32: Teflon pledget buttressing in fundoplication.

Contd...

Fundoplication can disrupt causing recurrence or failure. So it is ideal to use monofilament nonabsorbable 2 zero sutures. Polypropylene is commonly used. Vicryl or silk may get digested slowly eventually. Failure is due to disruption of wrap; loose wrap causing slipping of fundoplication; sliding hernia with wrap in abdomen; intrathoracic migration of fundoplication. Barium swallow confirms the diagnosis.

Fundoplication may slip downward causing hour glass stomach and obstruction.

Fundoplication wrap may get herniated into the thorax or paraoesophageal hernia may occur.

Gastric or oesophageal perforation can occur which needs proper suturing.

Injury to spleen (1-5%), vagi, pneumothorax, and subphrenic abscess are rare complications.

Laparoscopic Nissen's Fundoplication

Laparoscopic approach has become ***standard*** since 1992 for fundoplication. Preoperative preparation is same as open method. Contrast study; gastroscopy, 24 hour pH monitoring, oesophageal manometry, chest X-ray are needed. Severity of the reflux; presence of oesophagitis, Barrett's oesophagus, stricture, shortening are to be evaluated properly before planning the surgery. Patients who are intolerant or poorly responding to proton pump inhibitors; patients with large hiatal hernia; presence of complications are the indications for surgical intervention.

Technique - Under general anaesthesia, patient is with reverse Trendelenburg (30°)/head up with semilithotomy position. Surgeon stands in between legs. Three 10 mm trocars and two 5 mm trocars are placed. Supraumbilical port is 5 cm above towards left (to avoid falciform ligament) which is used for 30° laparoscope. Pneumoperitoneum is created. Camera assistant is on the right of the patient; assistant on the left; scrub nurse either right or left distally.

Hiatal mobilisation is done as like in Heller's cardiomyotomy. Gastrohepatic ligament (hepatogastric omentum) is incised. Hepatic branch of left gastric artery is divided; there may be aberrant left hepatic artery which may be the only branch supplying the left lobe of the liver (15%). It is safeguarded. Peritoneum is divided circumferentially all around. Right crus is identified and dissected; similarly left crus. Posterior vagus which is in the loose areolar tissue is also identified and dissected carefully for preservation. Phrenooesophageal ligament is divided all around.

Retrogastric window is created by incising the peritoneal attachment adjacent to gastric fundus near angle of His. Left inferior phrenic artery or few posterior short gastric vessels may be present here which should be fulgurated and divided. Umbilical tape or Penrose drain is used to sling around the OG junction and for traction. During left side mobilisation left pleura may get injured so care should be taken to avoid it.

Short gastric vessels are divided adequately using harmonic scalpel or bipolar cautery to mobilise the fundus. Splenic injury, short gastric vessel tear and gastric perforation are the complications which can occur, and should be avoided.

Hiatal repair is done by retracting the sling at OG junction towards left by approximating both pillars of right crus with left crus with their tendinous attachments using thick no. zero polypropylene interrupted sutures. Peritoneum overlying the crura should be included with the suture bites. Usually 3 sutures are placed 1 cm apart. It should not be too tight or too loose. Sling at OG junction when released oesophagus will retract and fill the hiatus without any constriction or without entering through the hiatus. Additional suture may be added if need arises.

Fundoplication - Grasper is passed from right side across the retroesophageal window towards left side of OG junction to hold the posterior wall of the mobilised fundus; it is pulled behind the oesophagus towards right side to form right limb of the fundic wrap. Anterior wall of the fundus forms the left limb of the wrap. By holding both limbs of the fundus/proposed wrap it is glided gently behind the oesophagus to position it properly (John Hunter's shoe shine technique). Colour of the wrap should be noted. If it becomes congested and bluish that means fundal mobilisation is inadequate compromising the vascularity. When traction pull on the right limb is released wrap should stay in place freely to confirm that wrap is adequately mobilised. 2 zero polypropylene suture is used for fundoplication. 60 French oesophageal bougie/dilator is passed per orally by anaesthetist to reach the OG junction which facilitates the floppy fundoplication. It is not necessary but optional. Bite (seromuscular) is taken from the right limb of the

wrap (posterior wall of mobilised fundus); next bite is taken from the wall of the oesophagus left of the anterior vagus (muscular); last bite is from the left limb of the wrap (anterior wall of the fundus). Usually 3 sutures are placed but not more. Only 2-3 area should be covered by the wrap to make it floppy. Floppiness is checked by passing 5 m grasper freely under the wrap in front of the oesophagus. Wrap may be fixed to crura using nonabsorbable (polypropylene) suture to prevent wrap migration.

Modified Toupet's partial posterior fundoplication is also done to prevent gas bloat syndrome by suturing the right limb of the wrap to oesophageal muscular wall at 10 O'clock position using interrupted polypropylene sutures; left limb of the wrap is sutured to the left wall of the oesophagus similarly at 2 O'clock position to complete the 270° wrap.

Postoperative care

Nasogastric tube is removed in 24-48 hours. Oral sips are started. Gastroscopy is done during follow up period.

Complications

Wrap herniation (1%) which occurs in 48 hours; left sided pneumothorax; perforation; spleen injury; gas bloat syndrome; dysphagia are different complications.

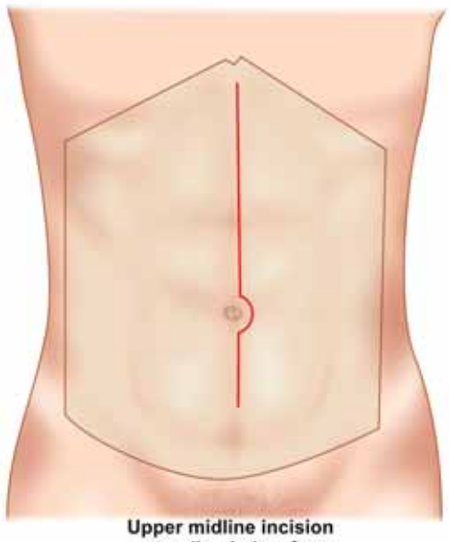


Fig. 19-33: Midline laparotomy incision is commonly used. Often upper horizontal or bilateral subcostal may be used.

Fig. 19-34: Midline or bilateral subcostal incision can be used.

OESOPHAGECTOMY

TRANSHIATAL OESOPHGECTOMY (ORRINGER AND ORRINGER, 1983)

It is commonly done procedure for carcinoma of oesophagus at lower third region. It is basically palliative procedure as nodal clearance not addressed. It is also logically a blind and blunt procedure as thoracic mobilisation of the oesophagus is not under vision. But it avoids the thoracotomy and its problems. Pulmonary complications are less and also duration of hospital stay compared to Ivor Lewis approach. It is also done for benign stricture of the oesophagus.

Procedure is done under general anaesthesia. Nasogastric tube should be in place. Blood should be kept ready in case there is bleeding during thoracic dissection. Intraarterial catheter is required. CVP line is better to keep always. Intravenous line on the left upper limb should be avoided. Position is supine with head end up (reverse Trendelenburg position). Head is turned towards opposite side. Neck is extended by placing a small blanket under upper thorax. Cleaning is done from chin to pubic symphysis. Draping is done **(Figs 19-33 and 19-34)**.

Abdominal dissection

Upper midline incision is placed. Often upper horizontal or bilateral subcostal may be used. Self-retaining retractor is placed. Abdomen is explored for secondaries in liver, peritoneum and coeliac lymph nodes. Left lobe of the liver is mobilised. Traction is given to stomach. Oesophagogastric junction is identified. Peritoneum and phrenooesophageal ligament is incised like mentioned above. Retrooesophageal window is created by sharp and blunt dissection. Accessory hepatic artery may be ligated. Short gastric vessels are ligated carefully without creating traction as vessels may get avulsed and can cause torrential bleeding. Splenic injury is a risk which should be avoided. Handling and traction over the spleen should be gentle with care. Left gastric vessels are doubly ligated securely. Energy sources like harmonic are very useful. But it is ideal to ligate left gastric artery. Vascular clips are other alternatives used. Left gastroepiploic vessels are ligated. Greater omentum is cut using harmonic or be sequential ligations to free greater curvature of the stomach. Retrogastric dissection is done by finger and scissor dissection. Right gastric and right gastroepiploic vessels should be retained. Both anterior and posterior vagi are cut **(Fig. 19-35)**.

Duodenum is mobilised by Kocherisation. Pyloromyotomy or pyloroplasty is done. Usually *Heineke Mikulicz* pyloroplasty is done. Pyloroduodenum is cut longitudinally; it is sutured transversely to widen the pylorus. Two layered interrupted sutures are commonly used. Inner 2 zero vicryl full thickness; outer seromuscular 2 zero silk sutures. Pyloroplasty should be perfect and proper as after pull up it will stay in the thoracic cavity and any bile leak will enter the pleural cavity and is life threatening. Many prefer pyloromyotomy because while gastric conduit is pulled upwards pyloroplasty suture may give way due to traction. Metallic clips are placed at the edges of the pyloroplasty or pyloromyotomy as identification radiologic markers **(Fig. 19-36)**.

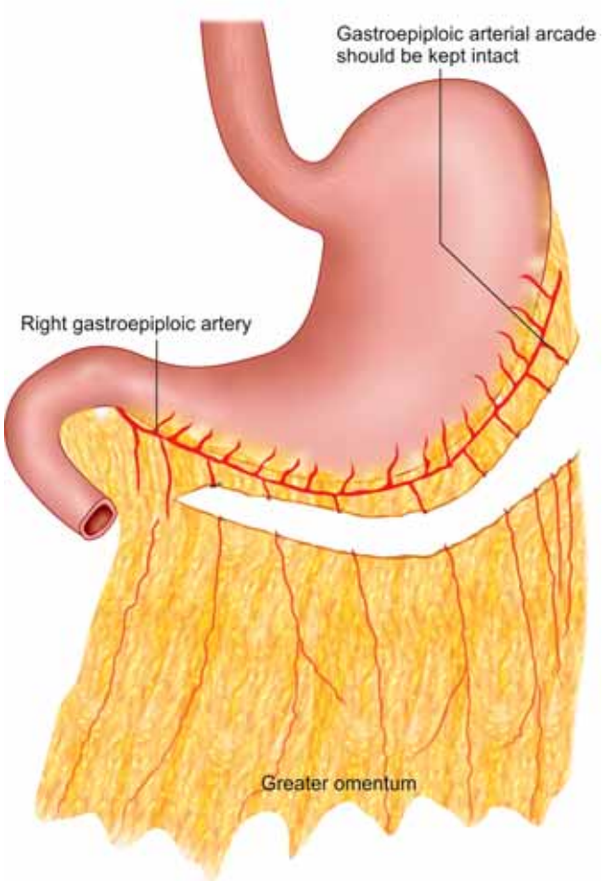


Fig. 19-35: Gastroepiploic arcade should be kept intact in gastric pull up procedures when stomach is used as conduit.

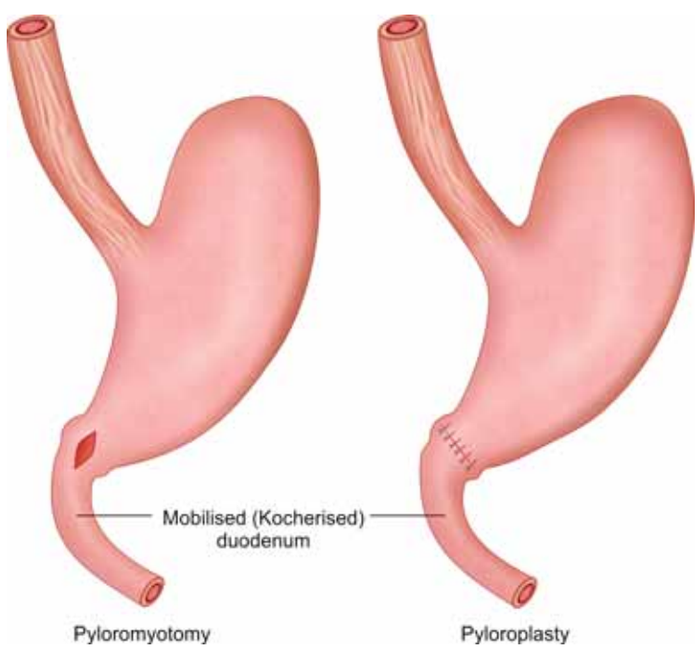


Fig. 19-36: Kocherisation is done; pylorus is widened usually by pyloromyotomy; often pyloroplasty is done.

Hiatus is gently dissected to free oesophagus; often a cut in the crus may be needed. Transverse phrenic vein which is present there needs ligation. This also facilitates the adequate accommodation of the pulled up stomach; if hiatus is not widened, congestion of the stomach can occur which is risky. Penrose drain or umbilical tape or any type of slings is passed around the OG junction, which helps in providing traction and further dissection. Hiatus should be widened about 3 fingers. Fingers are passed across the hiatus to feel the tumour and if it is adherent to aorta or vertebra transhiatal procedure is contraindicated. Pericardium can be gently reflected forward. Both side pleura are retracted laterally. Index and middle fingers are passed across the hiatus close to the oesophageal wall to dissect the perioesophageal loose areolar tissue. If fingers are kept adjacent to oesophageal wall it is less likely to injure the azygos veins even though there is small risk as procedure is blind. Fingers can be reached easily up to the carina of trachea. One should be very careful here as membranous trachea may be closer to oesophageal wall which may get injured. Injury to trachea membranacea is very difficult to manage and is near life threatening even though immediate right sided thoracotomy and suturing of the carina at its membrane is done but most of the time it is futile and patient succumbs. Dissection often still is possible to do under direct vision up to the arch of aorta; it is done with gentle traction, clipping of perioesophageal vessels and cutting the tissue; further traction and clipping like that sequentially. This is better facilitated by using a head lamp by the surgeon **(Fig. 19-37)**.

Dissection in the neck

Cervical oesophagus is approached usually through left side as in the neck oesophagus more towards left side. Surgeon stands on the left side of the patient. But if patient has undergone any surgery of the neck earlier then right side approach is used **(Fig. 19-38)**.

Incision is usually oblique vertical along the anterior border of the sternocleidomastoid muscle from sternal notch to mandibular level. Cosmetic low horizontal incision is also can be used. Sternocleidomastoid muscle is retracted laterally; *omohyoid* and often sternothyoid are divided. Carotid sheath with vessels is retracted laterally. Strap muscles are retracted medially to expose the thyroid and middle thyroid vein. Middle thyroid vein is ligated. Inferior thyroid artery is dissected and usually requires ligation but often preserved. Recurrent laryngeal nerve is identified and safeguarded. It is not always necessary to identify the recurrent laryngeal nerve. It is better to use *assistant's finger as retractor* on the medial aspect over trachea to prevent injury to recurrent laryngeal nerve by a metal retractor.

Oesophagus is visualised behind trachea as a vertical muscular tube. Lateral lobe of the thyroid is in front and lateral of it. Nasogastric

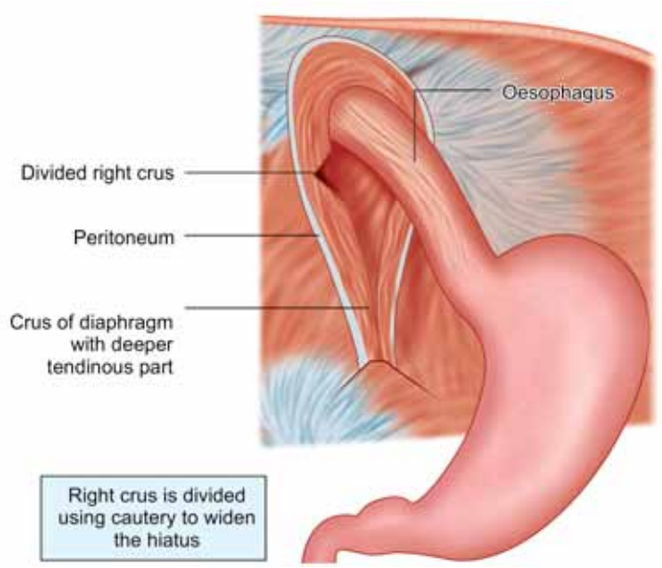
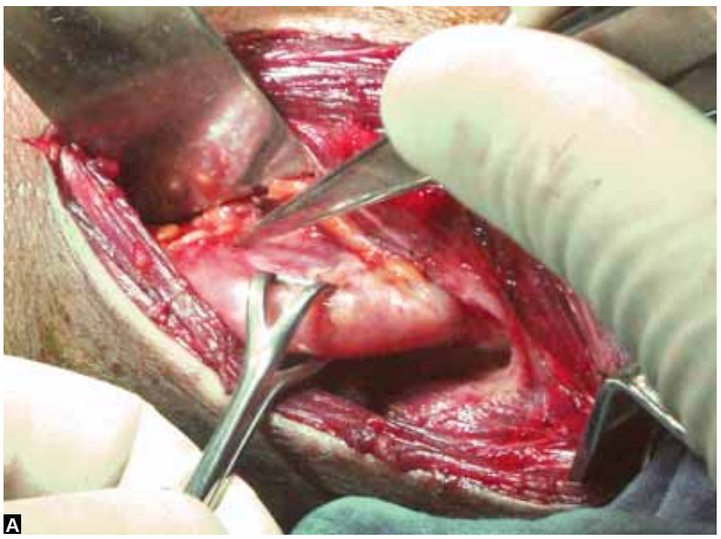
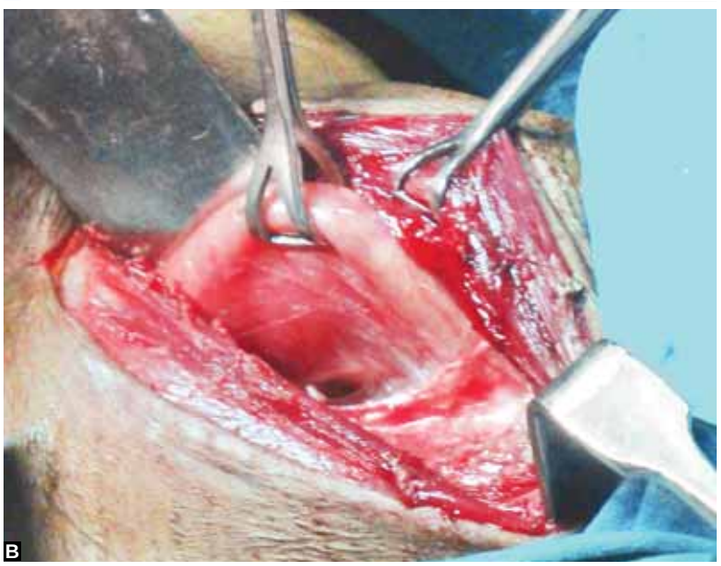


Fig. 19-37: To widen the hiatus right crus may be cut when needed.





Figs 19-38A to C: Neck dissection to mobilise cervical oesophagus.

tube can be felt easily by fingers. By careful blunt and sharp dissection retrooesophageal plane is created between oesophagus and vertebra. Care should be taken not to injure the oesophageal wall. Recurrent laryngeal nerves and tracheal posterior wall are also may get injured. Oesophagus is held using a Babcock clamp and gentle traction is exerted towards left side to complete the finger and sharp dissection around the oesophagus. A Penrose drain or sling is passed around the oesophagus. Oesophagus is further mobilised in the neck up to the sternum using finger. *Sponge on a stick* also can be used for posterior dissection of the oesophagus which is passed gently in front of the prevertebral fascia through neck wound.

Final mobilisation

With surgeon standing on the left side left hand fingers are passed through the oesophageal hiatus close to the oesophageal wall along the posterior mediastinum and right hand fingers are passed through the neck behind the trachea close to the oesophagus. Slight traction is needed to the oesophagus. Blunt gentle finger dissection is carried out circumferentially around the oesophagus. Fingers from below and fingers from above will meet each other to complete the dissection and mobilisation. Compression over the heart should be avoided; if there is any change in the arterial pressure fingers should be withdrawn temporarily and later dissection is completed again. Usually posterior dissection is carried out first; then anterior dissection. Upper part of the posterior dissection is done often from upper part using a *sponge on stick* **(Fig. 19-39)**.

Oesophagus is transected 5 cm distal to the cricopharyngeus between two occlusion clamps. Stay sutures are placed on to the proximal cut end of the oesophagus including the mucosa to prevent mucosal retraction. Linear stapler can also be used. A roller gauze or Penrose drain is tied around the distal cut of the oesophagus in the neck.

Oesophagus is pulled down into the abdomen across the posterior mediastinum and hiatus. Long Penrose drain or infant feeding tube is better as its free end is held with a haemostat in the neck; other end with the oesophagus and tumour is pulled down into the abdomen. Lengthy infant feeding tube or Penrose drain is released by cutting and is held with another haemostat; its other end is still in the neck being held by a haemostat. This allows the easy passage of the gastric conduit across the posterior mediastinum into the neck wound for further anastomosis. Tip of the gastric conduit should be pink, healthy and viable.

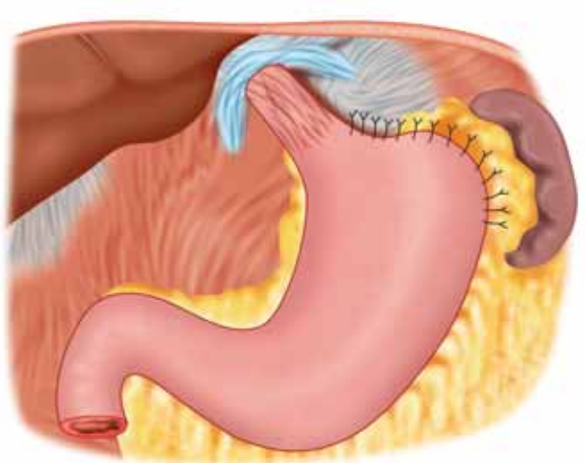


Fig. 19-39: Fundal mobilisation

Gastric conduit (Neooesophagus) creation

In the abdomen stomach is transected just distal to the OG junction using stapler. Stomach along the greater curvature is longitudinally transected distal to the OG junction for 6 cm. Stomach wall is sutured securely using 2 zero sutures in two layers. If stapler is used stapler line may be supported with seromuscular sutures. Entire oesophagus with tumour is removed. Gastric conduit is passed across the posterior mediastinum towards the neck wound. Often stay suture/s is/are placed on the wall/s of the gastric conduit to confirm that twist/rotation of stomach wall has not occurred. Often posterior part of the gastric conduit is fixed to the longus coli muscle in the neck with few serosal interrupted sutures. These *suspension sutures* are no longer said to be essential. Hiatus should be three finger width to prevent venous congestion over the pulled up gastric conduit. Extra width of the hiatus is narrowed by placing 2-3 interrupted silk sutures to the hiatus which prevents intestinal herniation. Often at the hiatus one or two interrupted sutures are placed between hiatus and anterior gastric wall (adjacent to hiatus). Pyloromyotomy/pyloroplasty usually stays 2-3 cm below the hiatus after gastric conduit pull through **(Fig. 19-40)**.

Anastomosis

Proximal cut end of the oesophagus is anastomosed to the anterior wall of the pulled up gastric conduit as end to side anastomosis. Adequate bleeding from the cut edges of both oesophagus and gastric conduit should be ensured. Oesophageal cut end should be made oblique (anterior flap/part of the oesophagus should be 1 cm longer than posterior flap). Anterior wall of the stomach is incised 3 cm lower to the tip of the gastric conduit. Usually vertical or transverse incision is made and is of 2.5 cm in size; often same sized elliptical piece of the stomach wall may be excised but it is not mandatory. Inner all layer full thickness/mucosa and submucosal layer 3 zero vicryl interrupted sutures are used; outer layer seromuscular/muscular 2 or 3 zero silk sutures are used to complete the anastomosis. Often posterior inner layer interrupted all sutures are placed first and held with different haemostats; knots are tied at the end one by one to achieve proper apposition and inversion. After posterior layer it is better to pass a nasogastric tube across the stoma into the gastric conduit and fix it. But many surgeons pass the nasogastric tube after the completion of the anastomosis by gentle milking of the tube tip. Anastomosis should stay above the level of the clavicle. It should be tension free also **(Fig. 19-41)**.

Suction drain is placed in the neck wound; drain is brought out through a separate wound and fixed to skin. Abdomen is inspected again for any blood trickling from the posterior mediastinum. Position of the gastric conduit gently felt and confirmed. Hiatus should able to accommodate three fingers. If it is more widened than 3 fingers then extra gap can be sutured with few interrupted sutures; this prevents bowel herniation across the hiatus. Feeding jejunostomy is done 15 cm distal to ligament of Treitz for postoperative care **(Figs 19-42 and 19-43)**.

Abdomen wound is closed in layers. Usually abdomen cavity is not drained; but oozing if expected tube drain is kept in the abdominal cavity. Neck is also closed in layers after placing a suction drain.

If pleural breach is suspected intercostal tube is placed in the thoracic cavity (in 75% of cases ICT is needed). Tube is removed in 72 hours once check chest X-ray shows adequate lung expansion and if there is no air leak or if pleural drain is less than 100 ml **(Fig. 19-44)**.

- Wide gastric conduit is important to preserve the submucosal collateral circulation.
- Adequate/extended Kocherisation is essential to avoid tension on the tip of the gastric conduit.
- Trauma should be avoided on the gastric conduit tip.
- Adequate (3 fingers) hiatal passage to prevent congestion of the gastric conduit.
- Twist/torsion/rotation of the gastric conduit should be avoided.
- Anastomosis should be above the level of clavicle (Cervical Oesophago Gastric Anastomosis; CEGA); it should be tension free; it should have good blood supply.
- Safe pyloromyotomy/pyloroplasty
- Preserve right gastroepiploic and right gastric arterial supply.

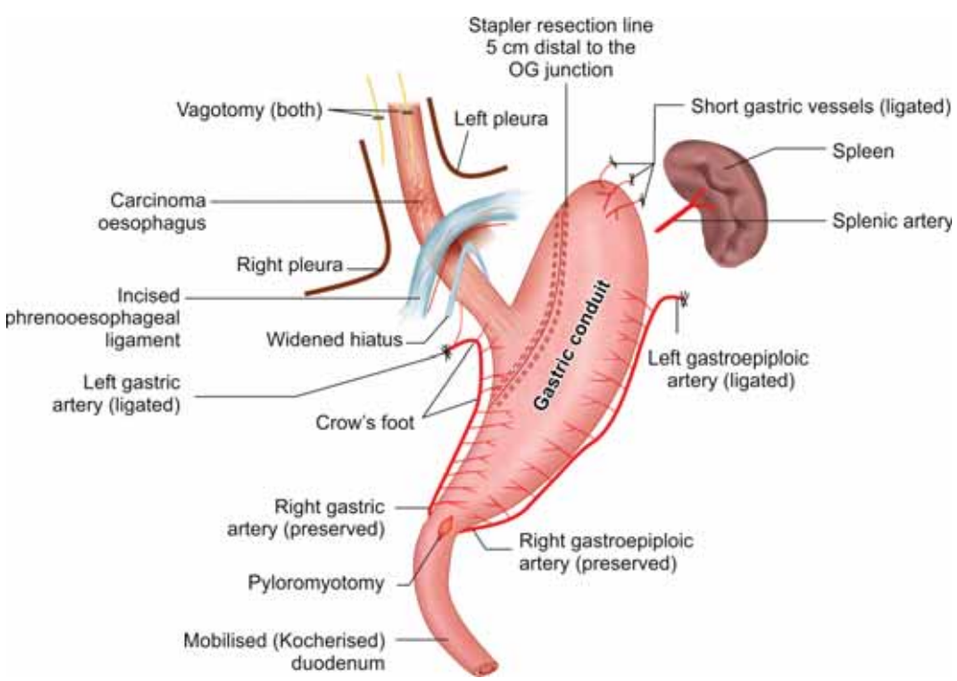


Fig. 19-40: Mobilisation and creation of conduit in transthoracic oesophagectomy.

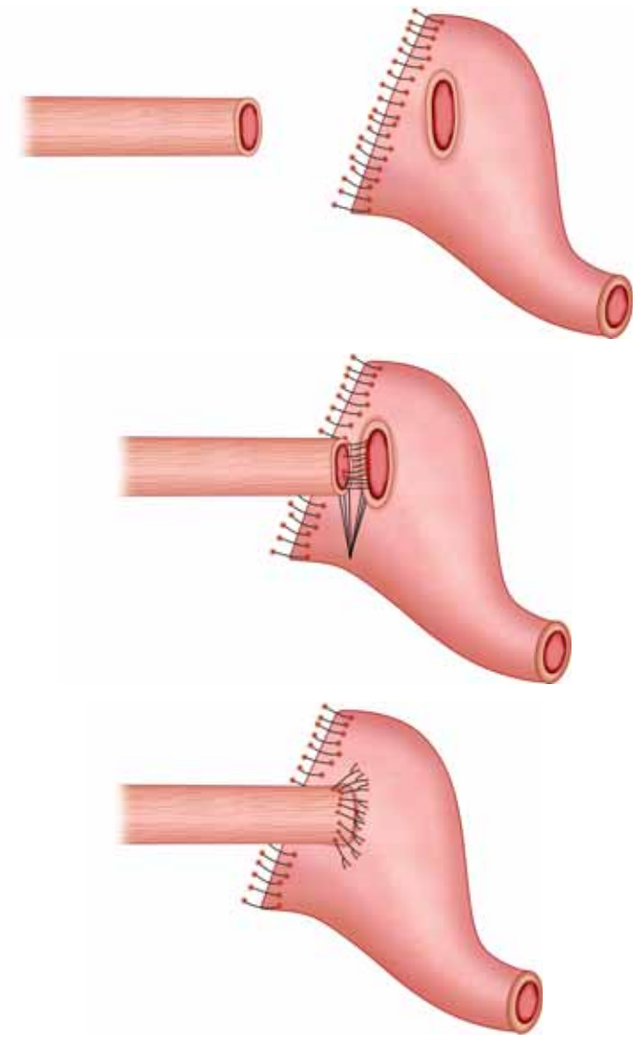


Fig. 19-41: End to side oesophagogastric anastomosis.

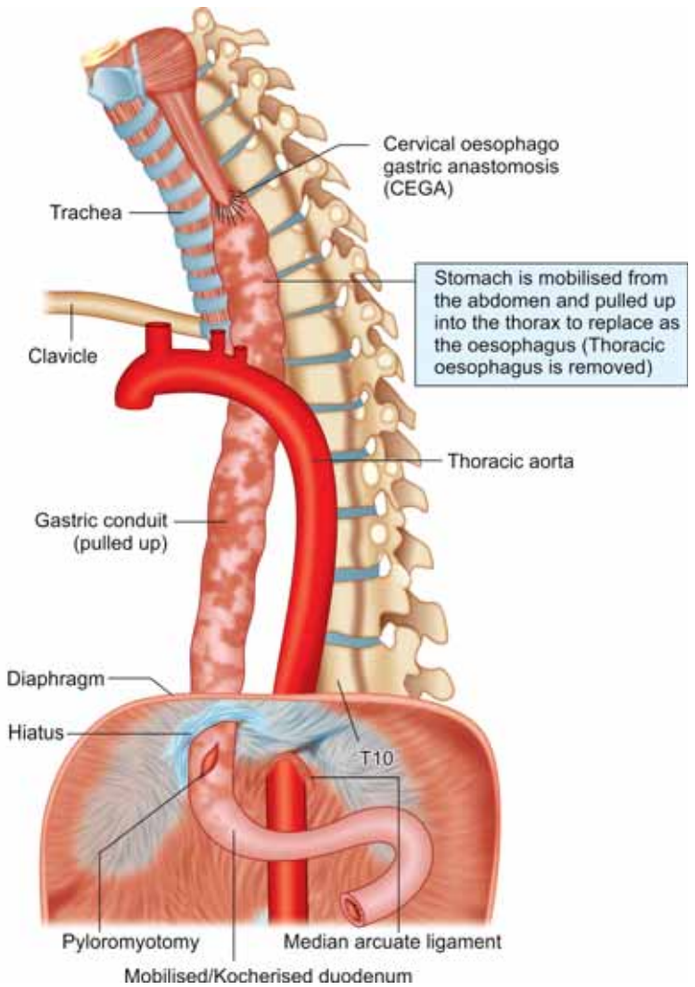


Fig. 19-42: Final look of oesophagogastric anastomosis.

Fig. 19-43: Transhiatal oesophagectomy.

Postoperative care

Nasogastric tube is removed in 5-8 days once bowel sound is heard. Water soluble contrast study may be done after removal of the nasogastric tube (7th day) to confirm that - there is no anastomotic leak; stomach empties adequately; there is no obstruction. Oral sips are started initially later to switch over to semisolid and solid diet.

Complications and problems

Injury to azygos vein and tracheal membrane (less than 1%) at carina even though rare are most dangerous complications. It needs immediate thoracotomy. In case of azygos vein injury, immediate right sided thoracotomy is done; azygos vein is ligated at azgos arch where it enters to superior vena cava. Massive bleeding can occur from avulsion of oesophageal arterial branches from aorta. Whatever the reason, immediate packing through the hiatus and thoracotomy should be done to deal these problems under direct vision. Small linear tear in membranous trachea can be repaired; but avulsion of this part is life threatening. Mortality in transhiatal oesophagectomy is less than 1%.

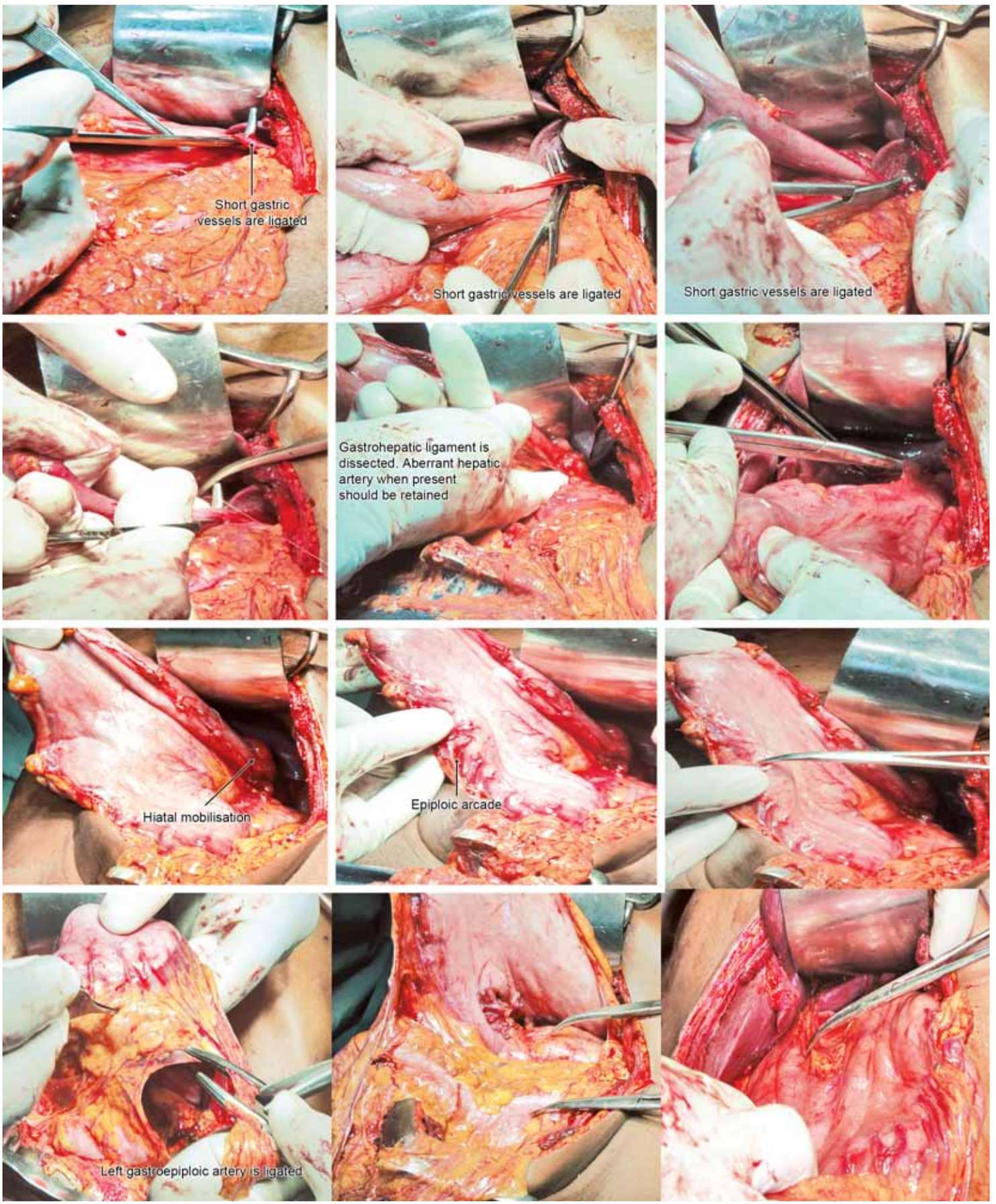
Injury to spleen may warrant splenectomy (3%). Gastric wall oedema, congestion and necrosis may occur. In such situation if gastric viability is doubtful reexploration is done. Gastric conduit is resected. Colonic conduit is used for maintaining the continuity.

Bile leak, leak through the pleural cavity is again risky, and is difficult to manage. It needs reexploration through thoracotomy and suturing or conversion as colonic conduit. Mortality is very high if there is bile leak into the thoracic cavity. Leak may be from gastric conduit suture line or from pyloroplasty suture site.

Anastomotic leak from oesophagogastric anastomosis site (< 10%) is even though not uncommon is less risky as leak is into the neck. Further it is less usually partial and will heal spontaneously. It is better in such situation to keep the nasogastric tube in situ until leak subsides. Rarely it needs surgical reexploration at neck and resuturing.

Thoracic duct injury and lymph ooze can occur. Chylothorax (1%) is suspected when drain persists more than 800 ml/day after 4th postoperative day. Cream is infused through the jejunostomy to observe an opalescent colour in the intercostal tube drain. Thoracic duct injury needs reexploration and duct ligation.

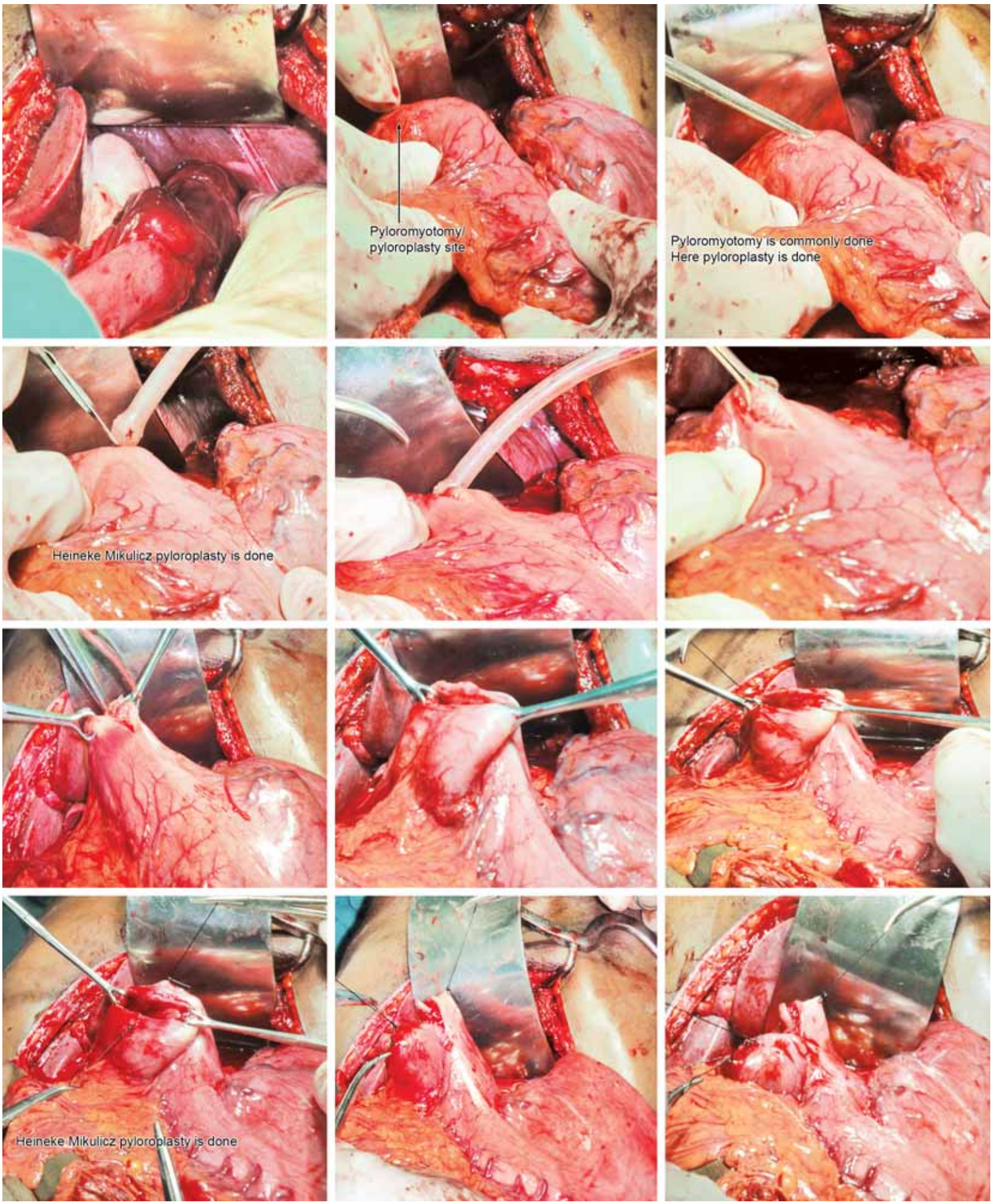
Figs 19-44(1)


Short gastric vessels are ligated
Short gastric vessels are ligated
Short gastric vessels are ligated
Gastrohepatic ligament is dissected. Aberrant hepatic artery when present should be retained
Hiatal mobilisation
Epiploic arcade
Left gastroepiploic artery is ligated

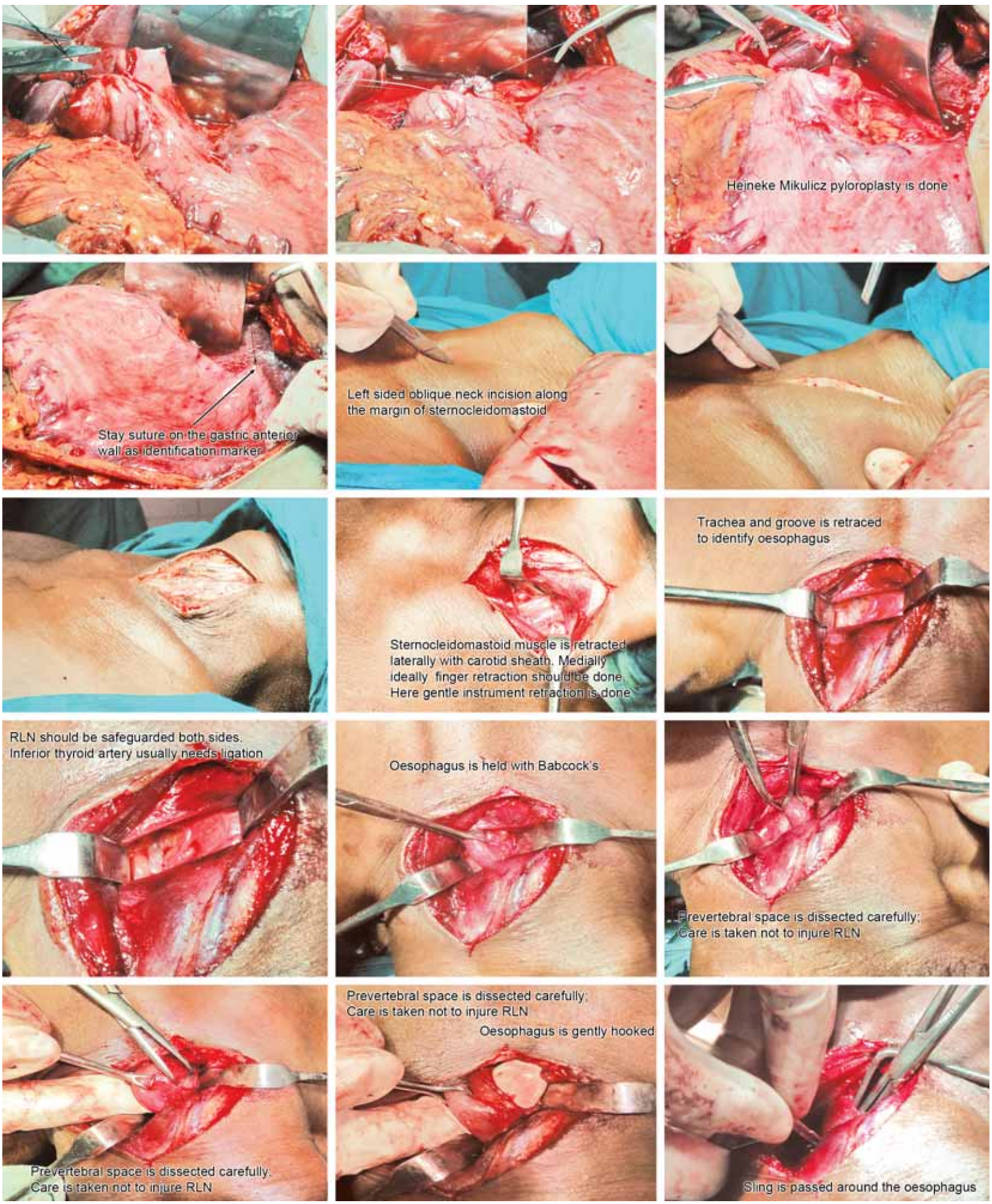
Figs 19-44(2)

Hiatal dissection
Gastrohepatic dissection
Left gastric vessels ligation
Artery and vein (caudal-coronary)
are often individually ligated
Here mass ligation is done
Transfixation is better always
Dissected hiatus
Vagus nerve

Figs 19-44(3)


Pyloromyotomy/
pyloroplasty site
Pyloromyotomy is commonly done
Here pyloroplasty is done
Heineke Mikulicz pyloroplasty is done
Heineke Mikulicz pyloroplasty is done

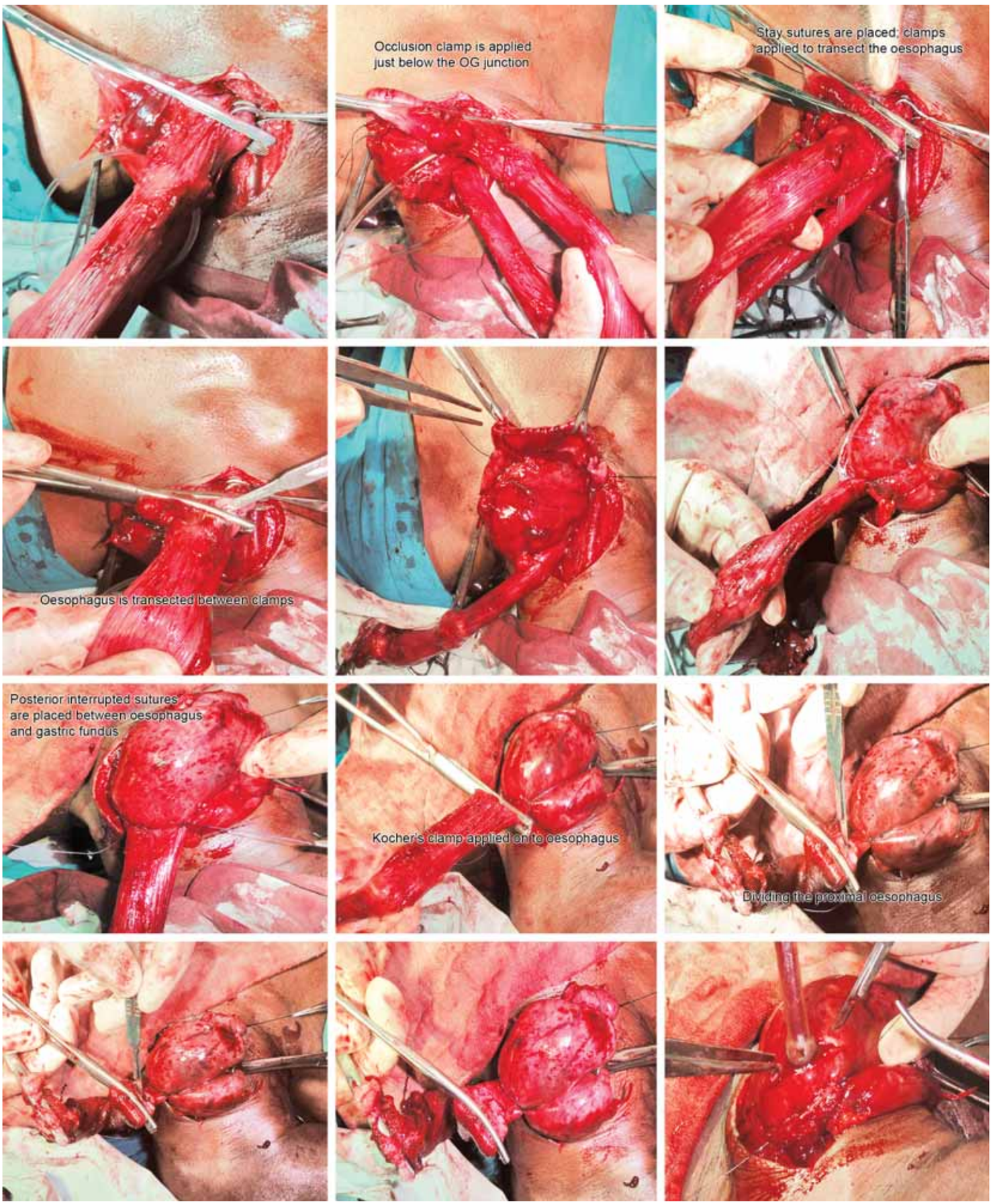
Figs 19-44(4)


Heineke Mikulicz pyloroplasty is done
Stay suture on the gastric anterior wall as identification marker
Left sided oblique neck incision along the margin of sternocleidomastoid
Trachea and groove is retraced to identify oesophagus
Sternocleidomastoid muscle is retracted laterally with carotid sheath. Medially ideally finger retraction should be done. Here gentle instrument retraction is done
RLN should be safeguarded both sides. Inferior thyroid artery usually needs ligation
Oesophagus is held with Babcock's
Prevertebral space is dissected carefully; Care is taken not to injure RLN
Prevertebral space is dissected carefully; Care is taken not to injure RLN
Oesophagus is gently hooked
Prevertebral space is dissected carefully; Care is taken not to injure RLN
Sling is passed around the oesophagus

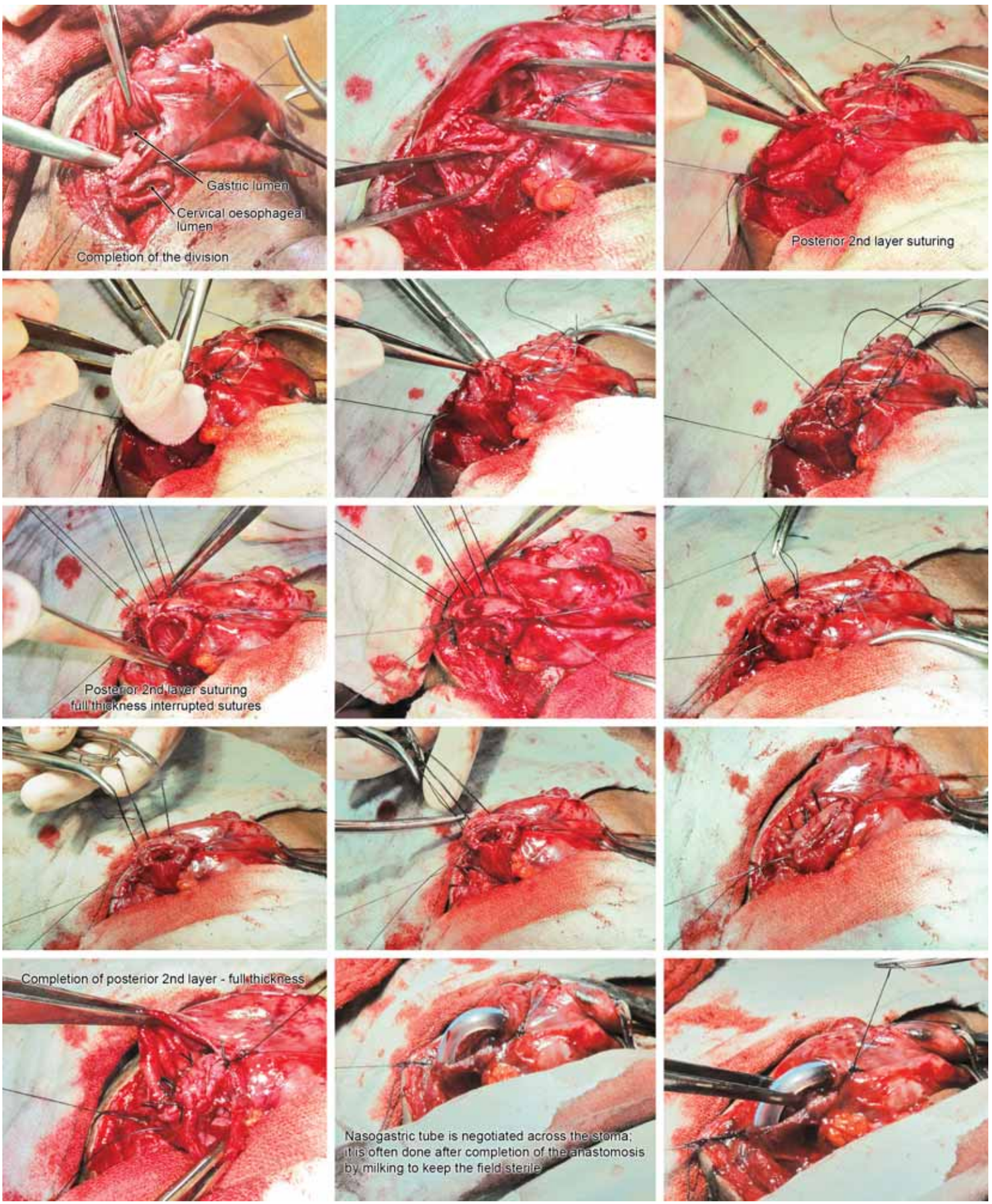
Figs 19-44(5)

Sling is passed around the oesophagus
Mobilisation of thoracic oesophagus by finger dissection from below and from above; traction should be given to sling
Usually oesophagus once mobilised is retrieved through laparotomy wound below Here oesophagus with growth is brought out through the neck wound
Usually oesophagus once mobilised is retrieved through laparotomy wound below Here oesophagus with growth is brought out through the neck wound

Figs 19-44(6)


Occlusion clamp is applied just below the OG junction
Stay sutures are placed; clamps applied to transect the oesophagus
Oesophagus is transected between clamps
Posterior interrupted sutures are placed between oesophagus and gastric fundus
Kocher's clamp applied on to oesophagus
Dividing the proximal oesophagus

Figs 19-44(7)


Gastric lumen
Cervical oesophageal lumen
Completion of the division
Posterior 2nd layer suturing
Posterior 2nd layer suturing full thickness interrupted sutures
Completion of posterior 2nd layer - full thickness
Nasogastric tube is negotiated across the stoma; it is often done after completion of the anastomosis by milking to keep the field sterile

Figs 19-44(8)

Anterior interrupted full thickness suturing is done
Anterior interrupted full thickness suturing is done
4th layer anterior outer interrupted sutures are placed to invaginate 3rd layer
Completed final outer anterior layer
Gently negotiating the stoma under the muscle

Figs 19-44(9)

Oesophageal specimen with growth
Closure of neck wound with a drain - optional - ideally tube drain
Laparotomy wound is closed after doing a jejunostomy

Figs 19-44(10)

Figs 19-44 (1 to 10): Technique of transthoracic blunt oesophagectomy with cervical oesophagogastric anastomosis.

Recurrent laryngeal nerve injury (5%) can occur while dissecting in the neck. Metallic retractor medially over the tracheooesophageal groove should be better avoided. Finger retraction is better.

Sepsis, empyema, mediastinitis, bronchopneumonia, ARDS are other complications.

Anastomotic stricture (3%) is not uncommon. It needs regular dilatation. Regurgitation, dumping, post-vagotomy diarrhoea are also common (17%). More frequent food of less quantity, sleeping in upright position, prokinetic drugs are beneficial.

Delayed gastric emptying may be due to pyloric obstruction, obstruction at hiatal level or redundant intrathoracic stomach (retort-shaped stomach into right thorax) lying in the posterior costophrenic gutter. Proper on table pyloromyotomy, 3 fingers hiatal width prevents this. Additionally prokinetic drugs and often dilatations are beneficial.

Survival rate for carcinoma after transhiatal oesophagectomy is 51% in 2 years and 29% in 5 years. It is comparable with the results of radical oesophagectomy and lymph node dissection.

IVOR LEWIS OPERATION (LEWIS-TANNER)

In 1946, Ivor Lewis (Tanner, 1947) described this procedure. Laparotomy is done. Tumour staging is done to mobilise stomach and stage the disease; right thoracotomy is done; tumour with part of oesophagus and stomach is resected; oesophagogastric anastomosis is done in the thorax. Technique involves coeliac node as well as adjacent thoracic node clearance. Original Ivor Lewis approach is initial laparotomy in supine position; repositioning into right thoracotomy position for thoracic dissection. Now commonly it is modified as synchronous combined abdominothoracic oesophagectomy without altering the position to approach abdomen and thorax. But finally it is surgeon's comfort and preference.

Patient is placed in semidecubitous position with right side upwards; it makes both abdominal and right posterolateral thoracotomy feasible without changing the position in the middle of the operation. Often midline incision is made in supine position; once initial abdominal part is over patient is positioned in right up position.

General anaesthesia with double lumen endotracheal tube is placed. Cleaning is done from neck along the right chest wall area up to pubic symphysis including entire abdomen. Draping is done. Head should be turned towards opposite side and right side neck should also be prepared so when need arises anastomosis can be done in the right side neck.

Once through upper midline incision exploration confirms the operability per abdomen thoracotomy is done in right posterolateral 4th intercostal space. Then abdominal mobilisation and thoracic mobilisation of the oesophagus is done **(Fig. 19-45)**.

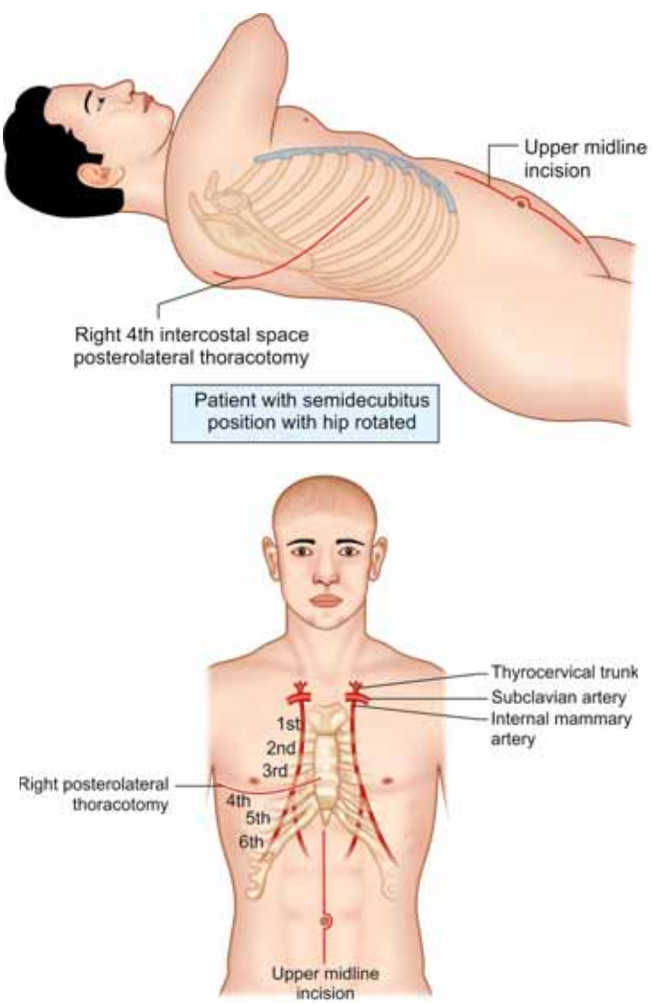


Fig. 19-45: Incision for Ivor Lewis operation.

Abdominal Mobilisation

Self-retaining retractor is placed. Abdomen is explored for secondaries in liver and lymph nodes. Once operability is confirmed, left triangular ligament is divided to retract left lobe of the liver. Phrenooesophageal ligament and peritoneum is incised horizontally and OG junction is mobilised circumferentially with creation of retrooesophagus window. Gastrohepatic ligament is incised; accessory hepatic artery is ligated and divided. Left aberrant hepatic artery which originates from left gastric artery should be suspected if artery is wider than 5 mm and it may be supplying exclusively left lobe of the liver; if suspected it should be isolated, dissected and preserved. Greater omentum is divided. Short gastric vessels are ligated and divided. Energy sources are better for this. Left gastric artery is ligated at its origin to include the fat and lymph nodes. It is double securely ligated. Left gastric vein is also ligated separately (it is coronary vein and is caudal to artery). Right gastroepiploic and right gastric vessels should be preserved carefully. Bilateral truncal vagotomy is done. Dissection along the greater curvature should be done outside the gastroepiploic arcade and arcade should not get injured. Duodenum is mobilised up to its 3rd part by Kocherisation. Duodenal ligament between the posterior part of the duodenum to Gerota's fascia laterally is a ligamentous structure needs to be divided during Kocherisation. Care should be taken not to injure the superior mesenteric vein while mobilising the 3rd part of the duodenum as traction injury can occur. Heineke Mikulicz pyloroplasty or pyloromyotomy (circular muscle is cut using no. 15 blade) is done. Often stay suture is placed on the anterior part of the stomach to avoid rotation while pulling the stomach into the thorax. Hiatus may be widened by cutting it transversely using cautery.

Thoracic Mobilisation

Right posterolateral thoracotomy is done through 4th or 5th intercostal space. In females incision is made through inframammary crease. Pectoralis major and serratus anterior muscles are cut using cautery along the 4th space. Intercostal muscles are cut adjacent to upper border of 5th rib in the lower part of 4th space to avoid injury to intercostal vessels. Internal mammary artery near the sternal margin is identified, doubly ligated and divided. Pleura is opened. 4th rib near its sternal end is cut using bone cutter. Intercostal vessels at its lower margin is ligated and divided. Finochietto retractor is used to retract the ribs and so to expose the thoracic cavity. Usually wet mops are placed under the blades of the retractor. If further retraction is needed 5th rib can be cut like 4th rib. Incision if needed can be extended posteriorly up to the paraspinal muscles. Thoracic cavity is explored for secondaries in the lung and nodes. Mediastinal pleura is incised longitudinally on the surface of the oesophagus. Nasogastric tube facilitates identification of the oesophagus. Endoscopy on table may be useful to identify the oesophagus or to improve the dissection. At one point oesophagus is mobilised circumferentially with sharp and blunt dissection; it is encircled with a sling (or umbilical tape or infant feeding tube). Sling is used as a traction to proceed with further mobilisation of the oesophagus. Oesophagus is mobilised below up to the hiatus through which finger can be passed easily as hiatus below is already dissected. Upwards dissection is done behind the tracheal carina. Small arterial branches entering are divided between ligatures or haemoclips or harmonic scalpel can be used. Monopolar cautery is usually avoided; but bipolar cautery is quite useful. Azygos vein is visible on the right side which is arching above towards the superior vena cava. Azygos vein is doubly ligated (two on each side) at the beginning where it arches. Double ligation is needed. Care should be taken not to injure the superior vena cava. Vascular stapler can be used for the same. Often azygos vein is ligated at the level of hemiazygos vein (T8) especially if oesophageal transection is being done at lower level. It is better if possible to ligate the thoracic duct at this level to avoid its injury and leak. Fat, lymph nodes and adjacent tissues are dissected which should be included in the oesophageal specimen. Oesophagus is mobilized from thoracic aorta. All small vessels are ligated or fulgarated using bipolar or by harmonic scalpel. Proximal mobilisation should be 10 cm from the upper margin of the gross tumour. Mobilised stomach is passed through the widened hiatus into the thoracic cavity. Rotation of the stomach should be avoided by identifying the stay suture. Stomach just beyond the OG junction along the lesser curve is divided using stapler. Otherwise transection is done in between two occlusion clamps and stomach side is closed with two layer sutures (inner continuous 2 zero vicryl sutures; outer interrupted 2 zero silk sutures). 10 cm proximal to the tumour oesophagus is transected between clamps; specimen is removed. Proximal margin should be sent for frozen section biopsy.

Oesophagogastric Anastomosis

On the anterior wall of the mobilised stomach just distal to the sutured/stapled line 1.5 cm width circular stomach wall is excised; alternatively just 1.5 cm horizontal/vertical incision is also sufficient instead of circular tissue removal. It is said that circular piece of stomach wall removal prevents anastomotic stricture formation but that is not proved; so it is of surgeon's preference. Oesophageal cut end is made oblique for anastomosis. Outer layer suturing is done using interrupted 2 or 3 zero silk sutures taking bite from seromuscular layers of stomach and muscular layer of oesophagus (Once posterior outer layer suturing is over if stomach is not yet incised or circular piece is not removed, then an incision is made over the anterior wall of the stomach 2 cm below the transected part of the stomach). Inner all layer full thickness bite taken from the stomach wall; bite is taken from the mucosa and submucosa of the oesophagus (often muscular layer bite is also taken) using 2 or 3 zero silk or vicryl. Knots can be placed inside. Similarly anterior inner layer interrupted sutures are placed with knots inside. Sutures should be placed for every 3 mm width with bite point at 3 mm from the cut edge. After that anterior outer layer sutures are placed as interrupted seromuscular sutures. As oesophagus is cut obliquely with anterior edge lengthier (1 cm) than posterior edge, anastomosis becomes tension free **(Fig. 19-46)**.

In another method: OG junction is transected using stapler or between clamps and sutured. Stomach is pulled upwards into the right thoracic cavity across the widened hiatus. Mobilised oesophagus with tumour is held upwards; two stay sutures using 3 zero silk are placed between oesophagus 10 cm proximal to the upper margin of the tumour and 5-6 cm below uppermost part of the mobilised anterior wall of the stomach. Posterior interrupted sutures are placed between seromuscular stomach wall and muscular oesophageal wall. Posterior wall of the oesophagus is cut 5-6 mm distal to the sutured layer using 15 no. blade to identify nasogastric tube and mucosa. Incision (full thickness) over the stomach is made similarly distal to posterior layer; bleeding edges can be suture ligated or cauterised using bipolar cautery. Posterior mucosal layers of the oesophagus and stomach taking proper bites including submucosa at 3 mm intervals and 3 mm distant from the cut edges of stomach and oesophagus. Knots are tied inside the lumen. This layer is usually interrupted sutures but continuous

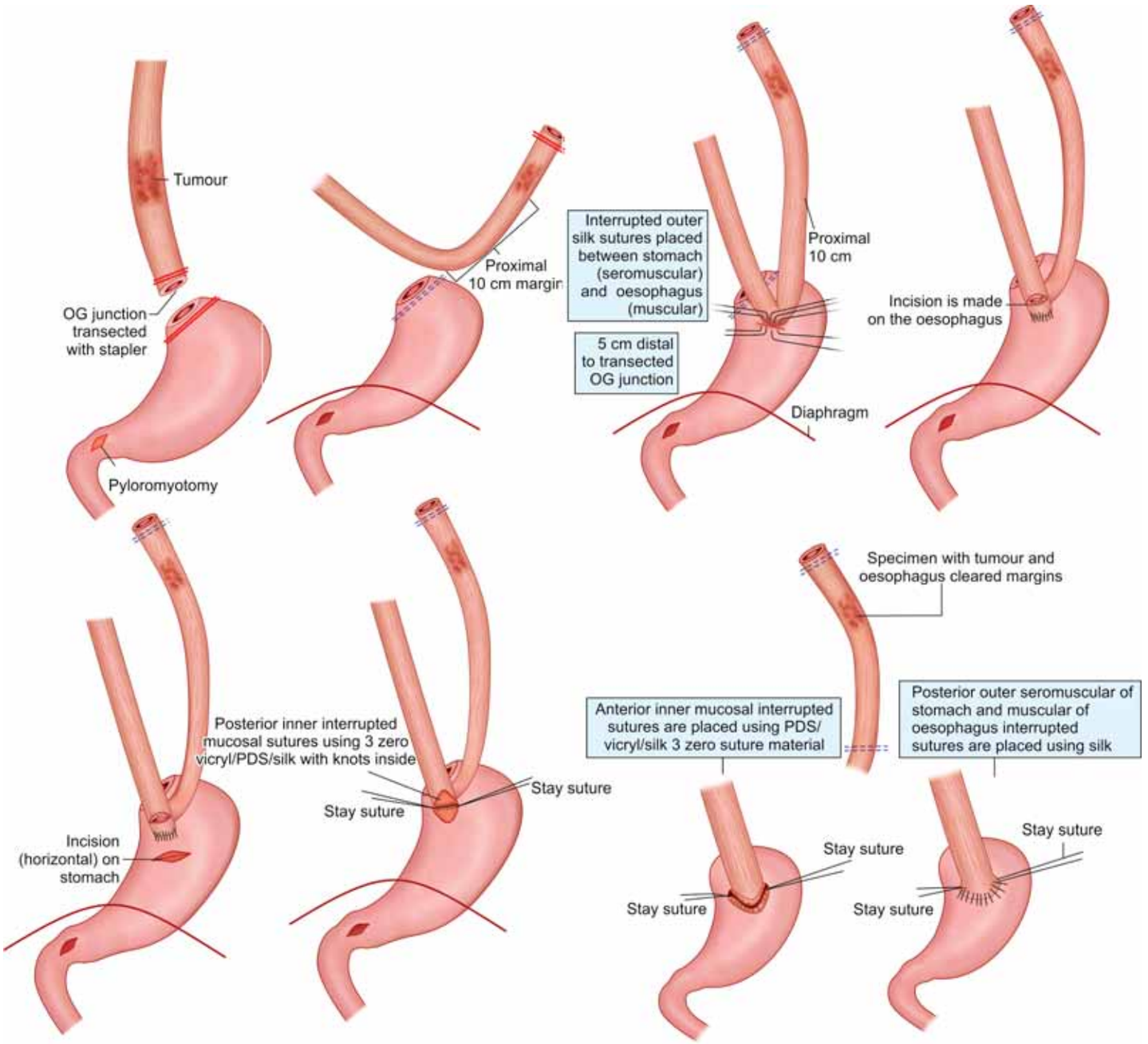

Tumour
OG junction transected with stapler
Pyloromyotomy
Proximal 10 cm margin
Interrupted outer silk sutures placed between stomach (seromuscular) and oesophagus (muscular)
5 cm distal to transected OG junction
Proximal 10 cm
Diaphragm
Incision is made on the oesophagus
Specimen with tumour and oesophagus cleared margins
Posterior inner interrupted mucosal sutures using 3 zero vicryl/PDS/silk with knots inside
Stay suture
Stay suture
Incision (horizontal) on stomach
Anterior inner mucosal interrupted sutures are placed using PDS/ vicryl/silk 3 zero suture material
Posterior outer seromuscular of stomach and muscular of oesophagus interrupted sutures are placed using silk
Stay suture
Stay suture
Stay suture
Stay suture

Fig. 19-46: Oesophagogastric anastomosis in thorax in Ivor Lewis operation.

suture is also can be placed. Anterior wall of the oesophagus is cut 1 cm distal to the level of posterior wall to retrieve the specimen. Anterior mucosal layers are sutured similarly with knots tied inside the lumen. Anterior layers (seromuscular) of stomach and of oesophagus (muscular) are finally sutured with interrupted sutures.

Note: Anastomosis can also be done using stapler.

Stomach is fixed to prevertebral fascia with interrupted sutures to prevent tension over the anastomosis. Omentum may be tagged over the anastomotic site. Hiatus should be 3 fingers wide. Hiatus is fixed to the stomach using few interrupted silk sutures. Jejunostomy is done 15 cm from the ligament of Treitz.

Intercostal tube is placed into the thoracic cavity. Thoracotomy is closed in layers. Abdomen is also closed in layers with or without tube drain **(Fig. 19-47)**.

Postoperative Care

Nasogastric tube should be kept in situ for 5-7 days. Chest tube is removed once adequate lung expansion has occurred which is confirmed by chest X-ray and pleural drain is less than 100 ml/day.

Complications

Anastomotic leak is dangerous as anastomosis is in the thorax.
Bleeding can occur; but usually subsides.
Respiratory distress, pneumonia, cardiac arrhythmias, DVT are other problems.
Stenosis of the anastomosis can occur which often needs repeated oesophageal dilatation using bougies (Maloney's).
Subphrenic abscess can occur which is diagnosed by CT scan. Guided tube drainage or open drainage may be needed.

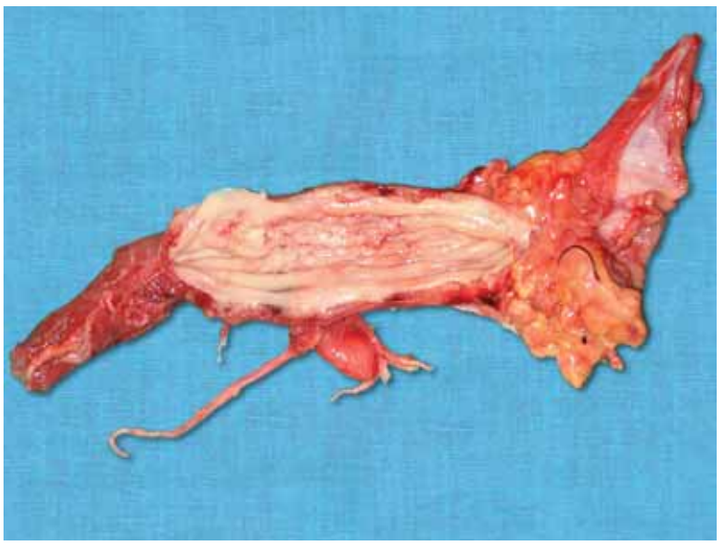


Fig. 19-47: Oesophagectomy specimen after resection.

Respiratory physiotherapy, prevention of deep vein thrombosis and sepsis control should be done. Oral sips started once nasogastric tube is removed. Normal diet is started in 10-14 days.

LEFT THORACOABDOMINAL APPROACH OESOPHAGOGASTRECTOMY (CHURCHILL AND SWEET, 1942)

It is done only if growth is in OG junction. Much proximal tumour is difficult approach through this as access is difficult. Phrenic nerve injury is a possible complication when diaphragm is cut radially and it may lead into diaphragmatic paralysis.

Double lumen endotracheal tube is used for general anaesthesia. Left side of the patient is upwards 60°-90° with right arm is straight in the arm board and left arm is suspended above towards head away from surgical field. Patient is supported with sandbags or supportive frames **(Figs 19-48 and 19-49)**.

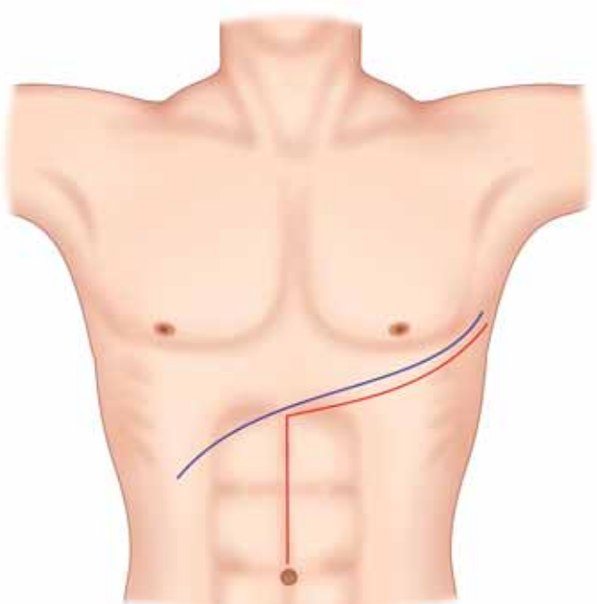


Fig. 19-48: Incision for left thoracoabdominal approach.

Fig. 19-49: Abdominothoracic (left) approach for OG junction or lowermost oesophageal carcinoma.

Technique

Incision can be either upper midline incision which is extended over the thorax or oblique incision between xiphoid and umbilicus extending towards left into the thoracic cage. First abdomen is opened; explored for operability/secondaries/lymph node and peritoneal status. Once operable incision is extended across the 6th intercostal space upwards and posteriorly towards scapula and erector spinae. Latissimus dorsi and serratus anterior are cut. Scapula is retracted upwards. Intercostal muscles are cut on the upper part of 7th rib. Pleura is opened. Costal margins are divided using heavy scissor or bone cutter or 22 no. blade. Internal mammary artery may require to be ligated. Diaphragm should not be incised radially even though it is technically looks easier as phrenic nerve may get injured. It should be incised circumferentially (*Merendino and associates safe zones*, 1956). Incision is made in a line 3 cm from the rib margin parallel to it for 15 cm length **(Fig. 19-50)**.

Inferior pulmonary ligament is cut using long scissor or cautery; above up to inferior pulmonary vein. Mediastinal pleura is incised longitudinally from the thoracic descending aorta. Both vagi are cut

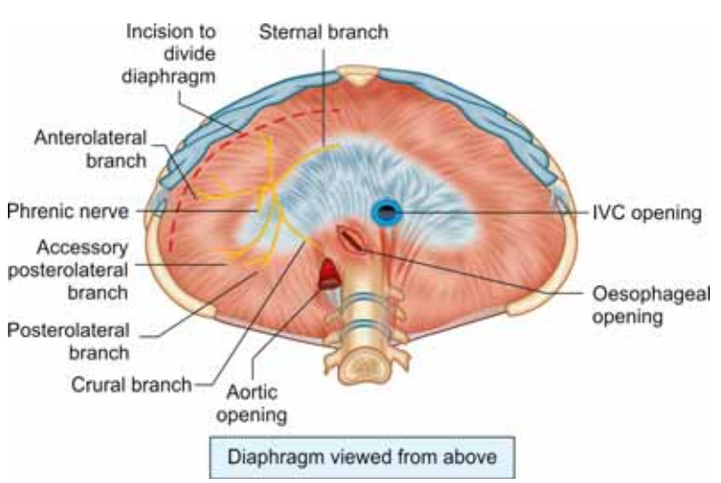


Fig. 19-50: Incision placed in diaphragm – safe zones (*Merendino and associates safe zones*)

high up below the level of lung hilum. Arterial branches entering the oesophagus are fulgarated using harmonic or bipolar cautery or ligated or occluded with haemoclips.

OG junction along the hiatus, lower oesophagus, stomach is mobilised through the abdominal wound same way like for other oesophagectomy (refer above). Gastroepiploic arcade should be retained along the greater curvature of the stomach while dividing the greater omentum; around 5 cm of redundant omentum should be attached to the stomach towards duodenal side. Right gastric and right gastroepiploic vessels are preserved. Kocherisation, hiatal dissection, ligation of left gastric vein (coronary vein – it is caudal to left gastric artery), left gastric artery, left gastroepiploic artery, accessory left hepatic artery are ligated securely to mobilise proximal stomach behind. Left gastric artery needs double ligation. Lymph nodes, fat should be cleared. Splenectomy may be done if needed. Pyloromyotomy is done. Oesophagus is transected using stapler 10 cm proximal to tumour; stomach is also transected 5 cm distal to the OG junction or the tumour (if tumour is extending into the stomach). Specimen is removed through the abdominal wound.

Crus of the diaphragm is cut if needed to widen the hiatus to prevent venous congestion of the pulled up mobilised stomach. Stomach is pulled across the hiatus up into the thoracic cavity. Anastomosis is done between the end of the oesophagus and anterior wall of the stomach as two layers. Posterior wall of the stomach may be fixed to the prevertebral fascia and hiatus using interrupted nonabsorbable sutures to stabilise the gastric pouch.

Abdomen is closed in layers. Intercostal tube is placed. Diaphragm is closed using interrupted horizontal mattress 1 zero polypropylene sutures. Second continuous suture layer may be added to this. Thoracotomy is also closed in layers.

Postoperative Care

Intercostal tube is removed once lung has expanded fully in 5-7 days. Respiratory physiotherapy, antibiotics, observation are done regularly. Nasogastric tube is removed in 7 days. Oral sips started later. Often contrast study is done to confirm the adequacy of the stoma.

Complications

Respiratory complications, anastomotic leak, infection, subphrenic abscess formation, stenosis of the stoma, paralysis of the diaphragm are the complications.

MCKEOWN THREE PHASE OESOPHAGECTOMY WITH LYMPHADENECTOMY (1972)

McKeown modified Ivor Lewis technique by mobilising the entire oesophagus through abdominal and right thoracotomy approach and with right cervical approach cervical oesophagogastric anastomosis is done in the right side neck.

Under double lumen endotracheal intubation general anaesthesia procedure is done. Original McKeown procedure was abdominal/thoracic one after another with change positions each time; then right sided neck approach for anastomosis. Now synchronized abdominal, thoracic and neck approaches are used even though technique is of three phases. Cleaning and draping is done exposing abdomen, thorax and right sided neck. In further modifications, often left side neck is used for cervical dissection of the oesophagus instead of original McKeown right sided approach.

First right anterolateral thoracotomy is done using submammary crease incision with 4th intercostal space approach. Many advocate first abdominal approach and the thoracic. It is essentially surgeon's choice. But operability can be initially well assessed through thoracotomy approach and then when tumour is above the lower 1/3rd oesophagus. After thoracotomy with rib resections and retraction, cavity is explored for metastases. Tumour is assessed for operability and nodal involvement. Incision is made on the mediastinal pleura. Oesophagus is mobilized with lymph nodes. Oesophageal branches are ligated or clipped and divided. Azgos vein is ligated at its arch level (four ligatures; divided between two ligatures each side). Different lymph nodes are carefully dissected and involved in the specimen. Bronchial artery is safeguarded.

Using upper midline incision laparotomy is done. Left triangular ligament is cut. Phrenooesophageal membrane is incised. Gastrohepatic ligament is divided. Retrooesophageal window is created. Short gastric vessels are ligated. Left gastroepiploic vessels are ligated and divided. Left gastric artery is ligated near its origin. Left gastric vein is ligated separately and divided which is caudal to artery (coronary vein). Nodes at this level are cleared. Right gastric and right gastroepiploic vessels are safeguarded. Gastroepiploic arcade is retained without traumatising it. Kocherisation is done to mobilize the duodenum. Pyloromyotomy is done. Oesophageal hiatus is widened adequately and hiatal dissection is done to communicate towards already dissected thoracic oesophagus.

Cervical dissection is carried out with oblique incision along the anterior border of the sternocleidomastoid muscle. Cosmetic horizontal incision also can be used. Deep fascia is incised. Carotid sheath is identified. Sternomastoid with carotid is retracted laterally. Omohyoid is divided using cautery. Thyroid with trachea is retracted medially using finger as retractor (assistant's finger). Inferior thyroid artery may require to be ligated. Oesophagus is identified by feeling the nasogastric tube inside. Oesophagus is dissected of from the prevertebral fascia using finger dissection. In front care should be taken not injure recurrent laryngeal nerves of both sides while hooking the oesophagus using finger. Oesophagus is slinged with infant feeding tube or umbilical tape or Penrose drain. Dissection is carried towards mediastinum with sharp and blunt methods to reach the thoracic dissection.

Oesophagus is transected 5 cm below the cricopharyngeus muscle using stapler. Specimen is removed through the thoracic cavity after stapling at 2 cm beyond the OG junction along the lesser curvature using stapler. Stapler line in the stomach is oversewn using continuous 3 zero vicryl sutures. Gastric conduit is gently pushed towards neck wound without causing any twist. Oesophageal proximal end is anastomosed to the anterior wall of the stomach with two layer interrupted anastomosis 3-5 cm distal to the tip of the gastric conduit.

Thoracotomy is closed after placing a chest tube. Abdomen is closed. Neck wound is closed with a suction drain.

Postoperative Care

It is same as in other oesophagectomies – chest tube care, nasogastric tube care, and observation for bleeding, leak and sepsis and respiratory problems. Chest tube, drain and nasogastric tubes are removed in 5-7 days.

Complications

Bleeding, leak, thoracic duct injury, gastric conduit problems, recurrent laryngeal injuries, tracheal injury, anastomotic stenosis – can occur.

EN BLOC RESECTION OF OESOPHAGUS (SKINNER, 1983)

It is en bloc resection of oesophageal carcinoma (radical oesophagectomy) with 10 cm proximal and distal clearance with removal of perioesophageal tissues, lymphatics, vessels of the oesophagus, azygos vein, bilateral pleural surfaces, pericardium anteriorly (partial removal), thoracic duct, cuff of the diaphragm, upper mediastinal and abdominal lymphadenectomy.

Laparotomy and right or left (for lower oesophagus) 6th intercostal space thoracotomy is done. Diaphragm is incised in safe area as phrenotomy. Abdominal oesophagus and coeliac nodal areas can be approached by large semilunar diaphragmatic division without doing laparotomy. All retroperitoneal tissues cephalad to pancreas including splenic and hepatic lymph nodes along with gastric nodes are dissected. OG junction is mobilised like usual oesophagectomy. Cuff of the diaphragmatic muscle is included in the oesophageal specimen. After en bloc resection, for lower oesophageal carcinoma, anastomosis is done above the aortic arch level. Thoracic duct is ligated just above the aortic hiatus through which it emerges from the abdomen.

In proximal (middle and upper) tumours, pleura is incised in superior mediastinum in front along the tracheooesophageal groove. Recurrent laryngeal nerves should be preserved. Oesophagus is dissected of the membranous trachea from thoracic inlet to carina. Azygos vein is ligated flush with the superior vena cava. Subcarinal lymph nodes are dissected. Posterior part of the pericardium is exposed. Pericardium is incised from superior pulmonary vein sleeve to inferior pulmonary vein sleeve. Pericardium is incised transversely to remove oval part of it. Bronchooesophageal arteries are ligated. Incision is extended in front of the aorta onto the left pleural cavity. Left pleura incised and included in the specimen.

In lower oesophageal tumour anastomosis is done in thoracic cavity in the pleural space or posterior mediastinum. In upper and middle tumours anastomosis is done in the right or left side of the neck. Approach and technique is similar as mentioned earlier. Neck nodes are cleared usually in en bloc dissection.

Patient often requires blood transfusions.

Postoperative care and complications

Respiratory care, intensive care is needed for 72 hours. Chest tube is removed once fluid quantity reduces less than 100 ml/day. Leak, pneumonia, mediastinitis lymph leak and cardiac arrhythmias are to be anticipated. Usual hospitalisation period is 14 days.

THREE FIELD LYMPHADENECTOMY FOR OESOPHAGEAL CARCINOMA

Forty per cent of upper 1/3rd tumours, 20% of lower 1/3rd tumours involve cervical nodes. Mucosal lesion has got 30% chances of nodal spread; submucosal has 50%; muscularis propria 60%; muscular and perioesophageal involvement has got 80% chances of nodal disease. Commonly nodes along the recurrent laryngeal nerves and behind the internal jugular vein are involved. Supraclavicular nodes

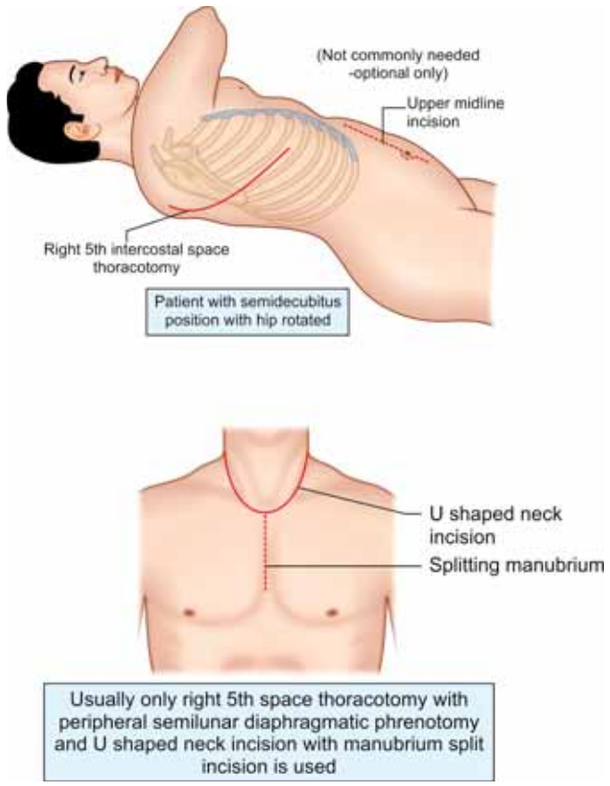

(Not commonly needed -optional only)
Upper midline incision
Right 5th intercostal space thoracotomy
Patient with semidecubitus position with hip rotated
U shaped neck incision
Splitting manubrium
Usually only right 5th space thoracotomy with peripheral semilunar diaphragmatic phrenotomy and U shaped neck incision with manubrium split incision is used

Fig. 19-51: Incision for three field dissection.

when involved has got worse outcome. Its benefit over two field lymphadenectomy is controversial **(Fig. 19-51)**.

Thorax and abdomen can be approached by right 6th space thoracotomy with large semilunar incision over the diaphragm. It is only optional not a mandatory to do laparotomy as once phrenotomy is done, abdomen can be approached comfortably through thorax.

First field - In the abdomen, coeliac, renal, superior mesenteric, hepatic, splenic, gastric nodes are dissected along with the mobilisation of the abdominal oesophagus, and ligation of left gastric and left gastroepiploic vessels retaining gastroepiploic arcade. Parahiatal nodes are also cleared. 2 cm distal to OG junction lesser curve is transected using stapler and stapler line is buried using continuous vicryl/silk seromuscular sutures. Kocherisation, pyloromyotomy is added. Gastric conduit is pushed into the thorax.

Second field - In the chest, posterior mediastinectomy is done to clear perioesophageal nodes, subcarinal nodes, nodes along the main bronchus, thoracic duct and azygos vein. Prevertebral and retrotracheal dissection is done to include further paratracheal nodes. Left recurrent laryngeal nerve is identified near its origin at the level of the aortic arch and dissected towards the neck; right recurrent laryngeal nerve is dissected at a place where it loops around the right subclavian artery with clearing the recurrent nodes adjacent to its superior mediastinal component (even though recurrent nodes are continuous chain nodes along the course recurrent laryngeal nerve in the mediastinum and neck, it is often classified as cervical and superior mediastinal components). Gastric conduit is pushed towards the thoracic inlet to reach neck for cervical oesophagogastric anastomosis.

Third field – U shaped neck incision is made with manubrium split to facilitate lower neck and superior mediastinal nodes properly. Brachiocephalic nodes, nodes lateral and posterior to carotid sheath, supraclavicular nodes and cervical recurrent nodes bilaterally are cleared with this approach **(Fig. 19-52)**.

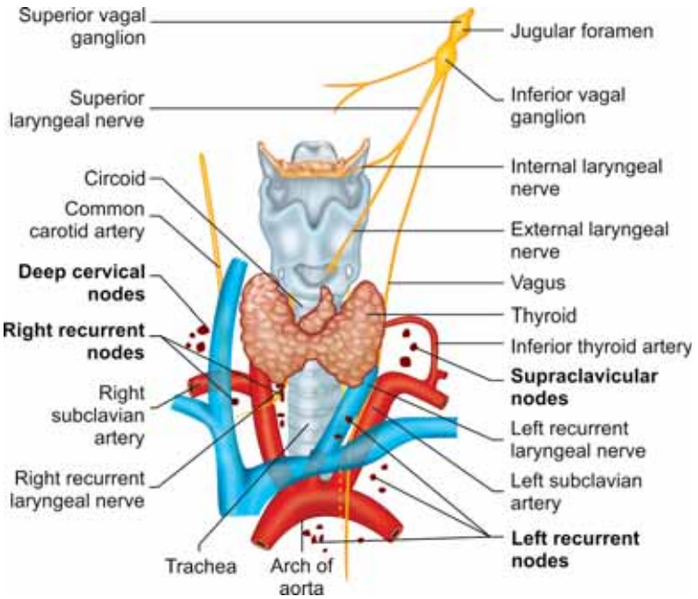


Fig. 19-52: Configuration of neck nodes in 3 field neck node dissection.

Anastomosis is done in the neck. Diaphragm is sutured using nonabsorbable horizontal interrupted mattress sutures often with two layers. Thoracotomy is closed after placing bilateral chest tubes.

Problems

Delayed postoperative recovery, long hospital stay, sepsis, respiratory complications, recurrent laryngeal nerve palsy (10-50%), need for tracheostomy often, leak and lymph ooze are the problems. Mortality is 1-10%.

MINIMALLY INVASIVE SURGERY FOR CARCINOMA OF OESOPHAGUS (VIDEO ASSISTED APPROACHES)

In 1996 DePaula did laparoscopic transhiatal oesophagectomy and reported a series of 48 patients. Later Luketich and Cuschieri described thoracolaparoscopic oesophagectomy.

Procedure is done in different positions. Initially thoracoscopic procedure is done to mobilise the oesophagus and to complete lymphadenectomy in the mediastinum. This is done in lateral decubitus position or in prone position also. Infracarinal and supracarinal lymph nodes are included in the specimen as part of lymphadenectomy – paraoesophageal, bronchopulmonary, subcarinal, tracheobronchial, recurrent and paratracheal nodes are dissected carefully. Later in supine position, laparoscopic mobilisation of the stomach and abdominal oesophagus is done. Gastric conduit is created using endostapler. Gastric tube is pulled into the cervical incision after placing a nasogastric tube into the peritoneal cavity and fixing to gastric conduit through a minilaparotomy. Specimen is removed through the minilaparotomy; gastric conduit is pulled up. Cervical oesophagogastric anastomosis is done.

Laparoscopic and thoracoscopic intrathoracic oesophagogastric anastomosis also can be done in lower oesophageal carcinomas.

Problems and complications are similar to open surgery. *Advantages are* – better visualisation and dissection, avoiding thoracotomy, faster recovery. *Disadvantages are* – technical expertise, learning curve, availability, cost, prolonged anaesthesia.

COMPLICATIONS AFTER OESOPHAGEAL RESECTION

Complications after resection of the oesophagus for carcinoma (commonly) are intraoperative, early or delayed/late (after 30 days) postoperative. It can be major or minor complications.

Intraoperative	*Early*	*Delayed/Late*
Injury to lungs, pericardium Azygos vein bleeding Injury to spleen, coeliac artery Injury to thoracic duct Injury to tracheal membrane	Abdominal bleeding – intraabdominal Gastrointestinal bleeding Respiratory complications like ARDS, pneumonia, collapse of lung Chylothorax, haemothorax, empyema Mediastinitis Cardiac complications Bowel ischaemia, bowel obstruction Anastomotic leak Recurrent laryngeal nerve palsy Subphrenic/ intrathoracic abscess DVT, pulmonary embolism Wound infections	Anastomotic stricture Delayed gastric emptying Internal diaphragmatic herniation through the hiatus

Anastomotic leak

It is the most problematic complication. It is around 14%. Leak may be into the neck wound or into the thorax. Leak into neck wound is safer and is usually resolves by conservative therapy. Leak into the thoracic cavity is life threatening. It needs immediate thoracotomy. Small leak can be closed. Gastric conduit can be drained by placing a T tube. Large leak needs repositioning of the gastric conduit into the abdominal cavity. Temporary oesophageal diversion is done in the neck as oesophagostomy. Later if patient recovers from acute shock and its problems, elective diversion using colon can be done. Leak often may be from the staple line placed along the lesser curvature. It is usually into the thorax. Management is similar to anastomotic leak. Leak also can occur from pyloroplasty or pyloromyotomy. It is usually into the abdominal cavity. It needs redoing of the pyloroplasty through relaparotomy. Site of leak is confirmed by water contrast dye study. Contrast CT is also helpful.

Tracheal membrane tear

Tracheal membrane tear is another complication which is often very difficult to manage with high mortality. Small tear is sutured using nonabsorbable interrupted sutures (polypropylene). Large tear is difficult to tackle. It is managed by anterior mediastinal tracheostomy with resection of clavicle and manubrium and half of first rib (anterior breast plate resection). Supportive pectoralis major muscle flap or intercostal muscle flap is also needed around tracheostomy.

Major complications	*Minor complications*
Anastomotic leak	Atelectasis of lung
Tracheal membrane tear	Problems of feeding jejunostomy
Cardiac complications	Wound infection
Gastric conduit necrosis	Urinary retention
Recurrent laryngeal nerve injury	Paralytic ileus
Delayed gastric emptying	
Respiratory complications	
Chylothorax	
Pancreatitis, mediastinitis, septicaemia	
Intracavitary abscess formation	
Deep vein thrombosis	
Renal failure	

OESOPHAGEAL SUBSTITUTES

Oesophageal substitute is the one which is used as an interposed functioning bowel tube between the proximal normal oesophagus in the neck or thorax and stomach in the abdomen. It can be used after removal of thoracic oesophagus in its entirety or partly ***(oesophageal replacement***); in this type, oesophagus is placed in the same or similar place after oesophagectomy. Or often diseased oesophagus is retained as in advanced carcinoma oesophagus or in adherent multiple strictures which is difficult to dissect safely; in this type it is used as ***oesophageal bypass*** through different routes commonly retrosternal. Usually stomach, colon, jejunum are used. Occasionally local flaps (myocutaneous or free flaps) may be used for cervical oesophagus along with pharynx.

When oesophagus is excluded and gastric conduit is used as bypass, oesophagus should be drained to prevent abscess or mucocele formation or blow out of the distended oesophagus. It is done by doing oesophagojejunostomy or proximal end of the excluded oesophagus is brought out as tube oesophagostomy. If there is a broncho or tracheooesophageal fistula (in malignancy or other causes), then excluded oesophagus can be left alone as fistula drains into the respiratory tract functioning as pseudodiverticulum.

Transposition Routes

Transposition is done through posterior mediastinum (*shortest route*), right pleural space (transpleural), retrosternal or subcutaneous route.

Posterior mediastinal route is ideal if oesophagectomy has been done prior to transposition. Otherwise it is not useful as a bypass route for cancer cases with inoperable tumour or in strictured oesophagus. It has got shortest distant between neck and abdomen.

Transpleural route is easier; but can cause gastric or colonic distension due to negative thoracic pressure. It is often used after thoracic oesophagectomy. It is not ideal for bypass substitute as thoracotomy is required.

Retrosternal route is through anterior mediastinum behind the sternum across its entire length. Length of this route is longer than posterior mediastinal route; but gastric or colonic conduits can be bridged across without any tension in this route. This is commonly used bypass route when oesophagus is not removed. It is anatomically separated from the oesophageal tumour and so bypass conduit will not get involved by tumour. Oesophagus in the neck is mobilsed like other similar procedure. Anterior fibres of the diaphragm are detached from the xiphoid process to access the retrosternal plane. Tunnel is created by passing fingers from below and from above by blunt dissection. It is avascular plane and hence bleeding is not common. Conduit is pushed gently upwards using hand and fingers; instrument pull should

Approaches for Different Level Tumours

Post cricoid tumour (Squamous cell carcinoma):
Treated mainly by radiotherapy. Radical radiotherapy— 5000-6000 rads. Often pharyngolaryngectomy is done along with gastric or colonic transposition. But complications are more in this procedure. Free jejunal transfer is the other option.

Upper third growth (Squamous cell carcinoma):
It is treated mainly by radiotherapy. Commonly it is advanced with left recurrent laryngeal nerve palsy and bronchial invasion. If it is early and operable, *McKeown three phased oesophagectomy* and anastomosis is done in the neck. Initially thoracotomy through right 5th space is done and oesophagus is mobilised. Then laparotomy is done to mobilise the stomach. Through right side neck approach, oesophagus with growth is removed. Anastomosis between pharynx and stomach is done in the neck.

Split sternum approach oesophagectomy is also practiced.

Middle third growth (Squamous cell carcinoma):
Ivor Lewis operation (Lewis-Tanner two-phased oesophagectomy): After laparotomy stomach is mobilised. Pyloroplasty is done. Through right 5th space thoracotomy is done and growth with tumour is mobilised. Partial oesophagectomy and oesophagogastric anastomosis is done in the thorax. Intercostal tube drainage is placed during closure. Right gastroepiploic vessels/epiploic arcade should be retained safely (essential). Azygos vein should be ligated securely. Mediastinal nodes should be dissected. Thoracic duct should be ligated if needed just above the aortic hiatus where it enters the thorax. Feeding jejunostomy is better to maintain nutrition. If the growth is inoperable, palliative radiotherapy is given.

Lower third growth (Squamous cell carcinoma + adenocarcinoma):
Here through left thoracoabdominal approach, partial oesophagogastrectomy is done with oesophagogastric anastomosis. Often jejunal Roux-en-Y loop anastomosis is done. *Orringer approach*, i.e. *transhiatal blind/ blunt total oesophagectomy* with anastomosis in the left side of the neck. Through laparotomy, stomach and lower part of the oesophagus are mobilised. Through left sided neck approach, upper part of the oesophagus is mobilised using finger. Blind dissection is completed by meeting both fingers above and below in the thorax. Later oesophagus is pulled up out above through the neck wound and removed. Continuity is maintained in the neck. It is a *palliative* surgery.

Other Approaches

Thoracoscopic-laparoscopic oesophagectomy and lymphadenectomy is becoming popular, safer and effective.

Radical oesophagectomy with 3-field clearance of abdominal/ thoracic and cervical nodes is also practiced in many centers. 3-Field clearance (coeliac, thoracic and neck) is done for mainly squamous cell carcinoma as spread here is upwards. In adenocarcinoma 2-field clearance is sufficient (abdominal—coeliac and thoracic) as spread is downwards.

Skinner en bloc resection used to be of practice in olden days in which tumour with oesophagus is resected along with thoracic duct, azygos vein, intercostal vessels crossing the vertebral bodies, pericardium and mediastinal pleura. There is no survival benefit with this procedure.

Vagal sparing oesophagectomy with HSV is tried to preserve pylorus functioning avoiding pyloroplasty to reduce the chances of postprandial fullness. But it is technically tedious.

Lymphadenectomy in carcinoma oesophagus: *Standard*: Nodes removed are—paratracheal, parabronchial, carinal, paraoesophageal, posterior mediastinal, paracardial, left gastric, along lesser curve of stomach. *Extended/three field/ultraradical*: As like standard above, with bilateral cervical lymphadenectomy, removal of upper mediastinal, coeliac, retroperitoneal, subhepatic nodes is done.

be avoided as it will damage the conduit. Often head of the clavicle, first rib and part of the manubrium is removed to widen the thoracic inlet. This reduces the compression over the conduit and maintains its blood supply optimally.

Subcutaneous route is done when all other routes are not possible to utilise. If patient has undergone prior open cardiac surgery then retrosternal route is not possible and subcutaneous route is used. It is technically easier but lengthier conduit is needed. It is antesternal route. Anastomosis takes up well; but conduit is visible on the chest wall **(Fig. 19-53)**.

Stomach (Gastric Conduit)

It is preferred one and is based on right gastric and right gastroepiploic arteries. It is the most commonly used oesophageal substitute at present. It needs only one anastomosis and take up is well due to good vascularity. But it can cause postprandial fullness with bile or acid regurgitation (> 50%). It also needs a pyloromyotomy/pyloroplasty for gastric drainage as vagotomy is done to prevent delayed gastric emptying. Entire stomach or tubed part or reverse tubed part can be transposed. Stomach has got lengthier gastroepiploic arcade closer to greater curvature which straightens when stomach becomes straight; it does not kink when moved/transposed unlike colon or jejunum (here fan-shaped mesentery kinks and get tensed when transposed). Colon after years gets dilated and becomes redundant leading into stasis improper emptying. Prior gastrostomy is not a contraindication for using stomach as conduit; gastrostomy feeding more with fluid dilates the stomach significantly making it as a better conduit. Site of the gastrostomy even though is not very important but preferred to place towards lesser curve side. Presence of gastric outlet obstruction or gastric resection or previous gastrojejunostomy makes it a relative *contraindication* for preparing it as a suitable conduit.

For bypass in an advanced carcinoma entire stomach is used without making tubes. Here OG junction is transected and entire stomach is mobilised as usual with retaining the gastroepiploic arcade with its blood supply from right gastroepiploic artery. Kocherisation, pyloromyotomy, ligation of left gastric and left gastroepiploic pedicle and short gastric vessels are done. Mobilised stomach is pushed upwards towards neck for anastomosis with the cervical oesophagus. **(Fig. 19-54)**

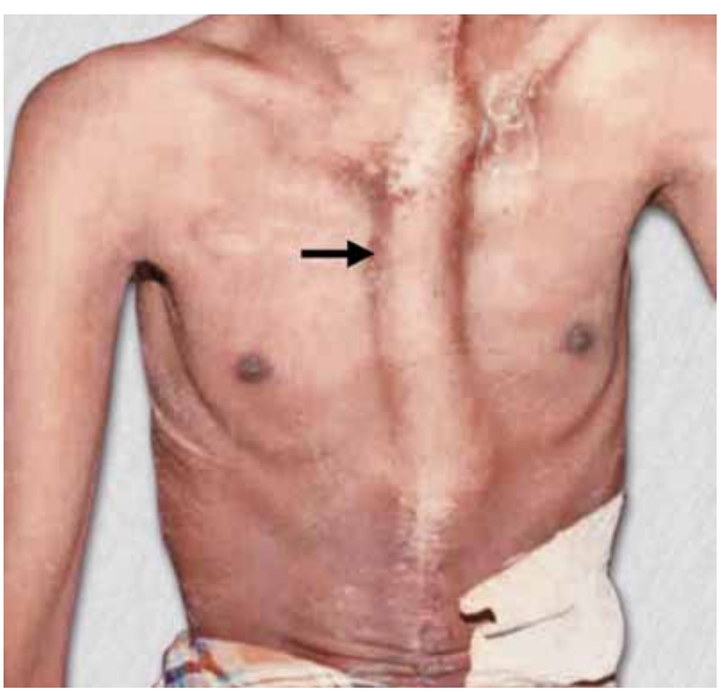


Fig. 19-53: Subcutaneous route - colon transposition.

For replacement tubed stomach is commonly used. It may be reversed gastric tube based on left gastroepiploic artery or non–reversed gastric tube based on right gastroepiploic artery. Greater omentum is dissected of from the transverse colon and from both flexures. Middle colic artery should be safeguarded. Short gastric vessels are ligated and divided. Splenectomy is usually not necessary. Left gastric vessels are ligated. OG junction is mobilised.

In reversed gastric tube, right gastroepiploic artery is ligated 4 cm from the pylorus. Double row stapling along the greater curvature at this point is applied transversely for 2.5 cm. Proximal stapling row is held and few staples adjacent to greater curvature is removed and 40 French rubber catheter is passed through this proximally along the greater curvature up to the fundus. Multiple staplers are fired parallel to the tube towards the fundus to create reversed gastric tube. Staple line is oversewn using continuous 3 zero silk sutures to bury the staple line. Tube placed should be loosely accommodated there. Omentum is wrapped around the gastric tube. Tube based on the left gastroepiploic artery is tunneled through posterior mediastinum if oesophagectomy is undertaken; otherwise under the xiphoid through retrosternal space if oesophagus is not removed (as bypass, where entire stomach is used without tube usually) and anastomosed in the neck to cervical oesophagus **(Fig. 19-55)**.

In nonreversed gastric tube, right gastroepiploic artery is used as base; here left gastroepiploic vessels, short gastric vessels and left gastric vessels are ligated. Pyloromyotomy is done; extended Kocherisation is needed. Circular stapler is fired 4 cm proximal to the pylorus to facilitate the passage of the consecutive series of stapler lines until the outer aspect of the fundus to create 2.5 cm diameter vascularised tube based on right gastroepiploic artery. Staple line is inverted with continuous seromuscular sutures. Omentum is wrapped around the gastric tube **(Fig. 19-56)**.

Advantages of gastric conduit – adequate length is available; good blood supply; good anastomotic take up; easier to mobilise.

Disadvantages of gastric conduit – need for pyloromyotomy/pyloroplasty; gastric conduit tip necrosis; anastomotic stricture; delayed gastric emptying.

Colon

Technique is more with the need of three anastomoses. Right colon is used with middle colic artery based as antiperistaltic loop. Left colon is used with ascending branch of left colic artery as isoperistaltic loop. Postprandial problems are les in colonic conduit compared to stomach. Colon is used as right/left/transverse segment depending on need and vasculature and preference. It can be isoperistaltic or antiperistaltic. When a short segment of colon is used it is called as *short segment colon in interposition (probably used in as pridge gap in localised)* benign diseases); total or subtotal oesophageal replacement is called as *long segment colon interposition* (in multiple strictures, carcinoma oesophagus). Colon behaves more or less as a passive conduit **(Fig. 19-57)**.

Colon functions as a passive conduit and empties much slower than oesophagus. Motility of the colon is of three types – *right sided retrograde annular contractions* which helps in fluid and electrolyte absorption; *annular contractions* of the transverse and descending

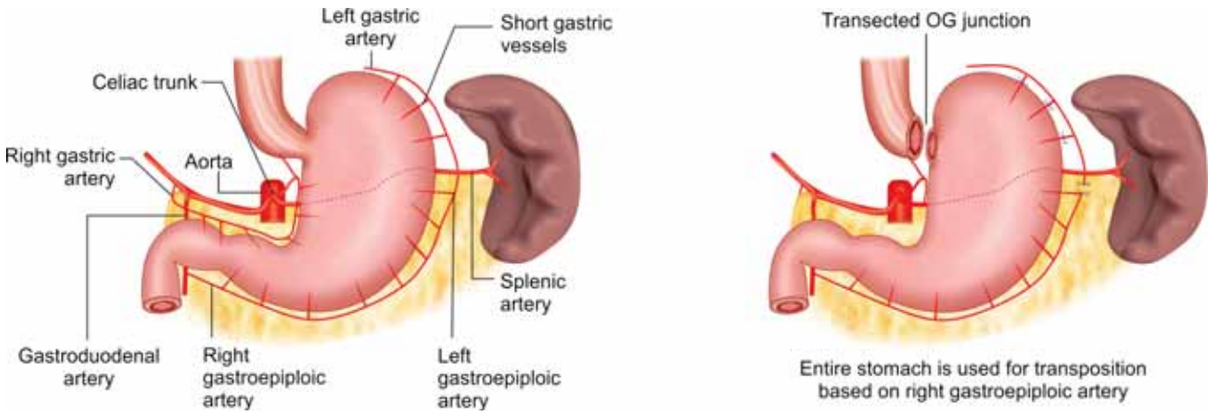


Fig. 19-54: Gastric conduit using entire stomach.

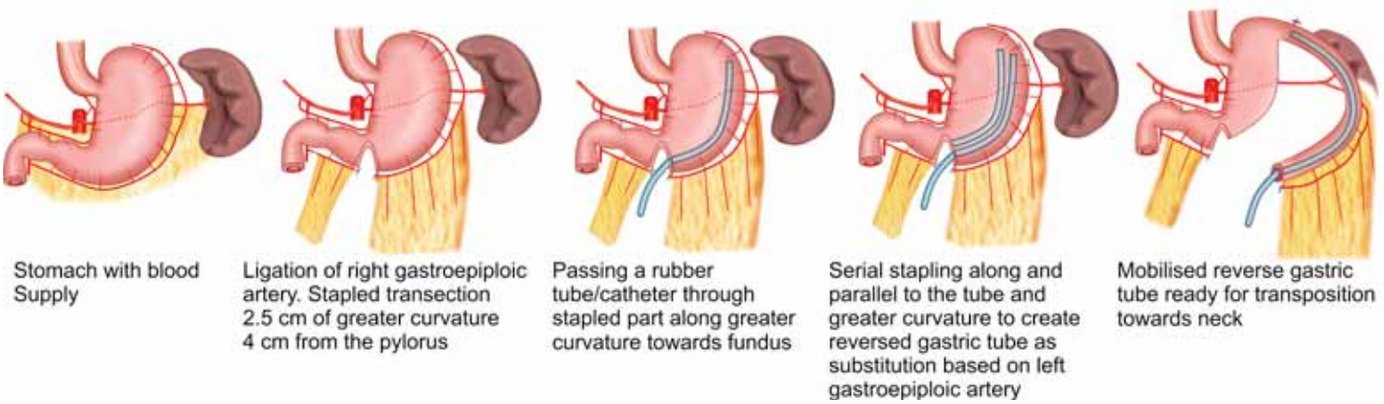

Stomach with blood Supply
Ligation of right gastroepiploic artery. Stapled transection 2.5 cm of greater curvature 4 cm from the pylorus
Passing a rubber tube/catheter through stapled part along greater curvature towards fundus
Serial stapling along and parallel to the tube and greater curvature to create reversed gastric tube as substitution based on left gastroepiploic artery
Mobilised reverse gastric tube ready for transposition towards neck

Fig. 19-55: Gastric conduit – reversed type.

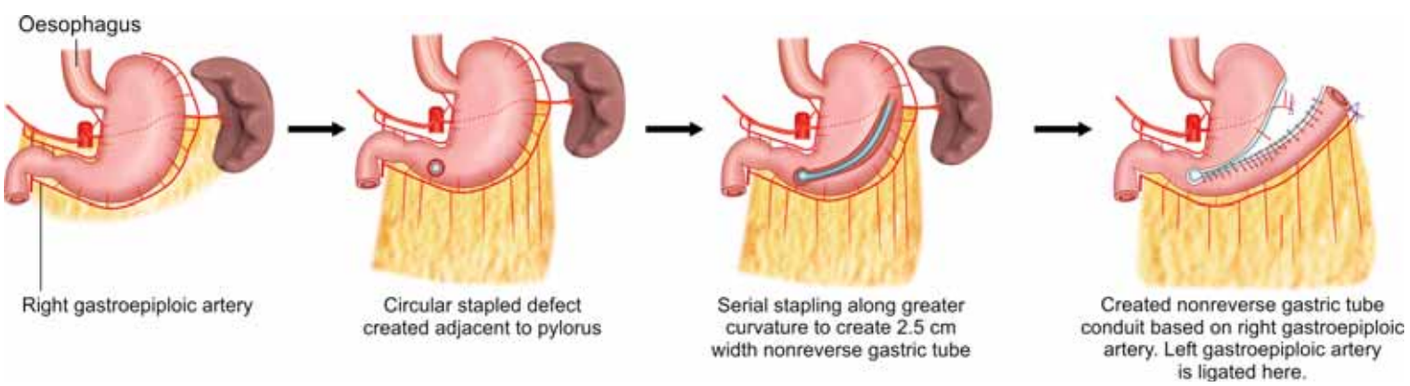

Oesophagus
Right gastroepiploic artery
Circular stapled defect created adjacent to pylorus
Serial stapling along greater curvature to create 2.5 cm width nonreverse gastric tube
Created nonreverse gastric tube conduit based on right gastroepiploic artery. Left gastroepiploic artery is ligated here.

Fig. 19-56: Gastric conduit – nonreversed type.

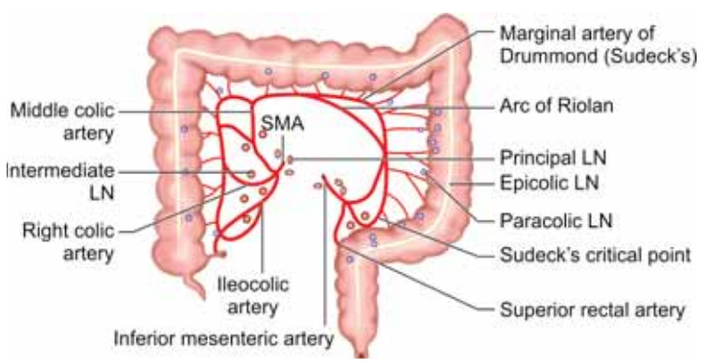


Fig. 19-57: Blood supply of colon.

colon which slowly propels faeces into the rectum; *strong propulsive contractions* of the distal colon into the rectum. So right side can be used as antiperistaltic; left side can be used as isoperistaltic. Arterial supply of the colon and venous drainage makes it more proficient to use as conduit for oesophagus. Ileocolic, right colic, middle colic (branches of superior mesenteric artery) and left colic artery and sigmoid branches supply the colon. Marginal artery connects branches of superior mesenteric and inferior mesenteric arteries. Marginal artery may be absent in 2% of individuals. Right colic artery may be absent in 12%; middle colic in 4% cases. Right (8%) and middle colic arteries (6%) or both (0.5%) may be multiple often. Atherosclerosis of the inferior mesenteric artery makes marginal artery poorer and

unsuitable for colonic conduit. There is no marginal vein on the right side colon and it is said that anastomotic leak in 25% of right sided colonic conduit substitute is due to venous congestion rather than arterial. More commonly preferred one is left side colon. *Reasons are* – smaller diameter of left colon matches relatively to oesophagus; constant and reliable blood supply of the left side colon; ability to propel solid content – make left colon is the first option. Right side colon is used as a reserve if left side colon is not available or cannot be used.

Indications – Colon is used when stomach is not available or not suitable for replacement. It can be used as bypass in advanced carcinoma oesophagus. It is useful in multiple oesophageal strictures, oesophageal atresia if stomach is not adequate for replacement. It is also used in patients for resurgery with failed gastric conduits of any reasons.

Contraindications – Primary colonic disease; inadequate blood supply to the colon; short/fibrosed colonic mesentery. Prior colonoscopy may be a need.

Technique – Adequate large bowel reparation is needed. For replacement it can be combined with the oesophagectomy and same upper midline incision is used. Colon is mobilised adequately. Both flexures, colonic mesentery are mobilised. Colonic arterial arcade is inspected by transillumination. Integrity of colonic mesentery and length of the colon is assessed. Marker stitches are placed at the proposed line of the colonic resection.

For left sided isoperistaltic colonic conduit, descending branch of left colonic artery which is communicating into the sigmoid arteries is ligated away from the main left colic trunk. Length of the colon needed for transposition is measured using umbilical tape. Atraumatic clamps are applied to the marginal artery right of the left branch of the middle colic artery and middle colic artery itself. If left side colon maintains adequate blood supply which is confirmed by fluorescein angiography and Wood's light examination, marginal branch at right of the left branch of middle colic artery and left branch of middle colic artery are ligated **(Fig. 19-58)**.

Now left side colon is exclusively supplied by the left colic artery. Colon is transected at proposed level with retaining the marginal arterial arcade and left colic artery. Right side part of the conduit is passed behind the colon and stomach; then across the thorax by suitable decided route to reach the neck. If only bypass is done without prior oesophagectomy, similar neck incision is done to reach the oesophagus. Oesophagus is transected and anastomosed to the colonic conduit at proximal right side colon. Proximal cut end of the oesophagus is anastomosed to side of the colon in the neck as end to side. Distal part of the left side end of the colonic conduit is anastomosed to the posterior surface of the stomach as end to side (end of the colon to side of posterior wall of the stomach). Posterior surface of the stomach acts as antireflux support. Anastomosis can also be done on the anterior surface of the stomach. Vertical gastrotomy is done for anastomosis. Colonic continuity is maintained by colocolic anastomosis. Feeding jejunostomy is usually done.

In right sided antiperistaltic colonic transposition, right colon is made to perfuse by middle colic artery. After deciding the line of and length of the needed right sided colon, atraumatic clamps are placed on to the marginal arteries, ileocolic, right colic, terminal ileal vessels to confirm the adequacy of perfusion of the proposed conduit through the middle colic artery. Once perfusion is confirmed, these vessels are ligated, middle colic artery is safely and carefully retained to maintain the perfusion. Isolated colon is transected distally terminal ileum 10 cm proximal to ileocaecal junction is transected proximally. Appendicectomy is done. Ileum with caecal end is transposed towards the neck with specified route. Length required is 4 cm more if route used other than posterior mediastinum especially retrosternal or subcutaneous **(Fig. 19-59)**.

Now many advocate transection at caecal level retaining the ileum. Ileotransverse anastomosis is done to maintain the bowel continuity. Oesophagoileal/colic anastomosis is done in the neck between the end of the oesophagus to side of the colon/ileum. Below colon is anastomosed behind or front of the stomach.

Problems with colon substitute

Preoperative preparation of colon is more complex and demanding. Multiple anastomoses (3) are required; it is more risky as far as colon is considered. Necrosis and leak is potentially life threatening in colon. Colon has got poor acid resistance unlike jejunum. Tendency to dilate gradually and causing redundancy is a problem. Extremely slow emptying time is another problem. Food is retained in the colon conduit for long time without emptying into the stomach.

Complications

Complications of colonic substitute depends on the length of the segment and indication for colonic substitute. Complications

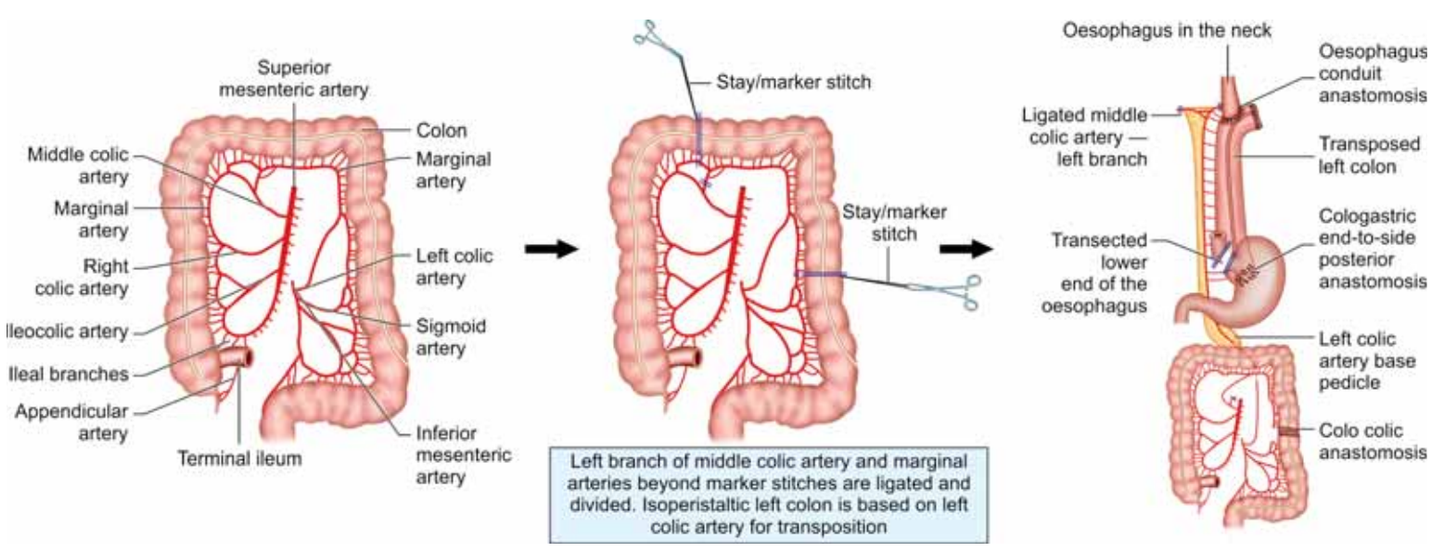

Superior mesenteric artery
Middle colic artery
Marginal artery
Right colic artery
Ileocolic artery
Ileal branches
Appendicular artery
Terminal ileum
Colon
Marginal artery
Left colic artery
Sigmoid artery
Inferior mesenteric artery
Stay/marker stitch
Stay/marker stitch
Left branch of middle colic artery and marginal arteries beyond marker stitches are ligated and divided. Isoperistaltic left colon is based on left colic artery for transposition
Oesophagus in the neck
Oesophagus conduit anastomosis
Ligated middle colic artery — left branch
Transposed left colon
Transected lower end of the oesophagus
Cologastric end-to-side posterior anastomosis
Left colic artery base pedicle
Colo colic anastomosis

Fig. 19-58: Left sided colon transposition.

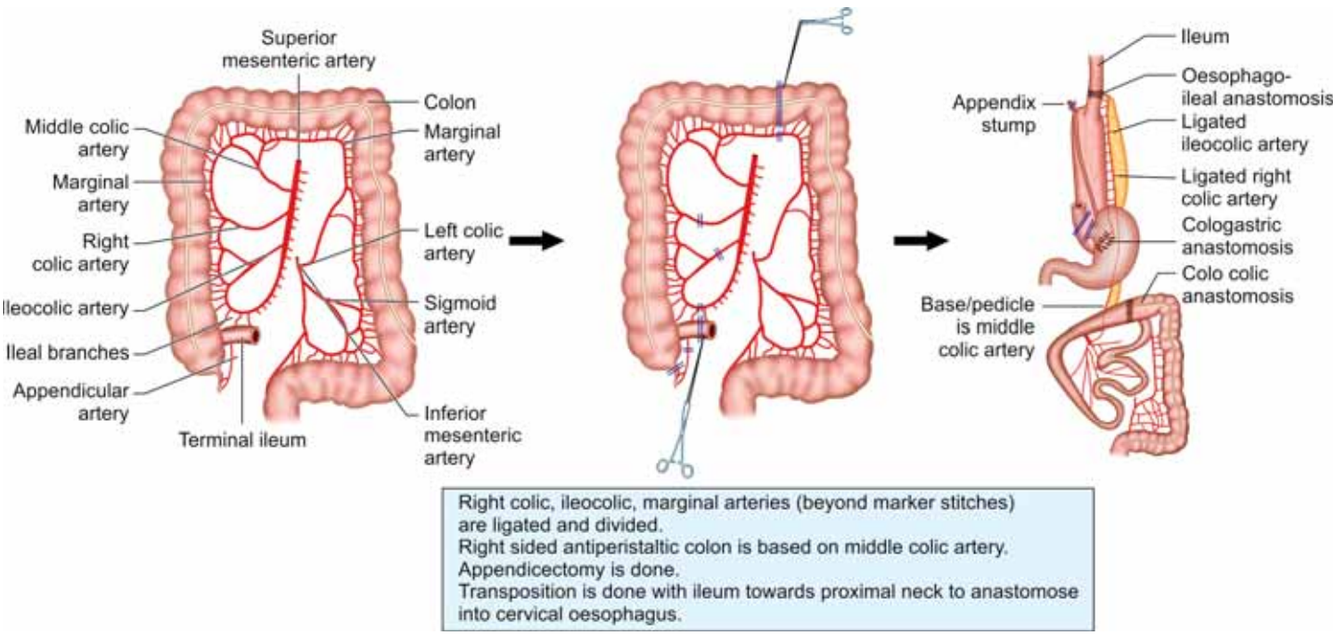


Fig. 19-59: Right sided colon transposition.

may be mechanical or functional. It may be immediate, late and long term. Immediate complications are anastomotic disruption, leak, septicaemia, empyema, and mediastinitis. Late and long term complications are many. They are - transhiatal herniation, colocutaneous/colobronchial fistulas, stricture at oesohagogastric or oesophagocolic sites, pouching effects of the localised part or entire colonic conduit causing redundancy at cervical or thoracic inlet or supraaortic or supradiaphragmatic or infradiaphragmatic portions of the conduit leading into mechanical delay in emptying; cologastric adenocarcinoma; peptic ulceration of the redundant colon and bleeding. Many of these complications need revision surgeries but with poor results.

Jejunum

Isolated required length of pedicled jejunum is transposed. Jejunal free transfer is also tried; vessels are sutured to internal mammary vessels or to the vessels available in the neck (linguofacial trunk or superior thyroid artery). Pedicled jejunum is also *supercharged (boosting)* with microvascular anastomoses with internal mammary vessels. It is used as a last option even though it is ideal. Segment of the 2nd/3rd/4th loop of the jejunum (distal to ligament of Treitz) is harvested with its mesenteric arcade to transplant in the neck with microvascular anastomosis. Jejunum caliber approximates proximal oesophagus. Free jejunal transfer can be used as isolated reconstructive flap for pharyngooesophagus. Function of the remaining large part of the small bowel is not disturbed. Segment of the jejunum should be supplied by a single vascular arcade of adequate dimension. Anastomosis is done proximally to pharynx and distally to oesophagus with microvascular anastomosis. Jejunum retains its effective peristalsis when transposed. Jejunal mesentery limits pedicled transfer of the jejunum; it can reach only up to the inferior pulmonary vein. Free jejunal transfer is ideal and suitable. Pedicled jejunum can be transplanted for 20 cm length; can be increased by supercharging. Otherwise free transfer is the only possibility. Pyloromyotomy is required; gastrostomy is done in case of pedicled jejunal transfer to lower oesophagus. Approach for pedicled jejunal transfer to lower oesophagus is by left sided thoracoabdominal.

Recipient vessels are evaluated for diameter, patency, length, flow and associated vein by CT/MR angiogram. Linguofacial trunk or superior thyroid artery is used. Arterial anastomosis is done superficial to hypoglossal nerve. External jugular vein or tributary of internal jugular vein is used as recipient vein. Anastomosis is done using interrupted or continuous 9 zero polypropylene sutures using microscopy. Tension should be avoided in vascular anastomosis site.

Other Substitutes Used

Radial forearm free flap based at radial artery is used similarly using microvascular anastomosis. Lateral thigh free flap is also often used based on 3rd perforator of the profunda femoris artery along with the accompanied vein. These are mainly used to reconstruct pharyngooesophagus in the neck with microvascular anastomosis.

CRICOPHARYNGEAL MYOTOMY WITH PHARYNGEAL DIVERTICULECTOMY (REFER ALSO CHAPTER 14 - SURGERY OF FACE, HEAD AND NECK)

It is done in pharyngeal diverticulum. It is usually towards left side. If diverticulum is less than 3 cm, just myotomy is sufficient. If it is more than 3 cm then diverticulectomy is needed. *Belsey diverticulopexy* with fixing the most dependent portion of the diverticulum to the prevertebral fascia of upper cervical region with nonabsorbable interrupted sutures is often done; but not very acceptable. Anatomical upper sphincter cricopharyngeus muscle is 2.5 cm in length but physiologic upper oesophageal sphincter is 4 cm in length. So myotomy should be more than 4 cm extending beyond the anatomic cricopharyngeus proximally (2 cm) **(Figs 19-60 and 19-61)**.

Incision

Under general anaesthesia with nasogastric tube in place left lower horizontal or oblique incision along the inner margin of the sternocleidomastoid muscle is used **(Fig. 19-62)**.

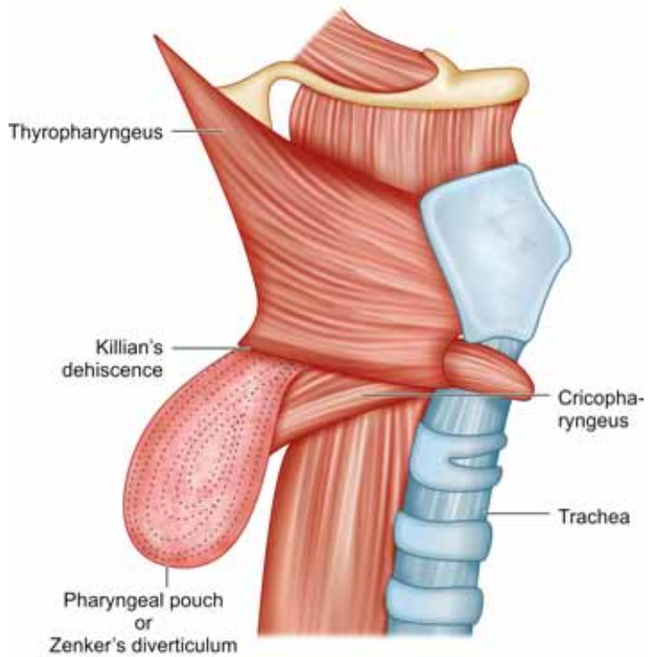


Fig. 19-60: Anatomy of pharyngeal pouch.

Fig. 19-61: Contrast X-ray look of oesophagus in pharyngeal pouch.

Dissection

Skin, platysma, deep fascia is incised; sternocleidomastoid muscle is retracted; omohyoid muscle is divided; carotid sheath is retracted laterally; strap muscles are retracted medially along with thyroid gland. Middle thyroid vein is ligated. Inferior thyroid artery is ligated; recurrent laryngeal nerve is identified and safeguarded which is in front of the diverticulum. Diverticulum is identified between inferior constrictor of the pharynx (thyropharyngeus) and cricopharyngeus

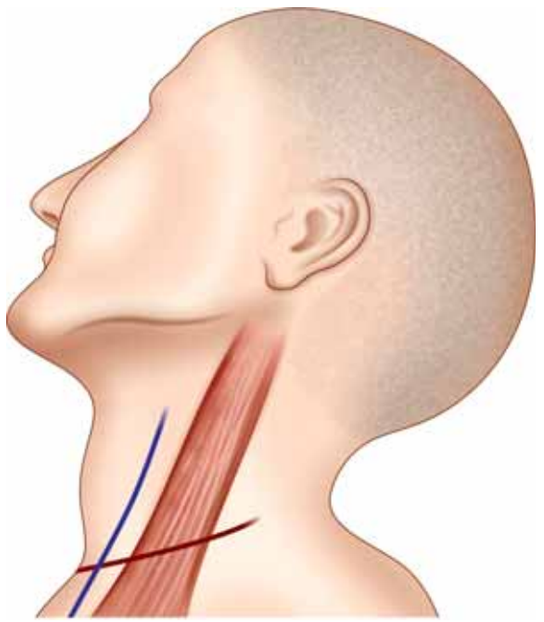


Fig. 19-62: Incision for excision of pharyngeal pouch.

(Killian's dehiscence). Fundus of the diverticulum is held with Babcock's forceps and diverticulum is dissected from surrounding tissues using peanut blunt dissection and scissor and bipolar cautery. Care should be taken not to injure recurrent laryngeal nerve and oesophageal mucosa.

Myotomy

Right angled haemostat/clamp is passed between the mucosa and transverse fibres of the cricopharyngeus without opening the mucosa. Instrument is elevated and fibres are incised for 5 cm below; later similarly upper fibres are also incised for few (2-3) cm **(Fig. 19-63)**.

Diverticulectomy

40 French Maloney's bougie is passed through the mouth into the oesophagus to identify the neck and opening of the diverticulum. Diverticulum is transected using 30 or 55 mm TA stapler. It also can be transected and hand suturing can be done using inner interrupted 3 zero vicryl and outer interrupted 3 zero silk sutures.

Drain is placed; wound is closed in layers. Maloney's bougie is removed. Nasogastric tube is kept for 48 hours and removed. Soft diet is started. Drain is removed in 4 days.

Complications

Leak from sutured site; infection; abscess formation; stricture formation. Complications like fistula formation, empyema, pneumonia and mediastinitis can occur whenever there is dense adhesion, sepsis, and large diverticulum extending into the thorax.

MANAGEMENT OF OESOPHAGEAL PERFORATION

Oesophageal perforation may be due to instrumentation or vomiting induced like Boerhaave's syndrome or postoperative leak. For cervical

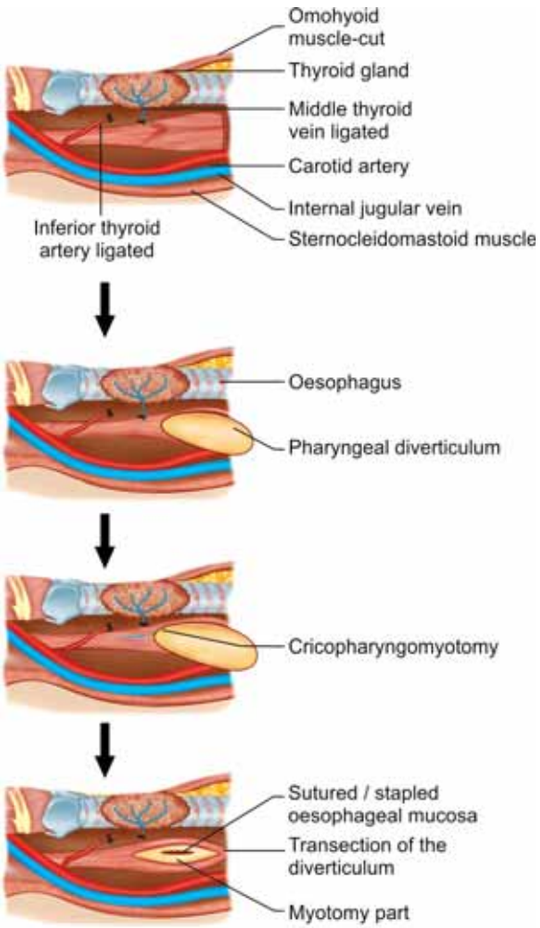


Fig. 19-63: Surgical technique for pharyngeal pouch.

oesophageal perforation lateral film with neck extension X-ray is taken. Contrast CT scan is diagnostic. Patient needs higher generation antibiotics, nasogastric tube at proximal part, intercostal tube, blood, CVP line, urinary cauterization.

Perforation may be bigger than what is thought of usually. Large perforation is difficult to close and in such situation, muscle or pleural or pericardial flap is needed to cover the defect. Resection and diversion to exclude the thoracic oesophagus are other options.

Right or left thoracotomy is done depending on the location of the perforation upper or lower part. Perforation may be clearly seen or may not be clear. In such situation, instillation of air or methylene blue per orally into the oesophagus by anaesthetist will help to identify the site of perforation. Often there will be necrotic material, sepsis, pus due to severe mediastinal infection.

In early cases (within 8 hours), perforation can be still closed in layers – inner mucosal interrupted 3 zero vicryl; outer muscular 3 zero silk sutures. Pleural flap from adjacent is elevated, covered over the suture line and sutured beyond using interrupted nonabsorbable sutures. Stapler closure can be tried but it is often difficult.

Perforation after 8 hours will have marked inflammatory oedema and is often difficult to close the defect with sutures. Here direct pleural flap or intercostal muscle flap is raised and covered over the defect directly. *Rectangular pleura flap* is dissected and raised from behind forward with base in front; elevated pleura is wrapped around the perforation fully and sutured to the oesophageal mucosa in depth using multiple interrupted 3 zero nonabsorbable sutures. *In intercostal muscle flap*, adjacent intercostal muscle is elevated from inside posteriorly adjacent to aorta with intact blood supply with its base at medial end; this vascularised flap is conveniently rotated forward encircling as a wrap around the perforated oesophagus and is sutured **(Figs 19-64 to 19-67)**.

Oesophagus is often *excluded/diverted* by doing cervical proximal oesophagostomy. *Cervical oesophagostomy* is done through left side neck incision along the anterior border of the sternomastoid. Mobilisation is done same as mentioned above. Sternocleidomastoid muscle is retracted outward after opening the deep fascia; omohyoid muscle is cut; carotid sheath is retraced laterally; thyroid and trachea is retracted medially using assistant's finger; recurrent laryngeal nerve is safeguarded (both sides). Middle thyroid vein and inferior thyroid artery if needed is ligated and divided. Prevertebral fascia is dissected to encircle the oesophagus by sharp and blunt dissection. Oesophagus is slinged using infant feeding tube or umbilical tape; significant length is mobilised both proximally and distally to prevent tension after doing oesophagostomy. Oesophagus with sling is brought out towards the middle of the wound. Sternocleidomastoid muscle and deep fascia are sutured using 3 zero vicryl. Platysma and skin is sutured in the wound leaving middle of about 4 cm length for oesophagostomy. Transverse incision on the half circumference of the brought out oesophagus is done; one should confirm that there is no tension. Partially opened up cervical oesophagus is sutured to skin using interrupted subcuticular 3 zero absorbable sutures.

Decortication of the lung with removal of both parietal and visceral pleura allows adequate lung expansion.

Two intercostal tubes are placed in the space on adjacent to the perforation site; other in the intercostal space itself.

Postoperatively patient needs ventilator support, antibiotics, total parenteral nutrition, jejunostomy feed and critical care management.

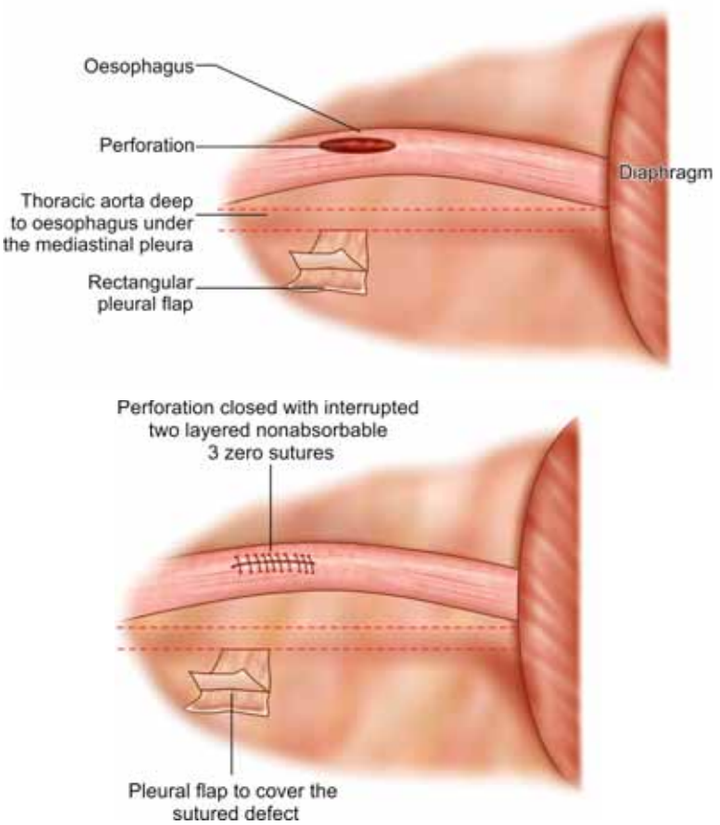

Oesophagus
Perforation
Diaphragm
Thoracic aorta deep to oesophagus under the mediastinal pleura
Rectangular pleural flap
Perforation closed with interrupted two layered nonabsorbable 3 zero sutures
Pleural flap to cover the sutured defect

Fig. 19-64: Primary closure of oesophageal perforation with pleural flap switch.

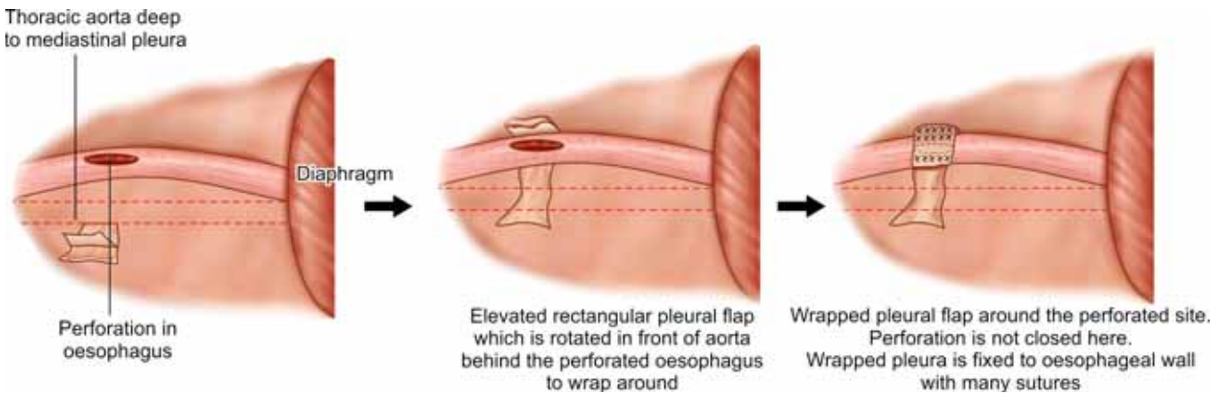

Thoracic aorta deep to mediastinal pleura
Diaphragm
Perforation in oesophagus
Elevated rectangular pleural flap which is rotated in front of aorta behind the perforated oesophagus to wrap around
Wrapped pleural flap around the perforated site. Perforation is not closed here. Wrapped pleura is fixed to oesophageal wall with many sutures

Fig. 19-65: Oesophageal perforation is not closed here; instead rectangular pleural flap is mobilised to cover the defect and suture on the oesophageal wall away from the perforation defect.

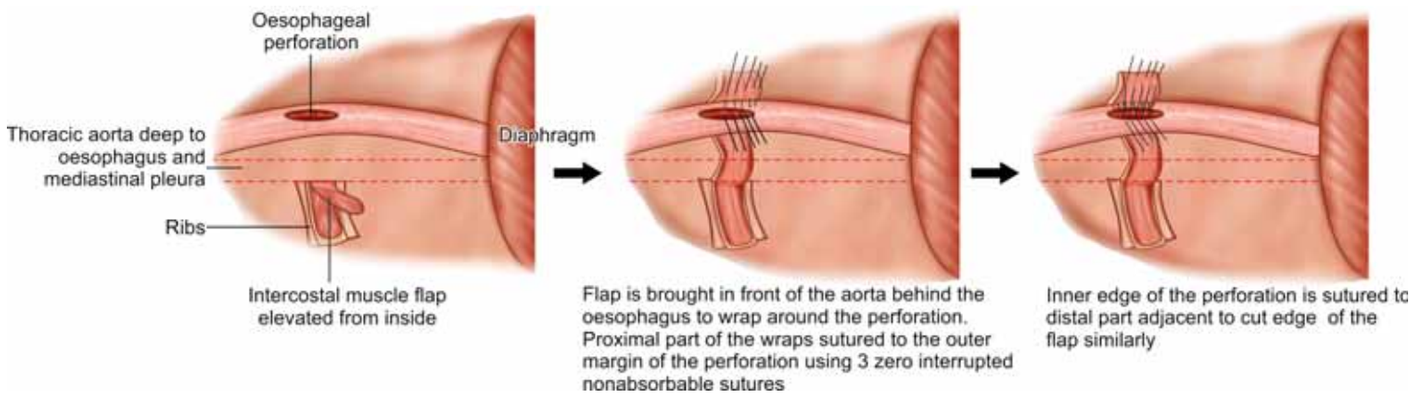

Oesophageal perforation
Thoracic aorta deep to oesophagus and mediastinal pleura
Diaphragm
Ribs
Intercostal muscle flap elevated from inside
Flap is brought in front of the aorta behind the oesophagus to wrap around the perforation. Proximal part of the wraps sutured to the outer margin of the perforation using 3 zero interrupted nonabsorbable sutures
Inner edge of the perforation is sutured to distal part adjacent to cut edge of the flap similarly

Fig. 19-66: Closure of the oesophageal perforation with intercostal muscle flap.

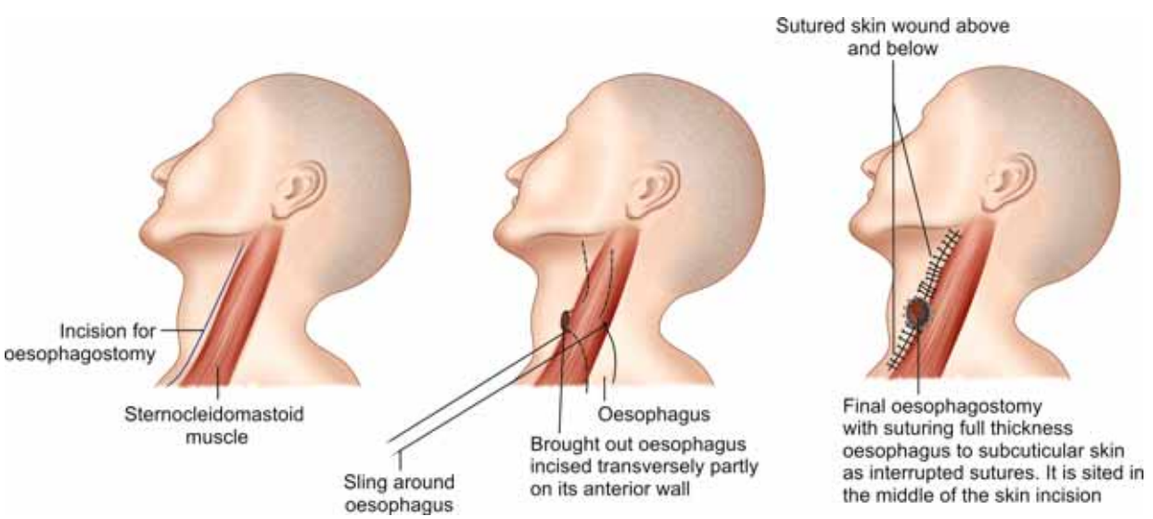

Sutured skin wound above and below
Incision for oesophagostomy
Sternocleidomastoid muscle
Sling around oesophagus
Oesophagus
Brought out oesophagus incised transversely partly on its anterior wall
Final oesophagostomy with suturing full thickness oesophagus to subcuticular skin as interrupted sutures. It is sited in the middle of the skin incision

Fig. 19-67: Cervical oesophagostomy for severe oesophageal perforation.

Condition has got high mortality. Other complications are empyema, mediastinitis, septicaemia, subphrenic abscess, respiratory failure and acute renal failure. Repeat CT chest, blood or blood product transfusions, monitoring by reassessing the patient with biochemical analysis is needed.

INTUBATION SURGERIES FOR ADVANCED CARCINOMA OF OESOPHAGUS

Intubation of oesophagus across the growth was practiced earlier as a palliative technique to relieve dysphagia is no longer commonly

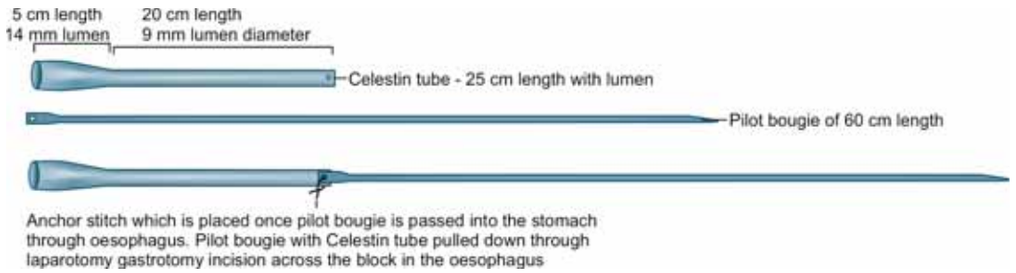

5 cm length
14 mm lumen
20 cm length
9 mm lumen diameter
Celestin tube - 25 cm length with lumen
Pilot bougie of 60 cm length
Anchor stitch which is placed once pilot bougie is passed into the stomach through oesophagus. Pilot bougie with Celestin tube pulled down through laparotomy gastrotomy incision across the block in the oesophagus

Fig. 19-68: Celestin tube used for oesophageal intubation.

done. It is a surgical legacy. Atkinson tube, Celestin tube, Souttar tube, Mousseau-Barbin tube were used. Now endoscopic self-expanding metal stents (SEMS) are commonly used and ideal.

Celestin tube (armoured tube with a long tail) — It is a flexible polythene tube which is wider proximally with a barrel shaped funnel. It is 25 cm in length. It is 9 and 14 mm in diameter at luminal level. It is oval on cross section. There is a fine pilot bougie of 60 cm length made up of solid polythene. It is passed through endoscopy and laparotomy. Through an oesophagoscope pilot tube is passed across the growth into the stomach; oesophagoscope is removed; Celestin tube is anchored after plugging into the proximal end of the pilot bougie using a stitch through holes in both. Mini upper midline laparotomy is done. Anterior gastrotomy is done on the proximal part of the anterior wall of the stomach; end of the pilot bougie is identified and withdrawn through gastrotomy wound to pull down the anchored Celestin tube until proximal funnel impacts against the narrowed segment of the oesophagus. Excess end in the stomach is trimmed. Gastrotomy and laparotomy is closed. It is traction tube **(Fig. 19-68)**.

Souttar tube (coiled German silver wire)—Block is first dilated with bougies; tube is passed over small sized bougie and pushed across the block. It is mainly useful for lower oesophagus. Its introduction does not require laparotomy. It is a pulsion tube.

Mousseau-Barbin tube—Cheaper but needs laparotomy. After laparotomy anterior wall of the stomach is opened.

MB tube is passed from mouth with the help of anaesthetist by stitching its tip to nasogastric tube and pulled down into the stomach. Tip is cut near the cone part. It is sutured to anterior wall of the stomach. Gastrotomy is closed. It is a traction tube **(Fig. 19-69)**.

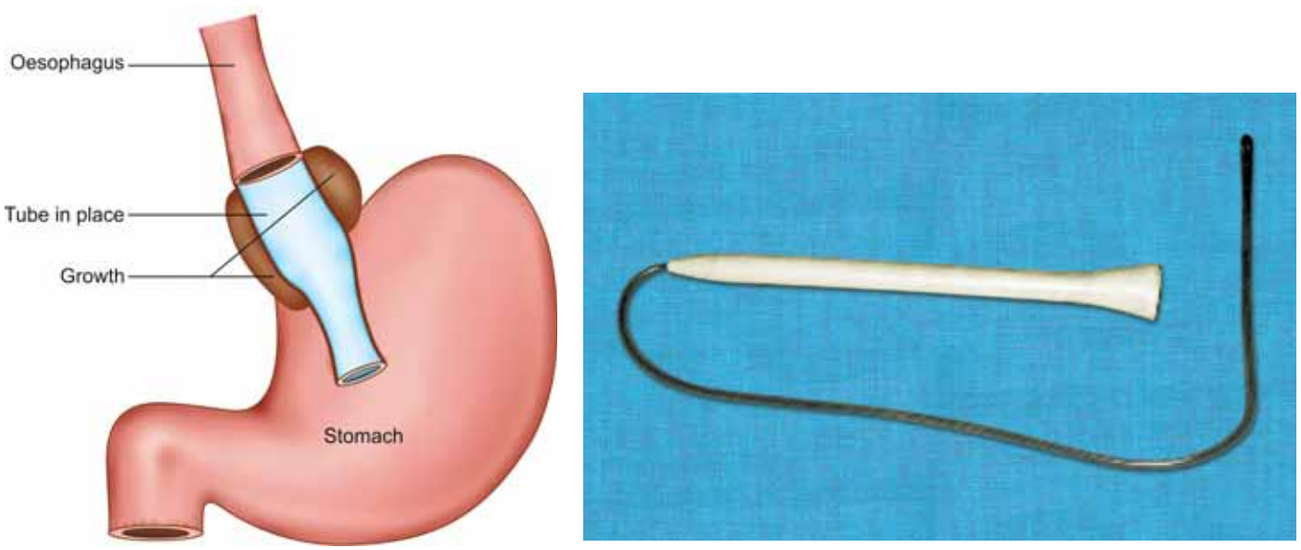


Fig. 19-69: *Mousseau-Barbin tube* – placement in advanced carcinoma of oesophagus. It is not used nowadays.

Chapter

20

Surgery of Stomach and Duodenum

SURGICAL ANATOMY OF STOMACH AND DUODENUM

The stomach lies obliquely in the upper left part of the abdomen occupying epigastric, umbilical and left hypochondriac regions. Most of it lies under left costal margin and ribs. Cardiac orifice on surface marking is located 2.5 cm left of the midline in the left 7th costal cartilage. Pyloric orifice is located in the transpyloric line 1.2 cm right of the midline. Fundus extends upwards from a line along the left of the cardiac orifice to a point up to the left 5th intercostal space just below the nipple. Stomach is J-shaped when empty; pyriform-shaped when distended. Stomach is 25 cm in length. It has got capacity of 30 mL at birth; 1 litre at puberty; 2 litres in adult.

The stomach contains four anatomic regions **(Fig. 20-1)**:

1. Fundus.
2. Cardia.
3. Body.
4. Pylorus – pyloric antrum and pyloric canal.

Angle of His is angle of entry of oesophagus into the stomach which is 30°-70°. In cadaver, it reduces to 20°. This oesophagogastric junction is often termed as cardia. Fundus is the segment of the stomach above an arbitrary horizontal line drawn from the angle of His. Fundus of the stomach is covered by the peritoneum anteriorly; posteriorly, it is covered in most parts except a crescent-shaped part along the upper right part of the fundus and posterior lesser curvature and this area is called as bare area of stomach. Occasionally, it is wide enough to cause difficulty in mobilizing the stomach. Behind fundus of the stomach is related to the diaphragm **(Fig. 20-2)**.

Stomach per se anatomically is a very mobile organ which is easier to understand. But while doing surgical procedures like gastrectomies, it is mandatory to mobilize the proximal or distal stomach and so stomach is often considered as *two gastric units* – proximal and distal **(Fig. 20-3)**.

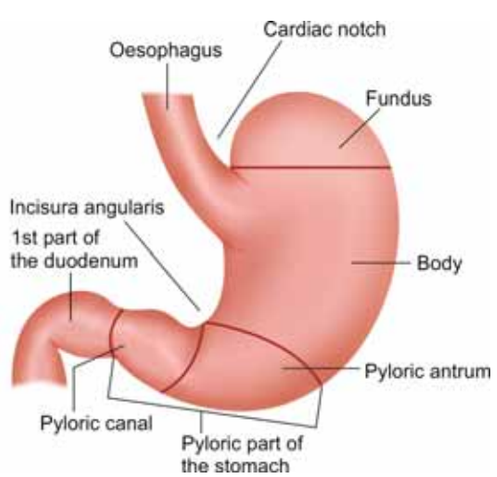


Fig. 20-1: Parts of the stomach.

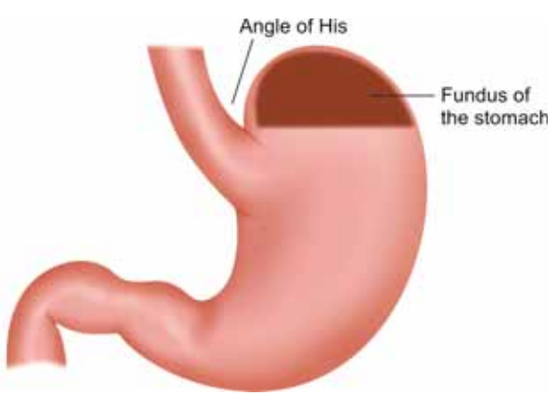


Fig. 20-2: Angle of His.

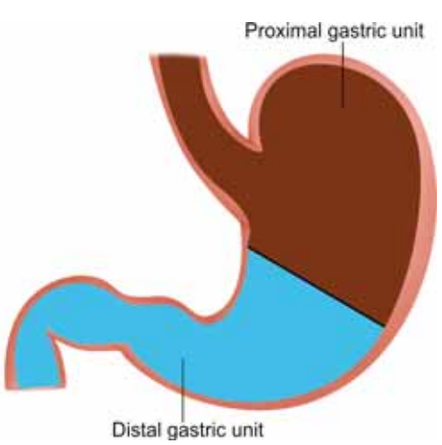


Fig. 20-3: Stomach is considered as two units – proximal and distal. It is relevant while doing gastrectomies.

Proximal gastric unit contains proximal stomach with fundus, oesophagogastric junction, oesophageal hiatus and distal oesophagus. *Distal gastric unit* contains gastric antrum, pylorus and 1st part of the duodenum. It is related in front to the posterior surface of the left lobe of the liver; behind to right crus of the diaphragm, right side to caudate lobe of the liver, left side to the splenic inner surface. Antral mucosa is flat without rugae. It is often demarcated from outside from incisura angularis along the lesser curve, even though it is very much variable. Line is usually located 4 cm proximal to the '*crow's foot*' of the descending part of the anterior vagus nerve; 10 cm proximal to pylorus. Antrum ends at pyloric canal as pylorus. Pylorus ends to thin walled duodenum as pyloric ring (pylorus means *gate guard*). Pyloric ring is formed by a septum from submucosal connective tissue at pyloroduodenal junction; circular muscle proximal to this ring is thickened, acting as pyloric sphincter; distal to this forms thin circular muscle layer of the duodenum. First part of the duodenum is 2.5 cm in length. Pyloric orifice is located at the level of lower border of L1 vertebra in transpyloric plane. Pylorus on the surface feels like a circular groove/constriction due to pyloric sphincter. Pylorus feels like a firm nodule with prepyloric vein located in front of the pyloric constriction. Distal gastric unit is related behind to floor of the lesser sac, transverse mesocolon, head and neck of pancreas, aorta and celiac trunk with branches, gastroduodenal unit, common bile duct, portal vein and hepatic artery. In front, it is related to left and right lobes of the liver, transverse mesocolon, gallbladder with its neck often, anterior abdominal wall.

Oesophageal hiatus is formed by the two pillars of the right crus of the diaphragm. Phrenooesophageal membrane is present in front.

Stomach is often divided into two parts by a line drawn downwards and towards left from incisura angularis. Proximal part is called as cardia which is larger and is divided into fundus and body. Smaller distal pyloric part is again divided into pyloric antrum and pyloric canal. Fundus is above the line from angle of His, which is dome-shaped directed upwards which always normally contains gas. Body of the stomach is located between fundus and pyloric antrum and can distend enormously along the greater curvature. Lesser curve is very less distensible and at much posterior level than greater curvature. Lesser curve bears the maximum insult of the swallowed liquids. Body of stomach contains mucus cells, chief cells (peptic or zymogenic cells secrete digestive enzymes) and parietal cells (oxyntic cells secrete hydrochloric acid). Pyloric antrum is 7.5 cm in length which contains mainly mucous glands. Narrow tubular pyloric canal is 2.5 cm long **(Fig. 20-4)**.

Greater omentum is present along the greater curvature which extends downwards as a free apron on the abdomen; reflects back towards transverse colon where it is attached with avascular tissue. Within it exists the *omental bursa* which is of surgical importance, especially in radical gastrectomies. Omental bursa extends from the upper margin of the transverse colon along the superior leaf of the transverse mesocolon towards front of the pancreas, reflecting back in front to the greater omentum. Two layers of the greater omentum meet near the fundus in its upper part as gastrosplenic ligament.

Peritoneum on the posterior surface of the stomach near upper part reflects on the diaphragm as gastrophrenic ligament. Its upper part is avascular and through which a window can be created in vagotomy or during mobilization of the oesophageal hiatus. Its lower part contains short gastric vessels and lymph nodes.

Gastrocolic ligament is part of greater omentum extending from the greater curvature of the stomach and first part of the duodenum to the transverse colon. Mobilization of this ligament is essential in many gastric and pancreatic surgeries.

Fig. 20-4: Gastroscopy reveals the demarcation between the body and pyloric antrum. Antrum does not have rugosity.

Lesser omentum is much thinner and extends from lesser curvature towards the liver. Hepatogastric ligament is the proximal part of it extends from porta hepatis and lesser curvature of the stomach; above it extends as ventral mesentery of abdominal oesophagus. Hepatogastric ligament contains left gastric vessels, hepatic branch of anterior vagus, posterior gastric divisions of the vagus and lymph nodes. In 23% of individuals an aberrant left hepatic artery may be present in this ligament which may be exclusive supply of the left lobe of the liver.

Hepatoduodenal ligament is distal part of the lesser omentum extending from the liver to 1st 2.5 cm of the duodenum. Its free edge contains hepatic triad and lymph nodes **(Fig. 20-5)**.

Diaphragm separates the stomach from left pleura, pericardium and lower ribs (6th to 9th). Posteriorly stomach is related to diaphragm, left kidney, left adrenal gland, splenic flexure of colon, transverse mesocolon and splenic artery. Gastrosplenic ligament is spread between greater curvature of the stomach and spleen.

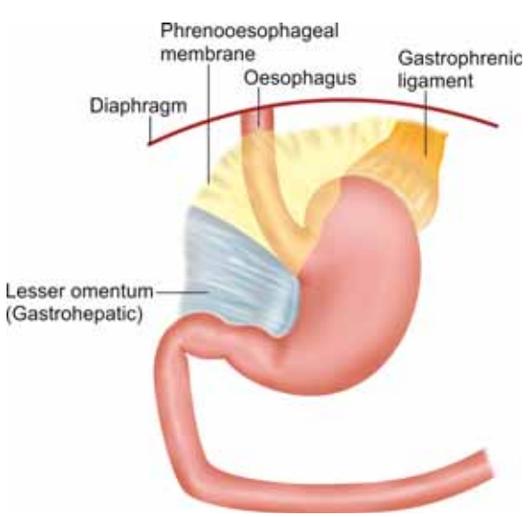


Fig. 20-5: Oesophagogastric junction and ligaments of stomach.

Arterial Supply of Stomach

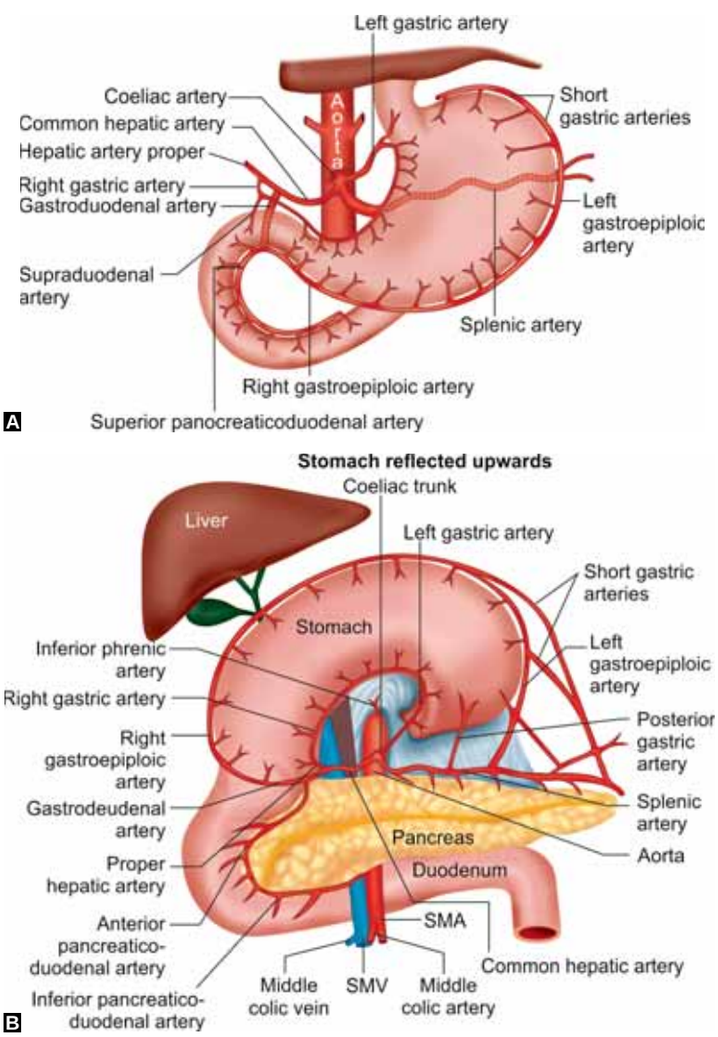
Stomach is supplied by left gastric artery, a branch of coeliac artery (smallest branch of coeliac axis); right gastric artery, a branch of proper hepatic artery; right gastroepiploic artery, a branch of gastroduodenal artery (a largest branch of common hepatic artery); left gastroepiploic artery, a branch of splenic artery; short gastric arteries, branches of splenic artery; left inferior phrenic artery, a branch of aorta; posterior gastric artery, a branch of left gastric/splenic artery or from coeliac trunk which supplies distal oesophagus, fundus and OG junction. Gastroepiploic arteries are also called as gastroomental arteries. Vessels in the omentum form an arcade called as *arc of Barkow* **(Figs 20-6A and B)**.

Left gastric artery after originating from coeliac trunk (90%) runs retroperitoneally upwards and left giving oesophageal branches. Then it runs downwards to reach the proximal lesser curve to continue along lesser curvature of stomach to anastomose with the right gastric artery. When it enters the lesser curve, it gives cardiooesophageal branch, often called as ascending branch which runs upwards. Left gastric artery then runs downwards as descending branch which eventually gives into anterior and posterior branches. Numerous gastric branches enter the stomach to supply it. As a variation, left gastric artery may originate from common hepatic artery, splenic artery, aorta, superior mesenteric artery; or as gastrosplenic trunk or heptogastric trunk. Rarely can it originate directly from aorta. Aberrant left hepatic artery may arise (24%) from left gastric artery, and in such situation, artery will be much wider than usual.

Right gastric artery commonly arises from proper hepatic artery (65%); but can arise from left hepatic artery (25%) or common hepatic artery (3%). It runs along the lesser curvature of stomach for 6 cm, 0.5 cm from lesser curve margin to join left gastric artery. Supraduodenal artery which usually arises from proper hepatic artery just proximal to right gastric artery can arise from right gastric artery (13%).

Common hepatic artery arises from coeliac trunk that runs behind the lesser sac towards right reaching the upper border of the duodenum. Here it gives large branch gastroduodenal artery which descends vertically downwards from 1st part of the duodenum behind to divide as *right gastroepiploic artery* and superior pancreaticoduodenal artery (which often divides into anterior and posterior branches running along the pancreaticoduodenal groove to communicate with inferior pancreaticoduodenal artery which is a branch of superior mesenteric artery). Common hepatic artery continues as proper hepatic artery which later gives supraduodenal artery and right gastric artery enters and runs along the free border of the lesser omentum in front of the portal vein and left of the common bile duct to reach porta hepatis. Here it divides into right and left branches.

Left gastroepiploic artery arises from the splenic artery distally close to greater curvature. Posterior gastric artery arises from splenic artery proximal to the origin of the left gastroepiploic artery. Often this is the only blood supply which is left in subtotal gastrectomy wherein left gastric artery is ligated at its origin and many short gastric vessels are also ligated.



Figs 20-6A and B: Arterial supply of stomach. View also shown after reflecting the stomach upwards.

Venous Drainage of Stomach (Fig. 20-7)

Right and left gastric veins drain into portal vein. Left gastric vein is caudal to left gastric artery and is also called as coronary vein. Left gastric vein receives tributaries from oesophageal hiatus and oesophagus; runs downwards and towards right to join commonly to portal vein (70%) or splenic vein near its junction to portal vein (30%). Left gastric vein communicates with azygos vein which will lead into the varices when there is portal hypertension. Left gastroepiploic and short gastric veins drain into splenic vein. Splenic vein block causes extensive varices in the proximal gastric unit. Right gastroepiploic vein drains into superior mesenteric vein. It receives anterior superior

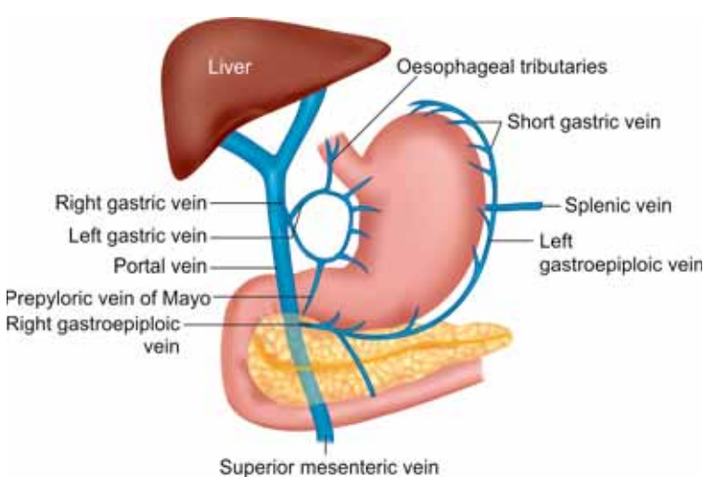


Fig. 20-7: Venous drainage of the stomach.

pancreaticoduodenal vein and middle colic vein in front of pancreatic head. Blockage of right gastroepiploic vein can cause duodenal varices. In portal hypertension, congestion of veins and varices can develop between right and left gastroepiploic vessels. Right gastric vein runs close to right gastric artery towards right along distal gastric unit to drain into the portal or superior mesenteric or splenic vein. Often *Henle's gastrocolic vein* may be present (70%) formed by right gastroomental vein and right colic vein; it is short run along the root of the transverse mesocolon and anterior surface of the head of the pancreas. Prepyloric vein of *Mayo* distinguishes pyloric canal from the first part of duodenum. It drains into the right gastric vein.

Nerve Supply of Stomach

Intrinsic innervation occurs through myenteric plexus of *Auerbach* and submucous plexus of *Meissner.*

Right vagus is posterior and left vagus is anterior. Right posterior vagus is away from oesophagus closer to aorta, unlike left vagus. Both right and left vagi are usually right of the midline in 80% of cases; but anterior vagus is more left compared to posterior vagus. Hence, it is better to name them as posterior and anterior even though right and left vagi are commonly used terminologies. Posterior vagus gives *criminal nerve of Grassi* (Professor Grassi, Rome), which supply lower oesophagus and fundus of stomach, which, if not cut properly during vagotomy, may lead to recurrent ulcer. It is a single nerve arising from posterior vagus that runs behind the cardia to supply part of fundus and proximal stomach. Vagus also gives splanchnic branches (*hepatic and coeliac branches),* ends as *nerve of Latarjet* (Latarjet – French surgeon, 1921) which supplies the antrum and maintains the antral pump. Each vagus gives divisions—splanchnic and gastric. Anterior gastric nerve from anterior trunk after running along the anterior surface of the lesser curvature ends as anterior nerve of Latarjet (greater anterior nerve of Mitchell) supplying the antral pump. Similarly posterior gastric nerve arises from posterior vagus. Anterior vagus gives hepatic branch (frequently multiple); posterior vagus gives a single stout coeliac branch to coeliac ganglion. Hepatic branch of the anterior vagus often gives a direct branch to the pylorus. Nerve of Latarjet arising from posterior trunk is much smaller and ends much proximal than tha t of anterior vagus. Parietal branches help in HCl secretion, which is an important concept in vagotomy that is done as a treatment in duodenal ulcer. *Truncal vagotomy* with posterior gastrojejunostomy is done for chronic duodenal ulcer with pyloric stenosis. Right vagus is thicker than left vagus; left vagus is embedded in the anterior oesophageal wall **(Fig. 20-8)**.

Among hepatic, anterior/posterior gastric and celiac divisions, coeliac division is the largest one. Coeliac division lies on the gastropancreatic peritoneal fold. It is a single trunk arising from the posterior vagus which supplies coeliac plexus.

Anterior vagus gives hepatic, gastric and antral branch. Hepatic branches originate as first branches of the anterior vagus below the diaphragm runs in the layers of the lesser omentum reaching liver; it gives the branches to liver and continues as plexus around hepatic artery giving branches to gall bladder, bile duct and pancreas. A pyloric branch begins here which runs along the right gastric artery downwards to supply pylorus and part of the stomach. One more branch runs along the gastroduodenal artery and right gastroepiploic artery to supply greater curvature of the stomach. About 5–10 gastric branches arise from anterior vagus supplying anterior portion of the proximal stomach and fundus. It runs closely associated with vessels of the lesser curvature entering the serosal layer of the stomach to run in the

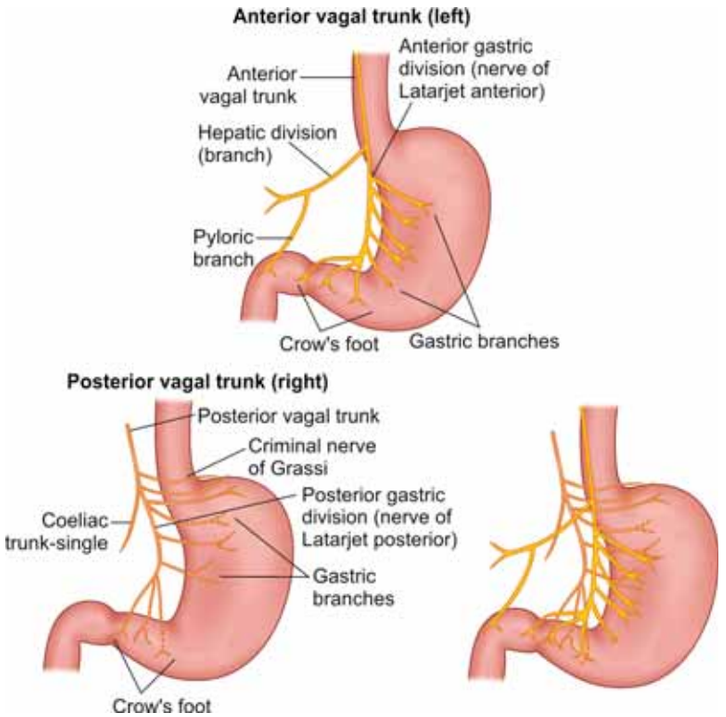


Fig. 20-8: Distribution of vagal trunks in the abdomen.

subserosal plane for 2 cm; then it enters the submucosal and mucosal planes. They supply parietal cells and smooth muscle cells of the body and fundus of the stomach. Often branch/branches may present at higher level at or beyond angle of His. Anterior nerve of Latarjet is the final continuation of the anterior vagus towards pylorus; near incisura angularis, it fans out many branches over the gastric antrum as 'crow's foot' (this word is coined by Goligher). Anterior and posterior nerves of Latarjet supply antropyloric mechanism. This nerve has to be preserved in highly selective vagotomy to retain antral pump function.

Posterior vagus gives single coeliac branch which joins coeliac plexus. It often receives a communicating branch from anterior vagus. Around 5–6 gastric branches descend and enter the posterior wall of the stomach to supply similarly to gastric branches of the anterior vagus. Posterior vagus continues downwards as posterior nerve of Latarjet to supply antrum and pylorus. Posterior nerve of Latarjet ends at more proximal level than anterior nerve of Latarjet. Criminal nerve of Grassi arises from the posterior vagus running behind OG junction to supply fundus and proximal stomach.

Vagus in the distal 6–8 cm of oesophagus also supplies the stomach by different fibres through distal oesophageal plexus. So distal 8 cm of the oesophagus should be skeletonised to achieve optimum results of the vagotomy. Proximal most branch of 'crow's foot' is 7 cm from pyloroduodenal junction. Junction of antrum and body is 4 cm proximal to this. Antrum does not have parietal and chief cells. So in highly selective vagotomy, dissection is done proximal to 'crow's foot'. In the OG junction, vagal fibers are located within the peritoneal fold left of the oesophagus. So all loose areolar tissue should be dissected towards left of the oesophagus and angle of His to achieve complete vagotomy.

Highly selective vagotomy **(***HSV)* is done in case of uncomplicated chronic duodenal ulcer (refractile ulcer) which is not responding to available medical line of treatment. In HSV, nerve of Latarjet is retained so as to retain antral pump and no drainage is required. Here only the fibres entering the stomach are ligated close to the lesser curve to reduce the acid secretion. Usually vessels accompanying nerves are also ligated together. In *selective vagotomy,* splanchnic branches are

retained but it is presently not done. Gastroduodenal pain is sensed via sympathetic fibres (T5-T10). Term *extended proximal gastric vagotomy* means additional division of the recurrent branch of hepatic vagal branches distributed to greater curvature along gastroduodenal and right gastroepiploic arteries.

Histology

The fundus and body contain parietal (acid producing) and chief cells. *Parietal cells* secrete acid and intrinsic factor. *Chief cells* produce pepsinogen. There are two types of pepsinogen secreted by chief cells—I and II. Pepsinogen I is produced only in stomach. In gastric atrophy, pepsinogen I is decreased. In the antrum, *endocrine cells* produce *gastrin* (G cells) and somatostatin (D cells). 12% of epithelial cells of stomach are parietal (oxyntic) cells; 45% chief (zymogenic cells); 40% mucous cells; 3% endocrine cells. Submucosa is strongest, collagen rich layer of gastric mucosa. Gastric mucus is a mucosal barrier containing mucopolysaccharides which maintains the integrity of gastric mucosa. Muscles of the stomach wall are outer longitudinal; middle circular and inner oblique. Middle circular and innermost oblique muscles blend in angle of His forming collar of *Helvetius*.

Lymphatic Drainage of Stomach

Lymphatics of proximal half of stomach drain into left gastric, splenic, and superior pancreatic lymph nodes. From antrum, it drains into right gastric, right gastroepiploic and subpyloric lymph nodes. From pylorus, it drains into right gastric and subpyloric lymph nodes. Efferent lymphatics from suprapyloric region drain into para-aortic lymph nodes and so into left supraclavicular lymph nodes. Efferent lymphatics from subpyloric lymph nodes drain into superior mesenteric lymph nodes. Lymphatics near *oesophagogastric* (OG) junction communicate with oesophageal lymphatics. In carcinoma stomach if upper lymphatics are blocked, retrograde spread through lower lymphatics can occur. Presently in carcinoma stomach, different resections are classified as R0, R1, R2, R3, or D1, D2 (dissection) based on levels of lymph nodes in the abdomen in relation to the stomach. R0 is no residual disease; R1 is microscopic residual disease; R2 is macroscopic residual disease; R3 is inoperable **(Fig. 20-9)**.

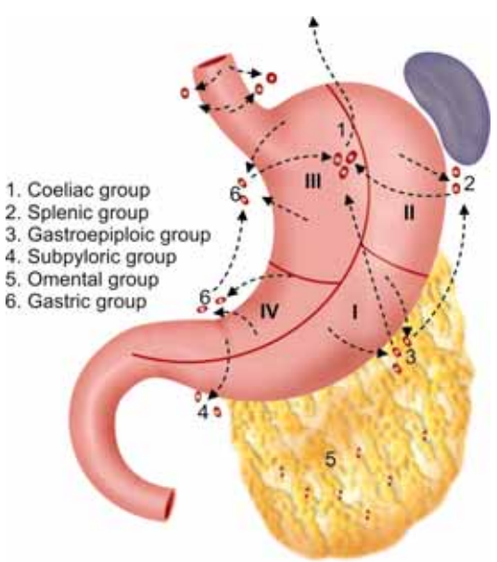


Fig. 20-9: Lymphatic drainage of stomach.

Zones of lymphatic drainage in stomach: Four zones.

Zone 1-inferior gastric: It lies in gastrocolic omentum along the right gastroepiploic vessels, draining pyloric portion of the greater curve to pyloric, coeliac and aortic lymph nodes.

Zone 2-splenic: It lies in gastrocolic and gastrosplenic omentum along the left gastroepiploic vessels draining from upper half of greater curve to pancreaticosplenic and aortic lymph nodes.

Zone 3-superior gastric: There is drainage from proximal two thirds of the stomach and the upper lesser curve along the left gastric artery. Zone 3 drains into perioesophageal lymph nodes.

Zone 4-hepatic: It is from distal portion of lesser curve and pylorus along hepatic artery into para-aortic nodes.

Lymph node groups

Group I: Perigastric nodes
Group II: Along the root of major vessels
Group III: At the root of superior mesenteric artery and hepatoduodenal ligament
Group IV: Distant lymph nodes.

SURGERY FOR DUODENAL ULCER PERFORATION

It is an emergency surgery. Preoperatively X-ray abdomen in erect or lateral decubitus confirms the diagnosis. Additionally ultrasound abdomen may be useful. Electrolyte estimation, renal functions should be confirmed. Initial resuscitation with proper fluid therapy, antibiotics, CVP line, nasogastric aspiration and urinary catheterisation should be done **(Figs 20-10 to 20-12)**.

Occasionally when stomach is empty, perforation may get sealed-off automatically or may form localized abscess in the lesser sac, subphrenic space or paracolic gutter. Mikulicz (1887) and Dean (1894) did first successful closure of perforation by suturing edges of the perforation. Later Cellan Jones (1929) and Graham (1937) popularized the omental plugging and suturing the perforation which was originally thought by Bennett (1899).

Technique (Fig. 20-13)

Emergency laparotomy through upper midline incision is done. All infected fluid is sucked out. Perforation is identified. Usually duodenal

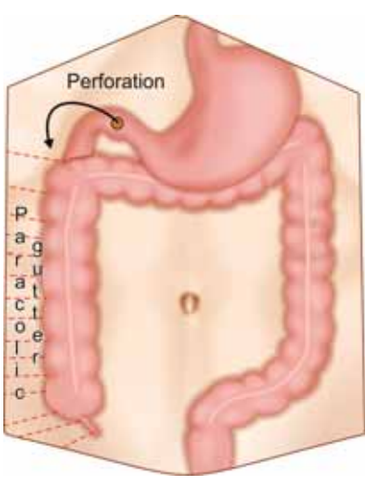
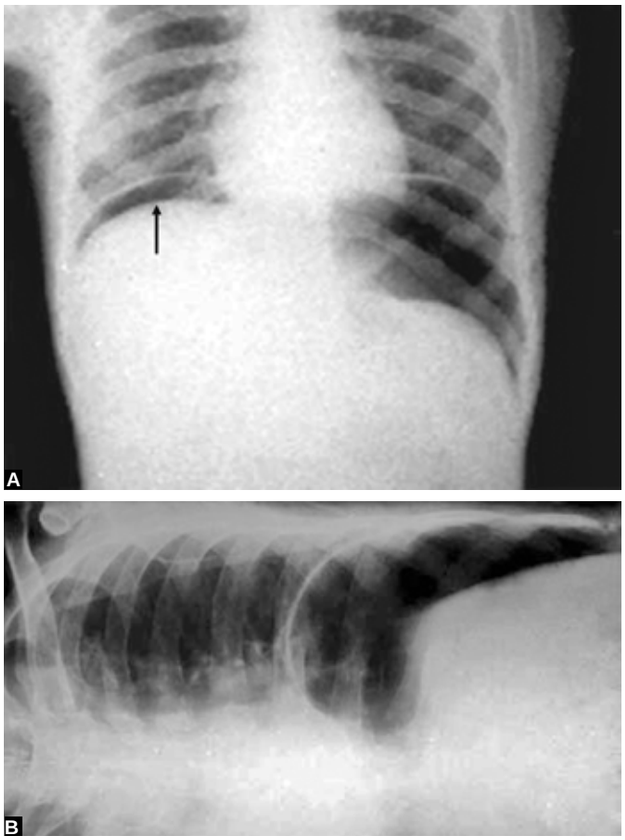


Fig. 20-10: Duodenal ulcer perforation. Here fluid from perforated site travels along the right paracolic gutter.



Figs 20-11A and B: X-ray chest and upper abdomen or lateral decubitus showing gas under diaphragm.

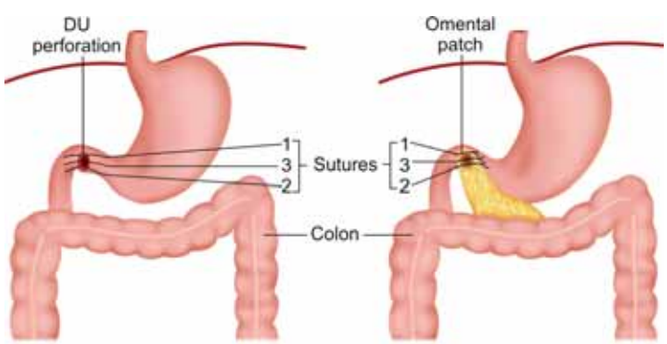


Fig. 20-12: Closure of duodenal ulcer perforation using Graham's omental patch.

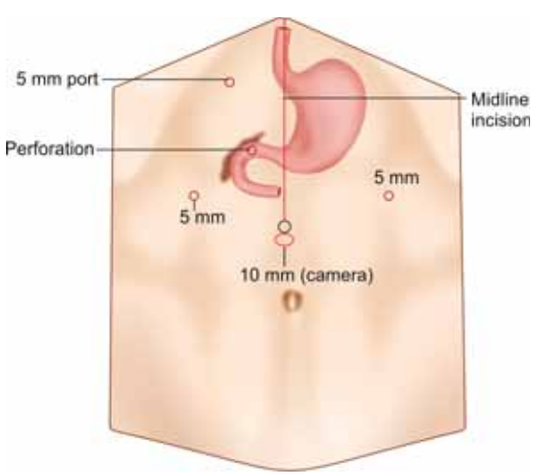
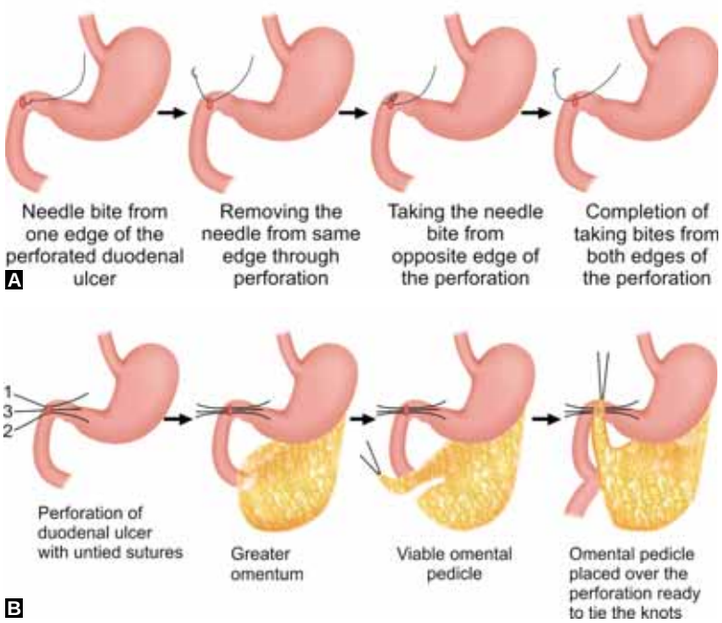


Fig. 20-13: Incision for closure of perforated duodenum for open and laparoscopic approach.

ulcer perforation is less than 1 cm in size. Giant ulcer is more than 2 cm in size. Omentum will be adherent to the site of perforation. It is gently separated. If duodenum is not perforated then stomach, posterior wall of stomach (lesser sac), small bowel and colon are thoroughly checked for possible sites.

Once perforation is identified, surrounding area is sucked out with suction. Liver, colon and proximal stomach are retracted. Suture material used for perforation is 3-0 vicryl or PDS or silk. As perforation edge is friable and oedematous, needle bites should be very gentle. Bite from each edge (5 mm from the edge) is taken separately. Each suture is kept away using haemostats on either side untied. Three stitches are taken at equal distances. Omental pedicle is held like patch. Viable segment should be used. Often it needs placing few ligatures to get adequate length of the omental pedicle. Omentum is placed on the perforation site to seal it. Knots are placed on it. Initially side sutures are tied on omentum; then center one to avoid tearing of the friable edge of perforated site. First suture towards the upper part i.e. apex of the omental pedicle is tied. All sutures should be interrupted horizontal one. Omental patch is placed *before suturing*—it is called as ***Graham Operation.*** Because of its *adhesion property,* it seals perforation; good vascularity and lymphatics promote the healing effectively **(Figs 20-14 to 20-16)**.


Needle bite from one edge of the perforated duodenal ulcer
Removing the needle from same edge through perforation
Taking the needle bite from opposite edge of the perforation
Completion of taking bites from both edges of the perforation
A
1
3
2
Perforation of duodenal ulcer with untied sutures
Greater omentum
Viable omental pedicle
Omental pedicle placed over the perforation ready to tie the knots
B

Figs 20-14A and B: Closure of duodenal perforation—technique.

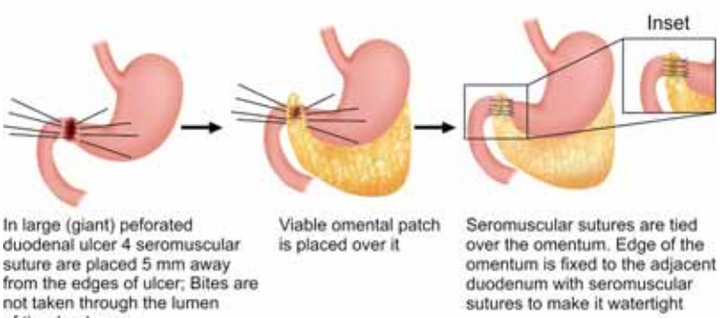
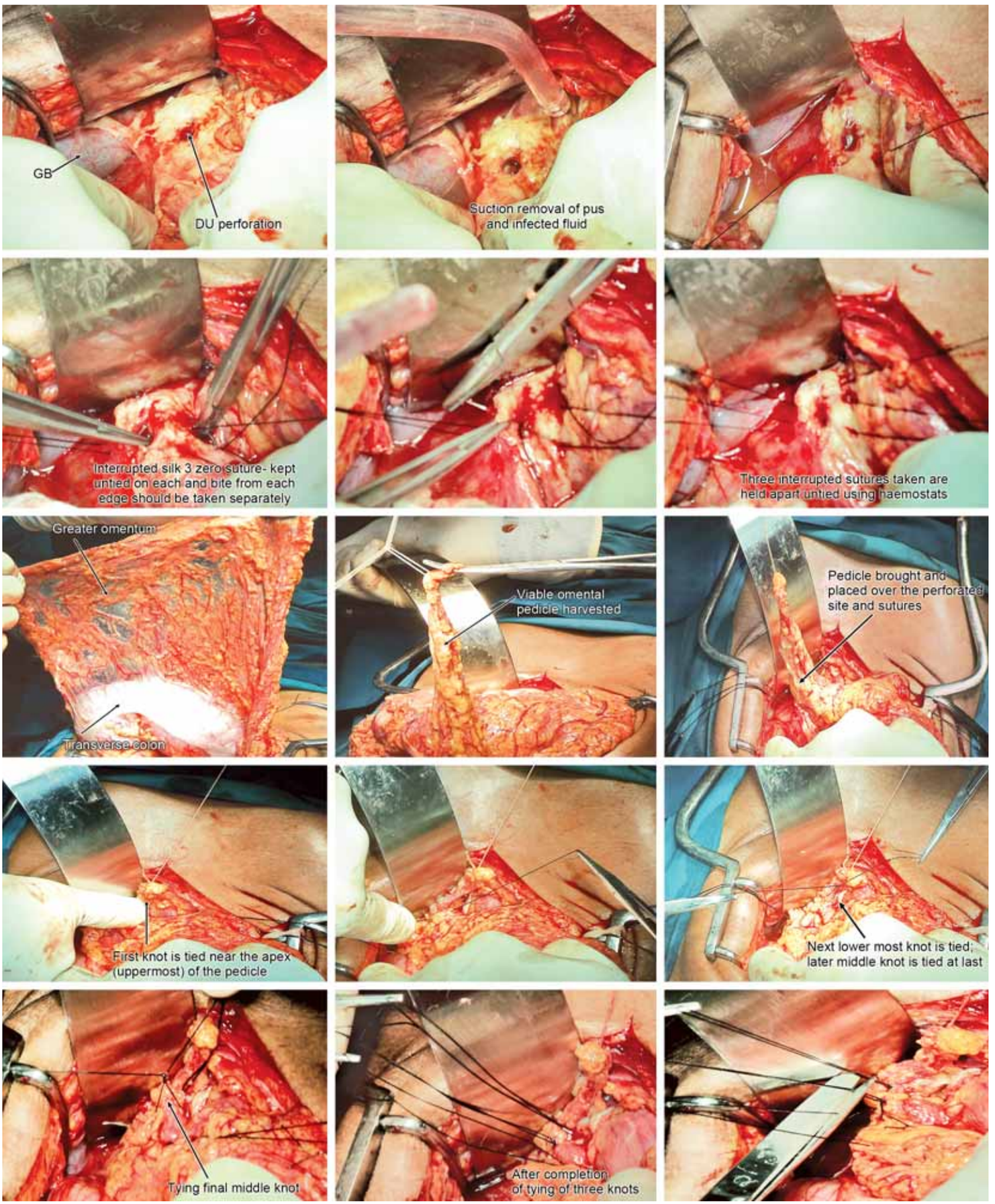
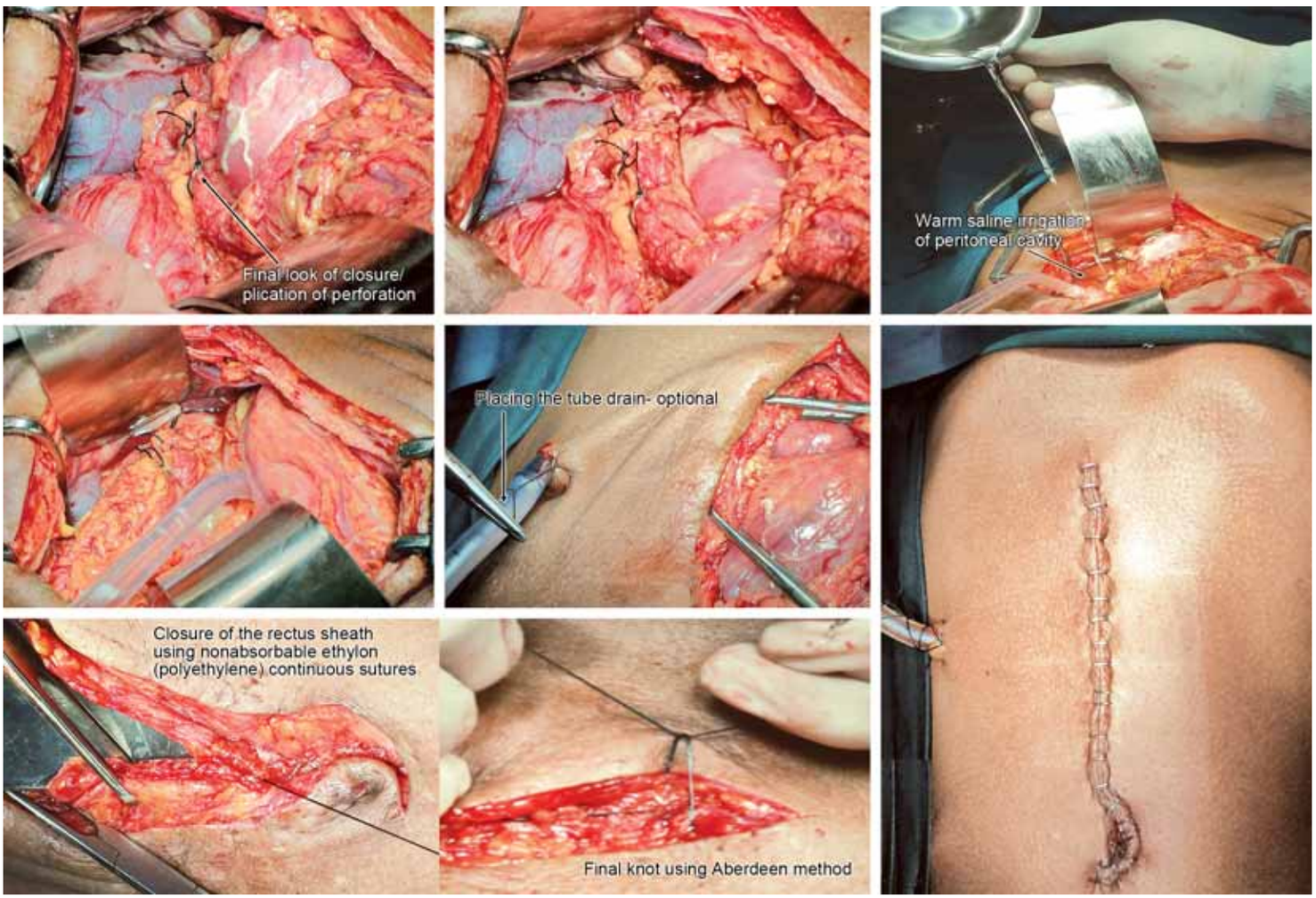

Inset
In large (giant) peforated duodenal ulcer 4 seromuscular suture are placed 5 mm away from the edges of ulcer; Bites are not taken through the lumen of the duodenum
Viable omental patch is placed over it
Seromuscular sutures are tied over the omentum. Edge of the omentum is fixed to the adjacent duodenum with seromuscular sutures to make it watertight

Fig. 20-15: Perforated giant duodenal ulcer is closed by taking only seromuscular bites to hold omental patch; here bites are not taken through the mucosal layer across the lumen.


GB
DU perforation
Suction removal of pus and infected fluid
Interrupted silk 3 zero suture- kept untied on each and bite from each edge should be taken separately
Three interrupted sutures taken are held apart untied using haemostats
Greater omentum
Transverse colon
Viable omental pedicle harvested
Pedicle brought and placed over the perforated site and sutures
First knot is tied near the apex (uppermost) of the pedicle
Next lower most knot is tied; later middle knot is tied at last
Tying final middle knot
After completion of tying of three knots

Figs 20-16(1)


Final look of closure/ plication of perforation
Warm saline irrigation of peritoneal cavity
Placing the tube drain- optional
Closure of the rectus sheath using nonabsorbable ethylon (polyethylene) continuous sutures
Final knot using Aberdeen method

Figs 20-16(2)

Figs 20-16(1 and 2): Closure of duodenal ulcer perforation.

Peritoneal wash (toilet) using 5–10 litres of warm saline is given. Drain is only optional. Drain is placed and abdomen is closed with modified Smead Jones technique (often if required using *tension sutures*. But tension/retention sutures are not recommended now, even though commonly practiced by significant number of surgeons). Drain is removed in 3–5 days. Nasogastric tube is removed in 5 days. Oral fluid is started once bowel sounds are heard adequately; patient passes flatus; no abdominal pain.

During discharge, patient is advised to avoid alcohol and to take H2 blockers or proton pump inhibitors for 6–12 weeks. After 12 weeks, *follow-up gastroscopy must be done.*

Complications

Subphrenic abscess formation: It is confirmed by CT abdomen. It can be treated conservatively or guided tube drainage or open drainage.

Reperforation rarely can occur which needs resection of distal stomach with perforated site and Billroth II anastomosis.

Duodenal obstruction is not uncommon. It causes gastric dilatation and persistent vomiting. With fluid therapy, nasogastric tube aspiration, it may subside. If not then oral contrast study of the gastroduodenum is needed. Relaparotomy and gastrojejunostomy is needed. Vagotomy to reduce the acid load is added depending on the general condition of the patient. HSV may be better option.

Duodenal fistula can occur occasionally. It may stop spontaneously. Occasionally it may require a diversion, serosal patch at the site.

Wound infection, burst abdomen can occur if patient's general condition is not good and nutritionally deprived.

Note:

Laparoscopy is beneficial for both diagnoses, as well as for therapy for perforation closure using omental patch. It is proposed and widely used for early duodenal perforation. It can be useful for most of the duodenal ulcer perforations except large or extensive one. If it is problematic, conversion options should always be kept in mind. Patient is in supine head up position (reverse Trendelenburg position); surgeon stands in between legs or on the left side. Monitor is on the head end right side. Cameraman is on the left of the surgeon. Trocar is placed as in the diagram. Technique is same as open method. Often omental patch integrity is tested by insufflation of stomach with air, and air bubble can be checked on the saline filled closed perforation site. Gastroscopy is also often used by many to confirm the same as well as to assure that sutures placed are not too deep. Mouret et al 1989 did first laparoscopic perforation closure. Nathanson et al later did laparoscopic closure of perforation. Intracorporeal knots are commonly used. Extracorporeal knots, fibrin glue fixation of omental patch, gelatin sponge sealing, stapled patch closure, placement of ligamentum teres into the perforation. *Advantages are*—better visualisation, less postoperative pain and early recovery. *Drawbacks*

are—difficulty in suturing, and inadequate peritoneal toilet which takes long time. *Contraindications are*—elderly, cirrhotic, cardiac patients, obesity and coagulopathy.

Large perforated duodenal ulcer is often difficult to close. Here instead of taking bites directly through the edges of the perforated ulcer across the lumen, seromuscular bites are taken 5 mm away from the edges of the ulcer on either side. Usually 4 such interrupted sutures are placed and viable omental patch is placed over it to tie. After that omentum again is sutured to the duodenum on its margin as seromuscular stitches to make it watertight.

Once perforation is closed, either by open or laparoscopic method, after recovery, patient should be advised *anti-Helicobacter pylori* therapy (triple regime for 14 days) with PPI for 3 months. It reduces rate of reperforation and ulcer recurrence in duodenal ulcer.

In patients with severe peritonitis and critically ill, after perforation closure, it is better to insert a nasojejunal tube or feeding jejunostomy for nutrition in postoperative recovery period. Even if patient develops a temporary duodenal leak, this supports nutrition well until the leak stops.

Occasional *large perforated duodenal ulcer* with oedema which cannot be closed is managed by serosal patch/duodenal drainage and pyloric exclusion/gastrostomy, duodenostomy and jejunostomy/Roux-en-Y jejunal patch over the perforation. Vagotomy with pyloroplasty; vagotomy with antrectomy are all other options used with care.

Definitive procedure can be done or not is a matter of debate. But if contamination is less and ulcer is chronic, highly selective vagotomy can be added in selected patients.

Gastric Ulcer Perforation

It is difficult to manage gastric ulcer perforation as plication may not hold properly. Gastric ulcer perforation causes large amount of gas leak showing gas under both sides of the diaphragm in erect X-ray film. Partial gastrectomy and gastrojejunostomy or gastroduodenostomy is preferred one.

GASTROSTOMY

It is the communication of the anterior wall of the stomach to the abdominal wall skin mainly for feeding purpose whenever oral or nasogastric feeding is not possible or there is fear of reflux and pneumonia and oesophageal stricture due to long-term nasogastric feeding.

Indications

It is used in multiple strictures of oesophagus, in congenital oesophageal conditions as an initial stage of surgery during radiotherapy period, in head and neck cancers for feeding purpose. It improves the nutrition; medications can be given through this tube as well. It keeps the small bowel function active. It is also done in major trauma, sepsis, major surgeries, burns and severe malnutrition.

Types

Gastrostomy can be *temporary* wherein gastrostomy tube is removed later to allow the gastrostomy to close spontaneously; or *permanent* where gastrostomy is kept permanently for life-long for feeding purpose **(Fig. 20-17)**.

Gastrostomy can be serosa/*serous lined*; it is temporary and easier to do. It can be *mucus lined* which is permanent and is technically difficult. Stamm (1894), Kader–Senn (1896), Witzel (1891) are temporary types. Depage–Janeway (1913), Spivack, Beck Carrell–Jeau (1905, 1912), Tavel are permanent types **(Figs 20-18 to 20-22)**.

Gastrostomy can be done by *open* method; *endoscopic* [Percutaneous Endoscopic Gastrostomy (PEG)]; or *laparoscopic-assisted endoscopic* method. PEG has become more popular nowadays. Stamm and Janeway gastrostomies can be done laparoscopically also.

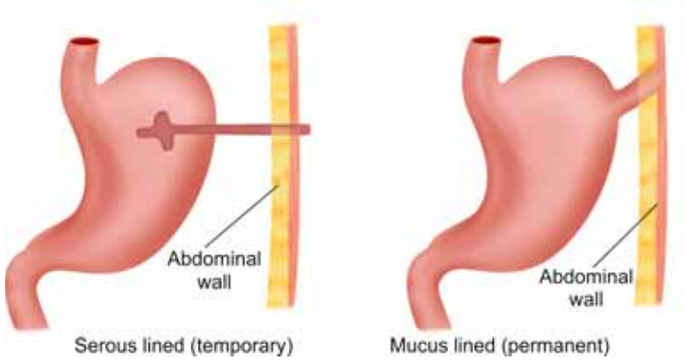


Fig. 20-17: Types of gastrostomies—serous-lined (temporary); mucus-lined (permanent).

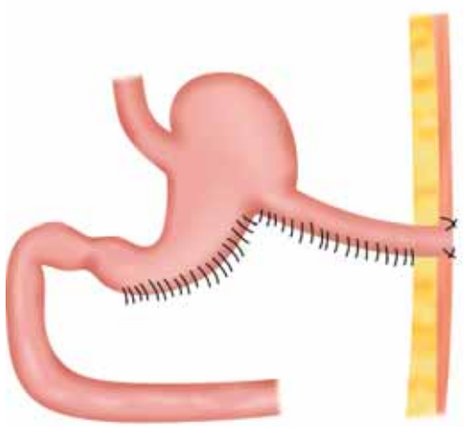


Fig. 20-18: Beck Carrell Jean gastrostomy. It is a mucus lined permanent gastrostomy.

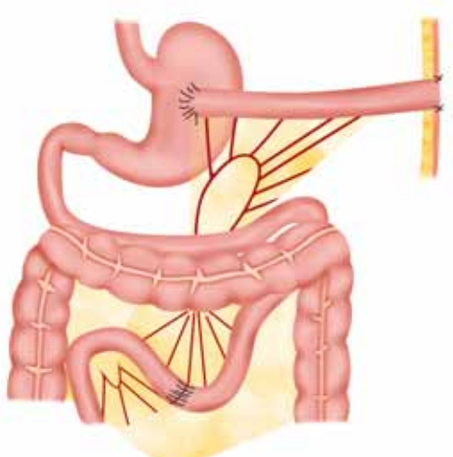


Fig. 20-19: Tavel permanent gastrostomy.

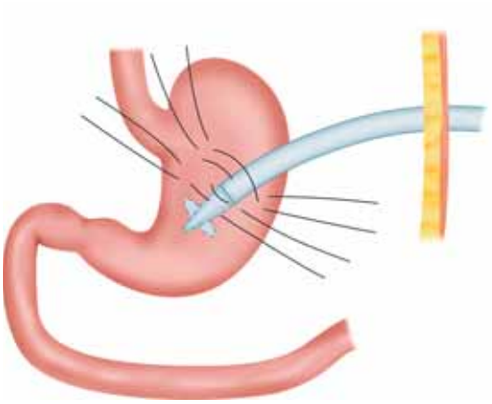


Fig. 20-20: Kader Senn temporary gastrostomy.

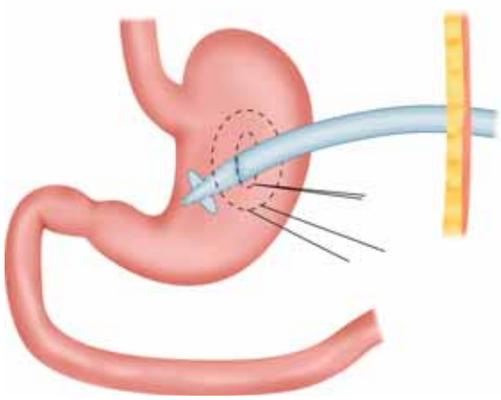


Fig. 20-21: Stamm gastrostomy is a temporary gastrostomy.

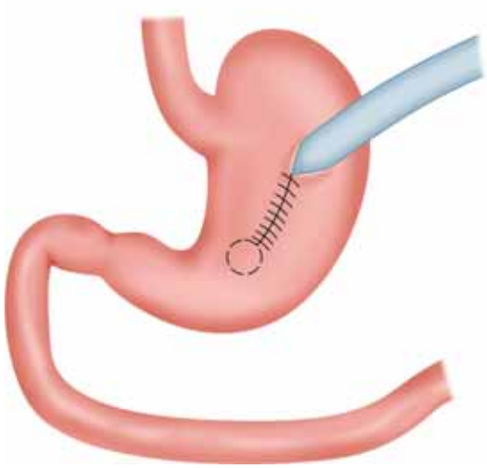


Fig. 20-22: Witzel's temporary gastrostomy.

Contraindications

Previous gastric surgeries, intestinal obstruction, gastric outlet obstruction, gastric diseases with impaired gastric emptying are contraindications.

Problems in gastrostomy

Leak—gastric fistula is very dangerous one. Gastrostomy is the commonest cause of gastric fistula. Infection can occur which can cause skin excoriation. Aspiration, pneumonia, diarrhoea is common—30%, bloating, abdominal cramps, displacement, blockage of the tube, trauma to other organs like colon.

Technique of Temporary (Stamm's) Gastrostomy

Commonly done type is Stamm's gastrostomy. It is serous-lined temporary gastrostomy. Upper midline incision is done. Stomach is held upwards towards wound using two Babcocks forceps applied at lesser and greater curvatures near middle of the stomach. In the midpoint of the stomach closure to greater curvature, marker stitch is placed. Purse string seromuscular suture is placed with a 2 cm diameter using 2-0 silk or vicryl. Using two Allis tissue holders, left edge of the cut linea alba is held apart; 2 cm vertical or horizontal incision is made on the skin over the middle of the rectus muscle; anterior rectus sheath is incised; rectus muscle is split; posterior rectus sheath and peritoneum is incised. Alternatively same can be achieved by a stab incision from skin towards the peritoneum under vision. Haemostat (medium sized or large) is passed from inside (peritoneum) out (towards skin) to grasp the selected gastrostomy tube (20 French Malecot/Foley's catheter/mushroom catheter) which is pulled into the peritoneal cavity. Incision is made within the purse string, suture placed (gastrotomy) using 15 number blade or cautery; tip of the gastrostomy tube is passed into the gastric lumen. Tip is usually directed downwards. If Foley's catheter is used, it is inflated with distilled water. Purse string suture is tied with knot to create inversion of serosa snugly on to the tube. It is supported by 2nd layer of purse string suture using 2-0 silk. This also ensures rapid closure of the stomach opening after removal of gastrostomy tube. Tube should be anchored to abdominal wall to prevent leak and spillage of the gastric contents. It is achieved by taking seromuscular bites from the stomach and to the peritoneal (or peritoneum with posterior rectus sheath) layer of the abdominal wall; 4 interrupted 2-0 silk or vicryl sutures are placed and kept untied initially. Once all four sutures are placed, they are tied and cut to anchor the tube to abdominal wall. Tube is fixed outside to the skin. Linea alba is sutured using polypropylene continuous sutures; skin is closed using stapler or nonabsorbable interrupted sutures **(Figs 20-23 and 20-24)**.

Temporary gastrostomy can be used for function in 48 hours. It should not be removed earlier than 3 weeks until proper sealing and track has formed.

Technique of Permanent (Depage Janeway) Gastrostomy

Permanent gastrostomy is mucus lined; it prevents regurgitation of gastric contents and avoids placing of a tube; it remains patent without any tendency to close. It is actually a permanent fistula **(Figs 20-25A and B)**.

Abdomen is opened forceps with upper midline incision. Stomach is held with two Babcock instruments adjacent to greater and lesser curvature. Occlusion clamps can be applied upper and lower part of the stomach to prevent spillage of the gastric content and bleeding from the cut edges. Flap from the gastric anterior wall is taken as rectangular. It can be horizontal with apex of flap towards lesser curve and base

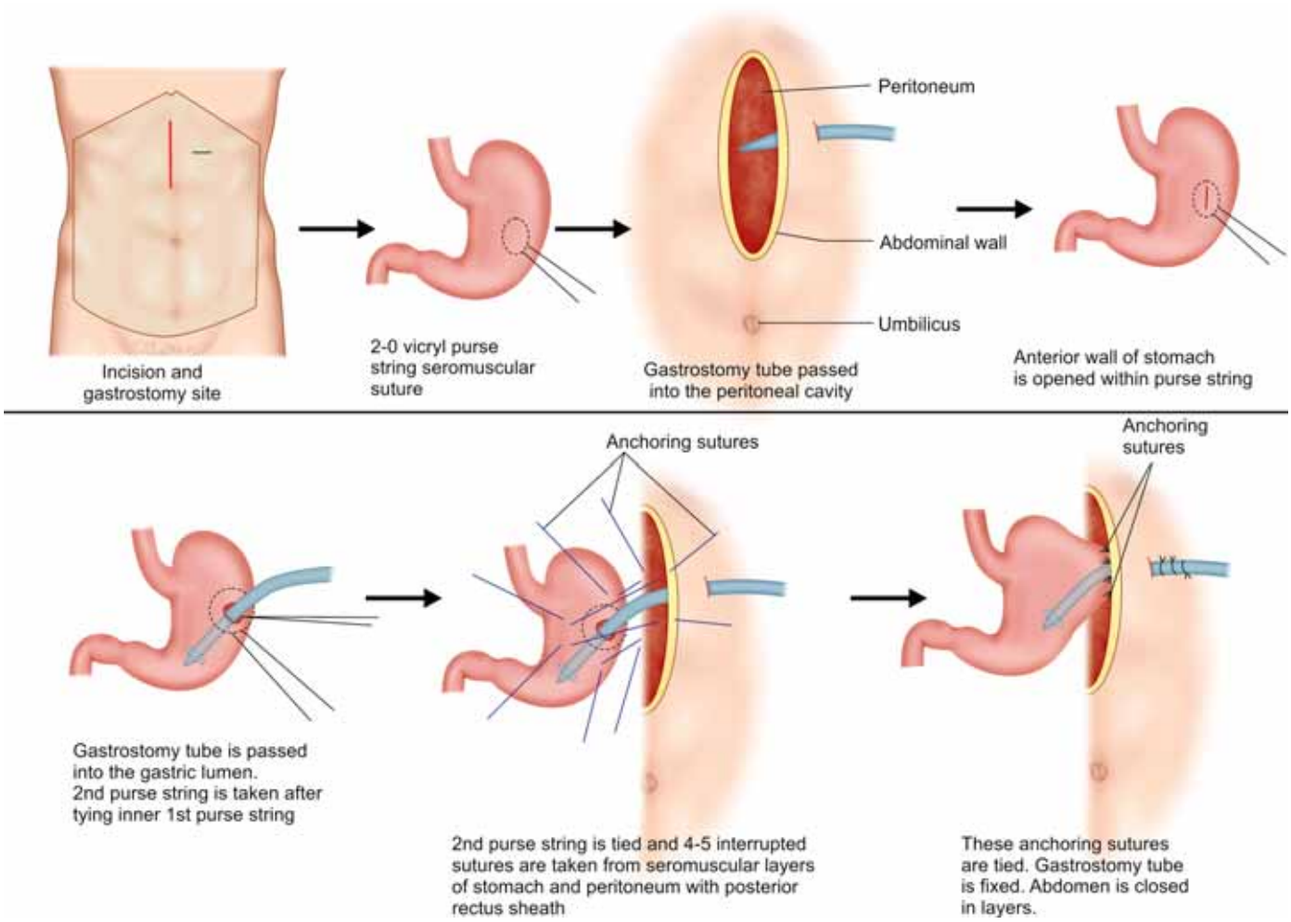

Peritoneum
Abdominal wall
Umbilicus
Incision and gastrostomy site
2-0 vicryl purse string seromuscular suture
Gastrostomy tube passed into the peritoneal cavity
Anterior wall of stomach is opened within purse string
Anchoring sutures
Anchoring sutures
Gastrostomy tube is passed into the gastric lumen. 2nd purse string is taken after tying inner 1st purse string
2nd purse string is tied and 4-5 interrupted sutures are taken from seromuscular layers of stomach and peritoneum with posterior rectus sheath
These anchoring sutures are tied. Gastrostomy tube is fixed. Abdomen is closed in layers.

Fig. 20-23: Stamm temporary gastrostomy—technique.

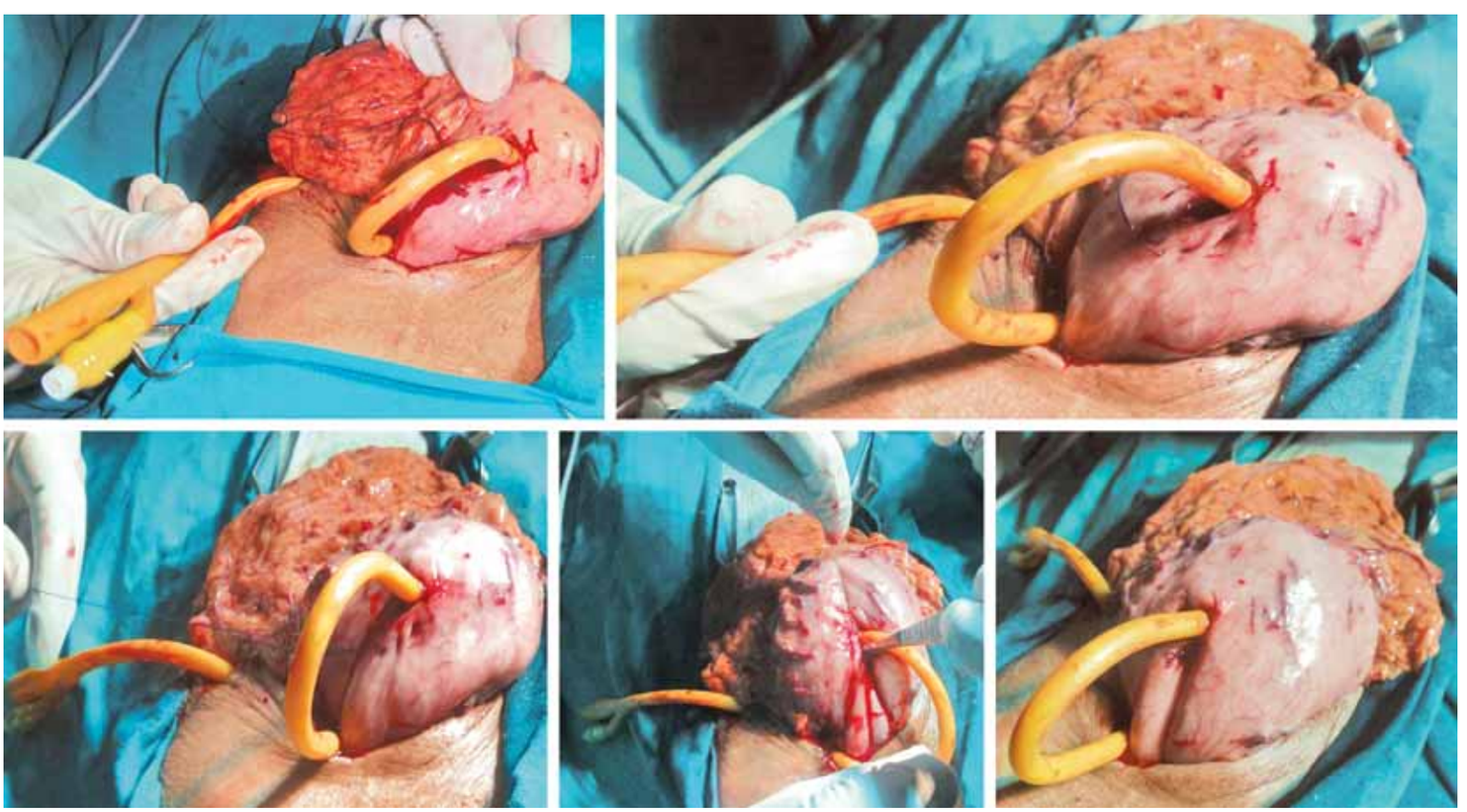
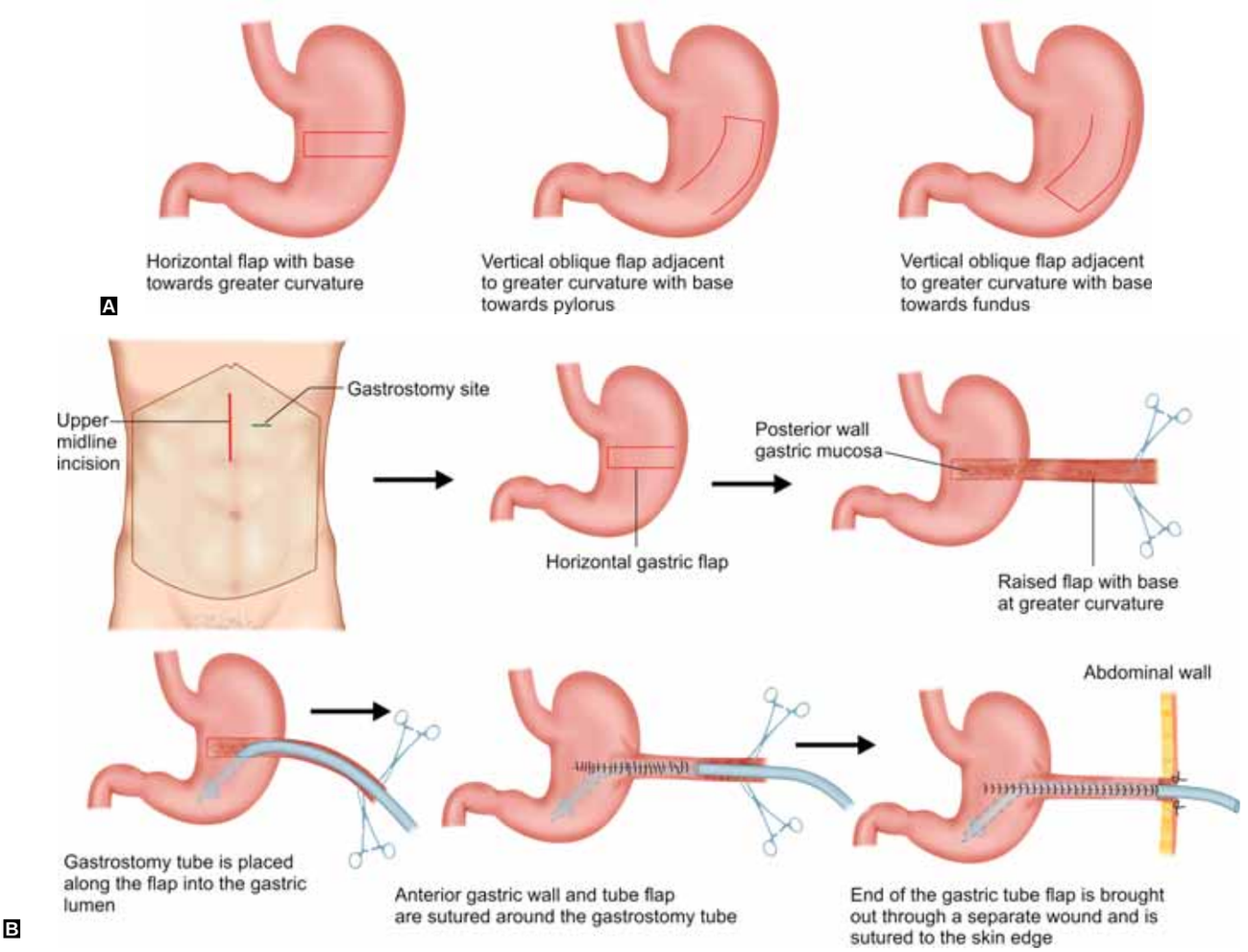


Fig. 20-24: Technique of temporary gastrostomy.


Horizontal flap with base towards greater curvature
Vertical oblique flap adjacent to greater curvature with base towards pylorus
Vertical oblique flap adjacent to greater curvature with base towards fundus
A
Upper midline incision
Gastrostomy site
Horizontal gastric flap
Posterior wall gastric mucosa
Raised flap with base at greater curvature
Abdominal wall
Gastrostomy tube is placed along the flap into the gastric lumen
Anterior gastric wall and tube flap are sutured around the gastrostomy tube
End of the gastric tube flap is brought out through a separate wound and is sutured to the skin edge
B

Figs 20-25A and B: Janeway's permanent gastrostomy.

towards greater curve; or along the middle of the anterior wall of the stomach more towards the greater curvature as a rectangular flap with base directed either below or above. Flap should be adequately wide and lengthy as after flap harvesting, it shrinks significantly. Once flap is elevated adequately, 20 Foley's catheter is placed across the inner part of the flap into the stomach. Flap is sutured like a tube around the catheter using inner interrupted 2-or 3-zero vicryl and outer interrupted 3-0 silk sutures. Similar sutures are placed along the stomach wound from the base in two layers. Anterior wall is fixed to peritoneum using 2 or 3 interrupted sutures. Such permanent gastric tube can also be created using stapler device comfortably. A stab wound or layer by layer opening of the abdominal wound of 1.5 to 2.0 cm in length along the middle of the rectus muscle using a horizontal incision is used to bring the gastric tube outside as exteriorization and gastric mucosa is fixed to the skin (usually skin is incised horizontally; anterior rectus sheath is incised horizontally; rectus muscle is split; posterior rectus sheath and peritoneum are incised). Abdomen are closed in layers.

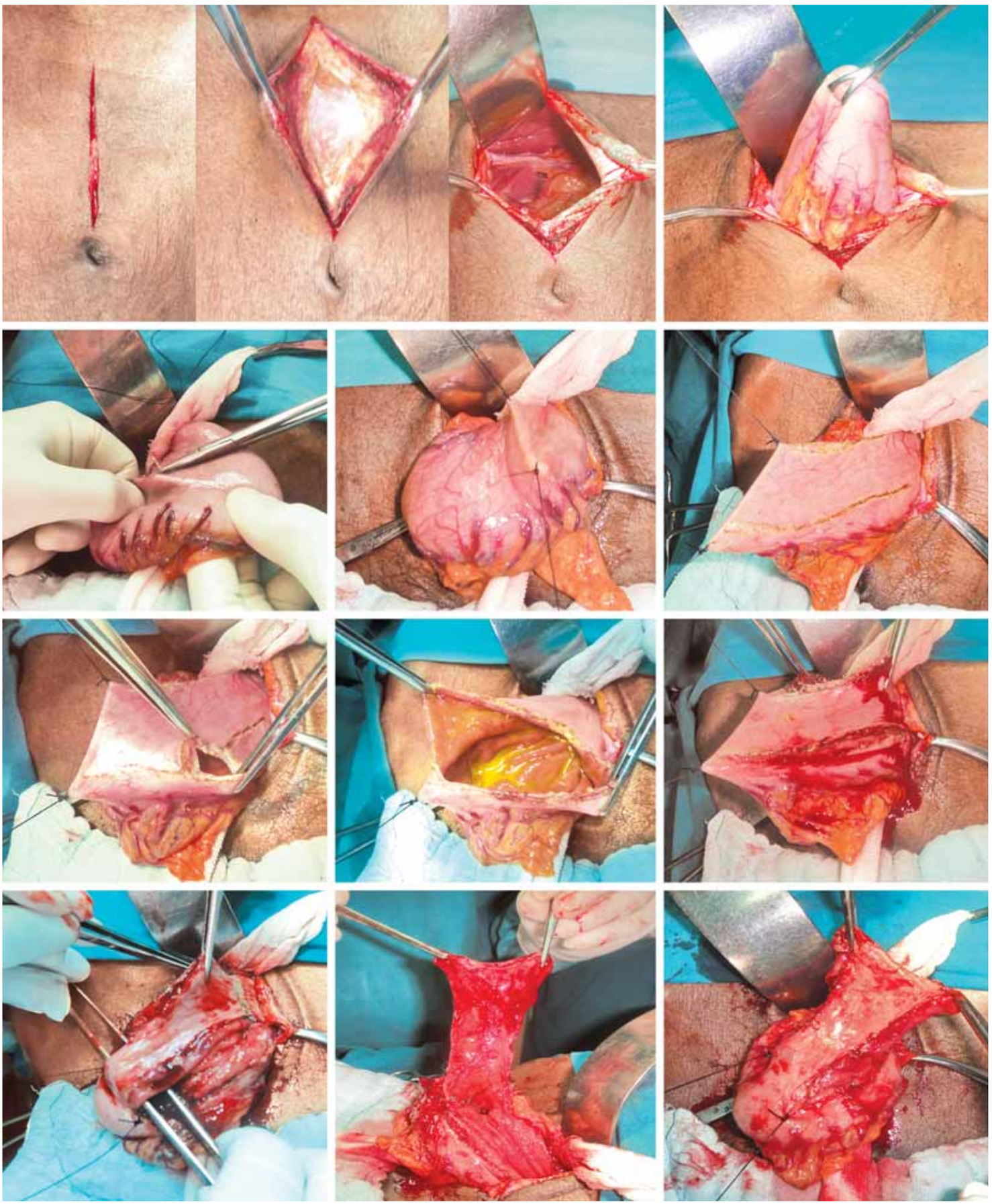
Fluid therapy can be started with catheter in situ in 48 hours. Catheter can be removed in 7 days. But tube (any tube of adequate size) should be reapplied and kept **(Fig. 20-26)**.

Technique of Percutaneous Endoscopic Gastrostomy (PEG)

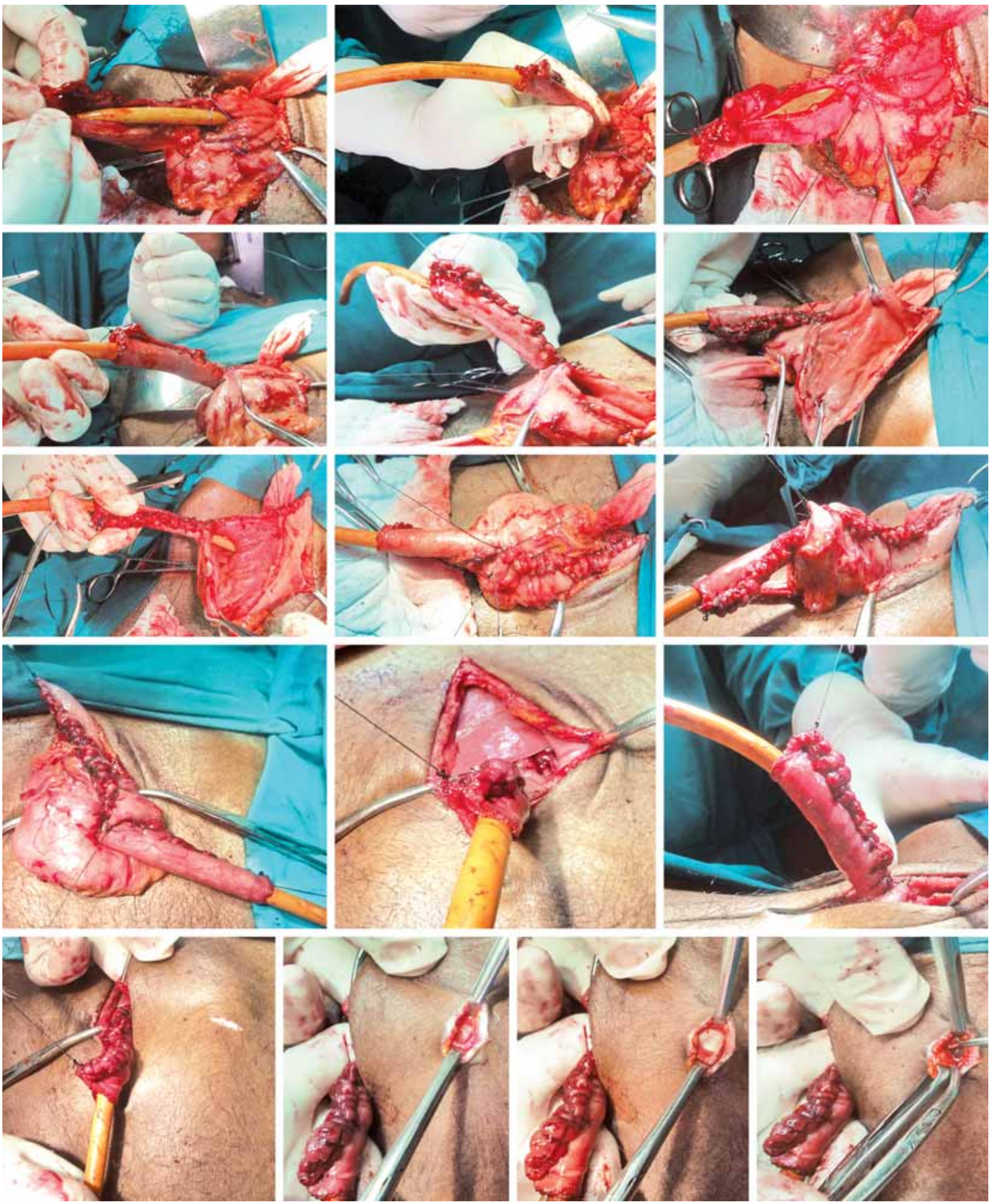
It is done using gastroscope without doing laparotomy. It is useful in children and adult for feeding and decompression. Stomach should be amenable for distension through endoscope; transillumination should be visible across the abdominal wall to do PEG. Dr Jeffrey Ponsky developed this method in 1980.

Ascites, coagulopathy, gastric outlet obstruction, gastroparesis, previous abdominal surgeries, gastrectomies, obesity are contraindications for PEG **(Figs 20-27A and B)**.

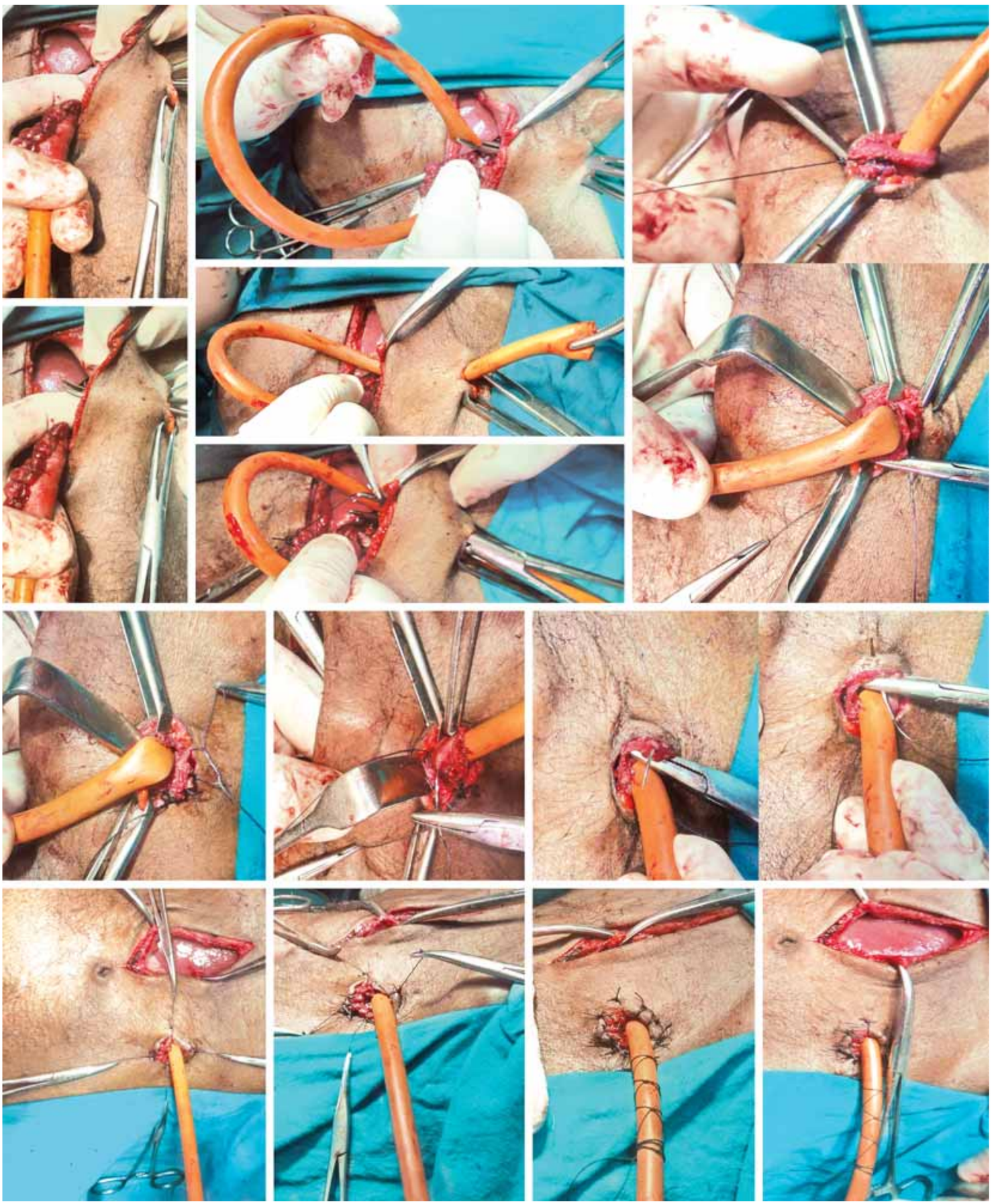
Patient should be kept nil oral like for gastroscope. Sedation, intravenous line and fluid are started. Patient is placed in supine head up position. Local anesthetic spray or gargle is instilled to the throat (oropharynx). Gastroscope is passed. Stomach is distended by air insufflation sufficiently so as to make anterior wall of the stomach abut into the abdominal wall. Room is made dark by switching of the bright lights to make transillumination better visible along the upper abdomen. Position is confirmed by finger indentation in the upper midline abdominal wall which is seen in endoscope image. Local anaesthetic agent is infiltrated (xylocaine 2%) in the upper abdomen in the suitable place for about 2 cm area. One cm skin incision is made. 16 gauge IV cannula with needle is passed under endoscopic vision per abdomen across the skin incision into the anterior stomach wall. Safe tract method is used while passing the needle. Cannula needle is connected to syringe with xylocaine and passed forward progressively with suctioning in the syringe; when needle enters the lumen (confirmed by endoscopic view), air bubble can be seen; if air bubble is seen but needle has not entered the gastric lumen then it is presumed that bowel is interposed, and needle is immediately withdrawn. Needle is removed; cannula is kept in place; a long thick



Figs 20-26(1)

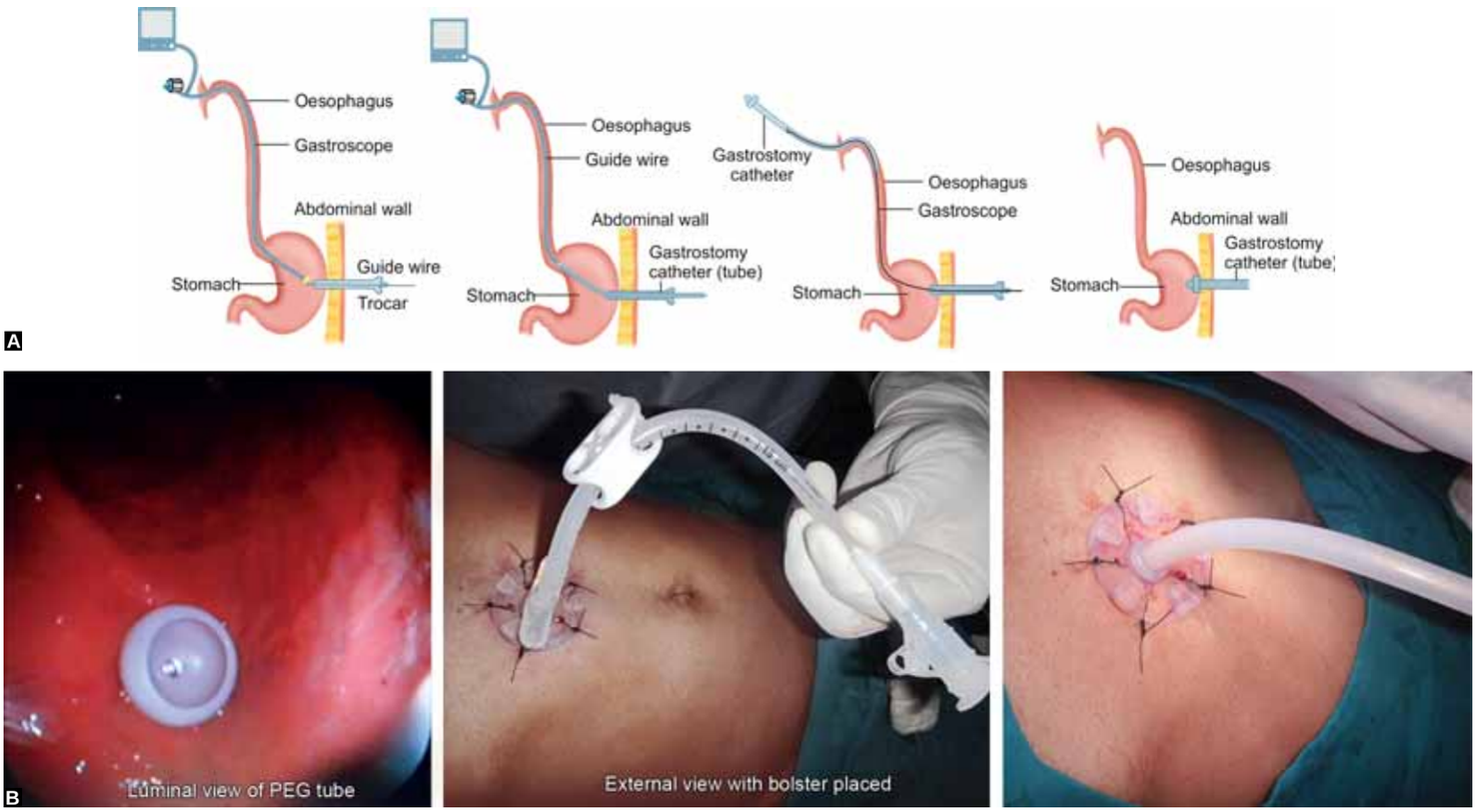


Figs 20-26(2)



Figs 20-26(3)

Figs 20-26(1 to 3): Janeway's permanent gastrostomy.



Figs 20-27A and B: Percutaneous endoscopic gastrostomy procedure.

(number 1) nylon or polyethylene or silk or guide wire is passed across the cannula into the stomach which is visualised through gastroscope. An endoscopic snare is passed through the working channel of the gastroscope into the stomach through which guide wire or nylon is held and pulled out along with endoscope. This causes guide wire or nylon to pass across the abdominal wall, stomach, oesophagus and mouth with one end in the abdominal wall and other end coming out through the mouth. Specialised PEG tube or de Pezzer catheter is tied to the guide wire or nylon at its oral end; nylon or guide wire at abdominal wall is pulled out with gentle traction until the PEG catheter or de Pezzer catheter comes and stays across the stomach and abdominal wall. Tube is fixed to the abdominal skin. Catheter position inside is confirmed by gastroscopy. An external bolster is kept on the tube to prevent migration. It is kept few mm away from the skin, usually by keeping sterile dressing pads or sponge underneath. Migration of PEG tube downwards may cause pylorus obstruction.

When one end of the guide wire/nylon brought out it is tied to the end of the PEG catheter and other end of the guide wire in the abdominal wall is pulled out to reach the PEG tube into the stomach and across the abdominal wall, it is called as "pull technique" which is the original method still popular. While pulling the tube, gastroscope is also passed from above to visualise the tube placement.

Instead of tying the guide wire end in the mouth to the PEG tube, PEG tube itself is pushed on to the guide wire across the mouth and is pushed by holding the guide wire ends at oral cavity, and at abdominal wall is held taut to reach the stomach and across the abdominal wall. Later gastroscopy is done to confirm the position, and guide wire is removed. It is called as "push technique".

Bowel interposition between stomach and abdominal wall is a real risk in PEG. Either small bowel or colon may get interposed. 'Safe tract' method (Foutch et al) can identify the bowel interposition. Here while passing the needle through the illuminated abdominal wall, skin incision continuous aspiration is created; if air gets aspirated before entering the endoscopically visible gastric lumen, it confirms the bowel interposition.

Feeding can be started in 48 hours. If needed catheter tube can be changed with a new one by railroad technique only after 4 weeks. Complications like skin infection, gastric wall necrosis, gastric leak, colon injury can occur occasionally.

Complications of PEG—Abdominal wall infection; migration of the gastrostomy tube; interposition of bowel (small or large) between stomach and abdominal wall while doing and getting injured is a real risk which may cause fatal peritonitis or external faecal fistula or gastrocolic fistula; separation of stomach wall from abdominal wall causing leak; inadvertent early pulling and extraction of the PEG tube which may settle spontaneously and only occasionally may need a laparotomy but observation of all such patients is a must.

Laparoscopic-assisted endoscopic gastrostomy is probably technically comfortable to a laparoscopic surgeon. Laparoscope is passed through an umbilical crease incision. With 15 mm Hg pneumoperitoneum, peritoneal cavity is inspected and proper site on anterior wall of the stomach is selected; pneumoperitoneum is reduced to 7 mm Hg. Four T fasteners are inserted into the peritoneal cavity to form a square pattern in the greater curvature and they are together held with traction to bring anterior wall of the stomach close to the abdominal wall; 16 gauge needle and guide wire or nylon is passed percutaneously through the abdominal wall into the stomach lumen. By doing gastroscopy, guide wire position may be confirmed and procedure may be continued by passing the PEG tube per orally across

guide wire which has been brought to mouth through gastroscope into anterior abdominal wall. Alternatively through a J guide wire across the needle into the gastric lumen and dilatation, PEG tube can be directly facilitated into the gastric lumen across the abdominal wall.

GASTROJEJUNOSTOMY

Gastrojejunostomy can be anterior or posterior or Roux-en-Y types. It can be antecolic or retrocolic. In palliative procedures, gastrectomies and antecolic anterior gastrojejunostomy are done. In chronic duodenal ulcer with pyloric stenosis after truncal vagotomy, posterior retrocolic gastrojejunostomy is done. Roux-en-Y gastrojejunostomy is done after subtotal high gastrectomy or in recurrent diseases or whenever there are complications after initial drainage procedures **(Fig. 20-28)**.

Anterior Gastrojejunostomy

Only gastrojejunostomy is done perhaps as a palliative procedure in gastric outlet obstruction due to advanced distal gastric tumour when patient is presenting with vomiting (by Wolfer). It is often done in advanced unresectable carcinoma of pancreas or duodenum with obstruction. Gastrojejunostomy along with gastric resection for malignancy is usually of antecolic type as mesocolon may get involved by the tumour or might have already involved.

Patient is kept with nasogastric tube. Often stomach wash using normal saline may be needed. Stomach wash is better given using a gastric tube like Ewald's. Electrolyte estimation, anaemia should be assessed. Adequate hydration with normal saline should be done.

Procedure is done under general anaesthesia. Upper midline incision is done. Abdomen is explored for secondaries in liver, peritoneum and ascites. Primary tumour is assessed for resectability. Advanced carcinoma can be resectable as palliation even though it is not operable with lymph node clearance. In fact, when possible resection is better palliation than gastrojejunostomy. Usually anterior gastrojejunostomy is done as a palliation. Posterior gastrojejunostomy is not possible in advanced carcinoma of stomach as posterior surface is not accessible and also often fixed. As anterior gastrojejunostomy is nondependent and takes more time to start functioning, it is better to add on enteroenterostomy between afferent and efferent loops (jejunojejunostomy – Braun's) **(Fig. 20-29)**.

Stomach, proximal to the growth/obstruction is selected. It should be mobile and more towards greater curvature. Two Babcock's forceps are used to hold the part of the anterior wall of the stomach at greater curvature proximally and distally for about 8 cm in between; often lower end may be slightly deviated towards the lesser curvature, but it is not mandatory. It is better to separate the greater omentum adjacent to the proposed gastrojejunostomy anastomotic site by ligating the branches of the gastroepiploic arcade for 8 cm.

Ligament of Treitz is identified at duodenojejunal junction; inferior mesenteric vein that runs underneath very closely is also a marker to identify the duodenojejunal junction. This step is essential to avoid inadvertent selection of ileal loop leading to disastrous wrong gastroileostomy. After opening, mucosal pattern also confirms the jejunum (valvulae conniventes mucosal folds). Thirty cm length of the jejunum is brought towards the selected part of the stomach as antecolic.

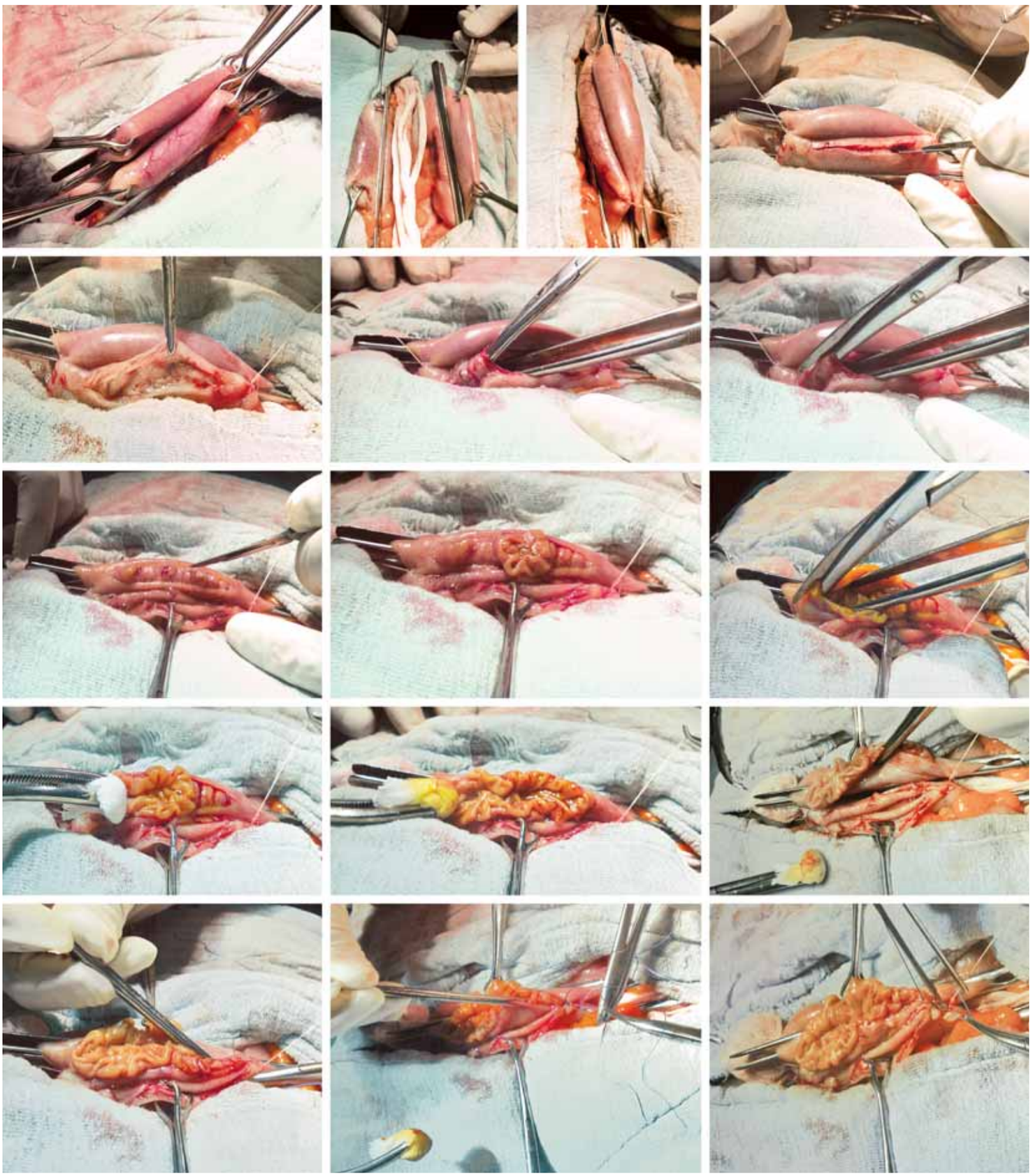
Segment of the jejunum is held parallel to the part of the stomach held with Babcock's forceps. Antimesenteric part of the jejunum is used for anastomosis. Stay sutures are placed using 3-0 silk or vicryl at the corners of the selected parts of the stomach and jejunum taking seromuscular bites from both stomach and jejunal corners. Two occlusion clamps are placed proximal to the selected parts of the stomach and jejunum. Clamps prevent bleeding from the cut edges, prevent spillage of the bowel contents into the peritoneal cavity and also to steady the bowel. (Presently many surgeons feel that occlusion clamps are not necessary as when cautery is used bleeding will not occur; spillage can be controlled by using good suction device; this is more true probably while doing retrocolic gastrojejunostomy, as applying occlusion clamp towards gastric side is more cumbersome; however in olden days, occlusion clamps like Carwardine's or Lane's twin clamps were used for the same). Wet gauze is often placed in between two bowel segments as a sausage to absorb the spilled contents posteriorly; but one should remember to remove it at the end **(Figs 20-30A and B)**.

Presently, it is proved that single layer interrupted (both edges two layers) or continuous 2 or 3 zero vicryl all layer sutures are sufficient. However whenever gastric wall oedema is present and nutrition is inadequate, two layers (both edges four layers) anastomosis is done. Here again, outer layer may be placed as continuous or interrupted seromuscular (Lembert in interrupted) sutures.

In four layer anastomosis, posterior seromuscular suture is placed as continuous or interrupted using silk sutures. In continuous type, sutures are placed from one end to other end for about 5–6 cm length each bite is taken at 5 mm interval; from the jejunal side, it is of practice that to take bite 5 mm posterior to the antimesenteric border so that later incision on the jejunum will run on the antimesenteric line; once it reaches other end, suture material with needle is kept in wet gauze which is again used at a later period for anterior seromuscular layer. During continuous suturing, once or twice knots may be placed in between to prevent loosening. Posterior seromuscular layer ideally should involve submucosa also, even though depth assessment is blind. In interrupted posterior seromuscular suturing, 3 zero silk is used in same place as continuous suture line; ideally all sutures are placed first and kept long; knots for each is tied afterwards; ends of tied sutures are not cut immediately instead are held upwards to give traction so that gastrotomy and enterotomy is done easily. Once opening is done in the stomach and jejunum ends of these sutures are cut. Stomach is incised first; then jejunum is incised; jejunal opening should be smaller than gastric opening as jejunal wall stretches and enlarges significantly.

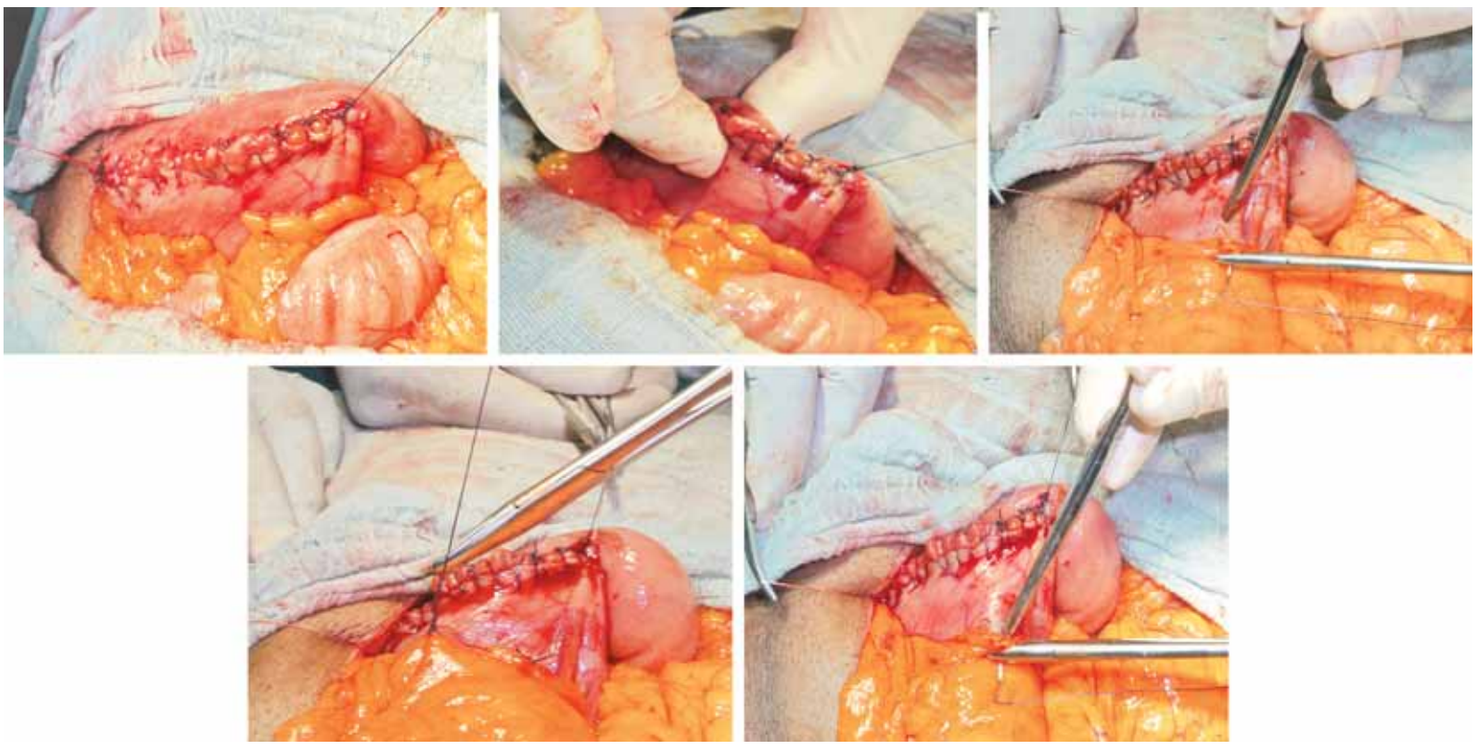
Anterior wall of the stomach is opened (gastrotomy) using number 15 blade or cautery for 5 cm; it runs 5 mm from the posterior seromuscular suture line. Ends of the cuts in gastric and jejunal side should be 1 cm shorter than posterior seromuscular suture line. It is often practiced to ligate small but definitive bleeders from the cut edges of the stomach using 4 zero vicryl (von Haberer submucosal sutures); however bipolar cauterization is more than sufficient for that. Gastric rugae mucosal pattern may be identified. Jejunum is opened using number 15 blade for corresponding length. First seromuscular layer is incised at full length; then mucosa is opened at one point; bile will exude out to confirm that lumen is exposed; nontoothed dissecting forceps placed into the lumen along the line of incision; using curved scissor rest of the jejunum part is incised. Jejunum also can be opened using cautery. Jejunal mucosa bulges out.

Second posterior all layer sutures are placed using 2-0 or 3-0 vicryl or silk. At the left angle, needle bites are taken from outside in of the gastric cut edge and inside out from jejunal cut edge which are tied with knots. Suture material is passed again into the lumen at the left angle; continuous sutures are taken as through and through all layers towards right side. Bites are taken at 2–5 mm intervals and 2–5 mm



Figs 20-28(1)

Figs 20-28(2)



Figs 20-28(3)

Figs 20-28(1 to 3): Gastrojejunostomy (GJ) technique. Note the isolation of the both gastric and jejunal parts; stay sutures; doing first gastrotomy and then jejunotomy; opening in the jejunum should be shorter than the gastric side; note the mucosal look and pattern of both gastric and jejunal wall; note the vessels in the cut edge of the gastric wall which can be ligated with 4 zero silk (von Haberer); note the posterior layer continuous suture and anterior inverting suture; clamps used are occlusion type ideally elliptical one; twin clamps can be used; stoma should be checked for patency; in posterior gastrojejunostomy, gastric wall should be fixed with interrupted seromuscular sutures to make stoma infracolic.

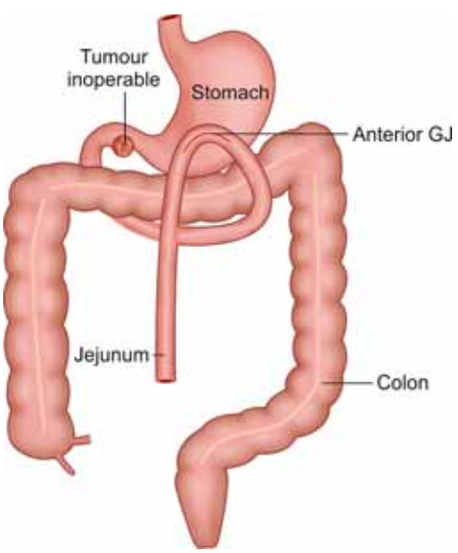
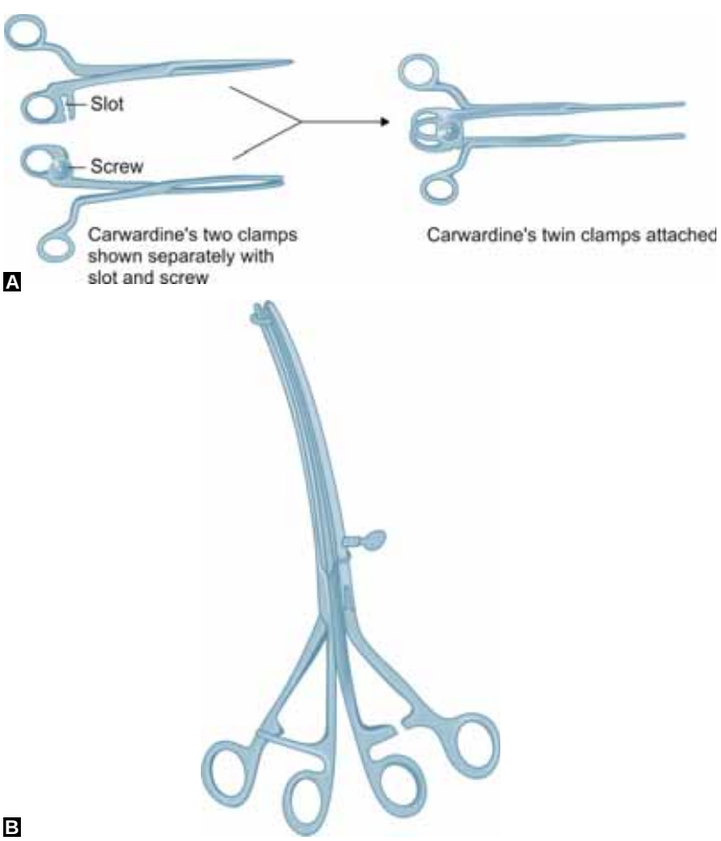


Fig. 20-29: Anterior gastrojejunostomy is done for advanced carcinoma of stomach.

from the edges. Care should be taken that all layers are included in the suture bites; less mucosa with more serosa is taken to avoid eversion but to create inversion. Once in 3-4 bites, locking of the suture is done to prevent purse string effect on the stoma. It is reached to the right edge.

Here needle bite is taken from inside-out of the jejunum at the angle and outside in of the stomach side to reach anterior wall and continue as anterior all layer (3rd layer) sutures. Continuous sutures of inside-out and outside-in can be taken. Connell stitch can be used here—with outside in of the stomach edge and inside out of the stomach edge



Figs 20-30A and B: Carwardine's twin clamp and or Lane's gastrojejunostomy clamp used for gastrojejunostomy.

again; then looping across the wound edge towards jejunal side to pass again outside-in and inside-out at jejunal edge which is again looped across towards stomach edge of the wound. This 3rd layer passes from right towards left. Prior to completion of the 3rd layer, it is often advisable to pass the nasogastric tube across the efferent loop. Near the left angle during ending, the suturing continues as through and through sutures. Last bite should pass beyond the beginning bite to avoid gap as a possible site of leak. Suture is tied to the end of the first bite suture. Second layer is also can be placed as interrupted all layer vicryl sutures.

Final 4th anterior seromuscular layer is placed, using already kept silk suture in the wet gauze after completion of the 1st layer. Bites as seromuscular inverting sutures are taken towards left end and are tied to the original end.

Corner sutures additionally may be placed, if needed. Stoma should admit two fingers to confirm adequacy. Patency and integrity of the stoma should be checked. Omentum can be wrapped around the stoma.

Often afferent and efferent loops are communicated with short enteroenterostomy (jejunojejunostomy) to avoid alkali reflux. It is done usually 20 cm from the gastrojejunostomy site. Patency and integrity of the stoma should be checked. Jejunojejunostomy is also done using stapler **(Fig. 20-31)**.

Gastrojejunostomy can also be done using stapling device. Stay suture is placed on the right side ends of the selected stomach and jejunum. Stomach and jejunum loop are brought together. Small gastrotomy and enterotomy are done in the left side of gastric and jejunal side. One fork of the linear cutting stapler device is inserted into the stomach side and other onto the gastric wall side. Both walls are adjusted properly with proper placing of the antimesenteric border of the jejunum. Device is locked; interpositions of other tissues are avoided by careful look; stapler is fired and removed accordingly. Staple line is observed for bleeding; such specific points are reinforced with 3 zero or 4 zero vicryl sutures. Gastrotomy and enterotomy wounds are closed using 3 zero vicryl continuous sutures. These both openings can also be closed using 55 mm linear stapler. Abdomen is closed in layers without keeping drain.

Posterior Gastrojejunostomy

It is done in case of duodenal ulcer after truncal vagotomy as a drainage procedure, especially whenever there is scarring and stenosis with gastric outlet obstruction. It is posterior, retrocolic, short afferent loop (5-8 cm), oblique or vertical gastrojejunostomy (of Mayo) with completed anastomosis lying in infracolic compartment. It is not commonly advocated in malignancy as tumour invasion of mesocolon may obstruct the gastrojejunostomy loop.

Preparation

Stomach wash is required using saline in case of gastric outlet obstruction. Electrolyte estimation, daily preoperative intravenous normal saline infusion, correction of alkalosis, magnesium deficiency are needed. Nasogastric tube is passed.

Technique

Upper midline incision is placed. Once truncal vagotomy is done, mop is kept in the vagotomy site which should be removed at the end prior to closure. Gastrocolic omentum is opened, through lesser sac posterior surface of the stomach is exposed **(Fig. 20-32)**.

Transverse colon is held forward through the laparotomy wound to expose transverse mesocolon. Through transillumination, middle colic vessels are identified. Avascular plane usually towards left of middle colic (but can be on either side) is identified; held with haemostat and opened (for 6-8 cm) to reach the posterior surface of the stomach which is brought through this rent in the mesocolon. Posterior surface of the gastric wall is held with Babcock's forceps on two sides—one at greater curvature (towards right), another at lesser curvature (towards left). (Greater curvature towards greater surgeon; lesser curvature towards lesser surgeon). Many advocate fixing the mesocolon edge to the stomach wall with interrupted 3 zero silk sutures 2 cm from the proposed gastrojejunostomy site to keep it infracolic. But it is usual practice to do this once anastomosis is over which allows the placement of occlusion clamps comfortably on the gastric wall side. First loop of the jejunum is identified by recognising duodenojejunal junction using ligament of Treitz and inferior mesenteric vein. Afferent loop should be only around 8 cm, unlike in anterior antecolic type. Occlusion clamps are placed on gastric and jejunal side. Sausage gauze can be kept between stomach and jejunal segments. Stay sutures are placed from corners of the selected parts of the stomach and jejunal wall using seromuscular 3 zero silk suture; Babcock's forceps can be removed. Posterior seromuscular continuous or interrupted 3 zero silk sutures are placed with each bites at 5 mm interval. (In single layer anastomosis, this step is not necessary) Gastric wall is opened using cautery or no. 15 blade and curved scissor. Jejunum is opened on the antimesenteric margin similarly. Jejunal opening should be less than gastric opening. Posterior all layer anastomosis is done using continuous 3 zero or 2 zero vicryl sutures; in between, locking achieved haemostasis becomes secure and prevents purse string effect on the stoma. It is continued as anterior all layer suturing using Connell suture or continuous sutures; it is tied to the original end of the vicryl. Then anterior seromuscular suture is placed as continuous or interrupted silk sutures. Clamps are removed; any bleeding points are controlled by suture. Stoma should allow two fingers through it. Mesocolon is sutured to stomach wall 1-2 cm away from the suture line (both anteriorly and posteriorly). It is done to prevent herniation of the small bowel through mesocolon (Stammers).

Variations in Technique

Traditional method is outer seromuscular using silk continuous sutures and inner all layer vicryl sutures. Outer seromuscular layer can be interrupted sutures. Inner layer is usually continuous.

Single all layer sutures using interrupted or continuous silk or vicryl can also be used for gastrojejunostomy.

Roux-en-Y gastrojejunostomy can be done in case of complications after gastrojejunostomy.

Stapler gastrojejunostomy reduces the operating time.

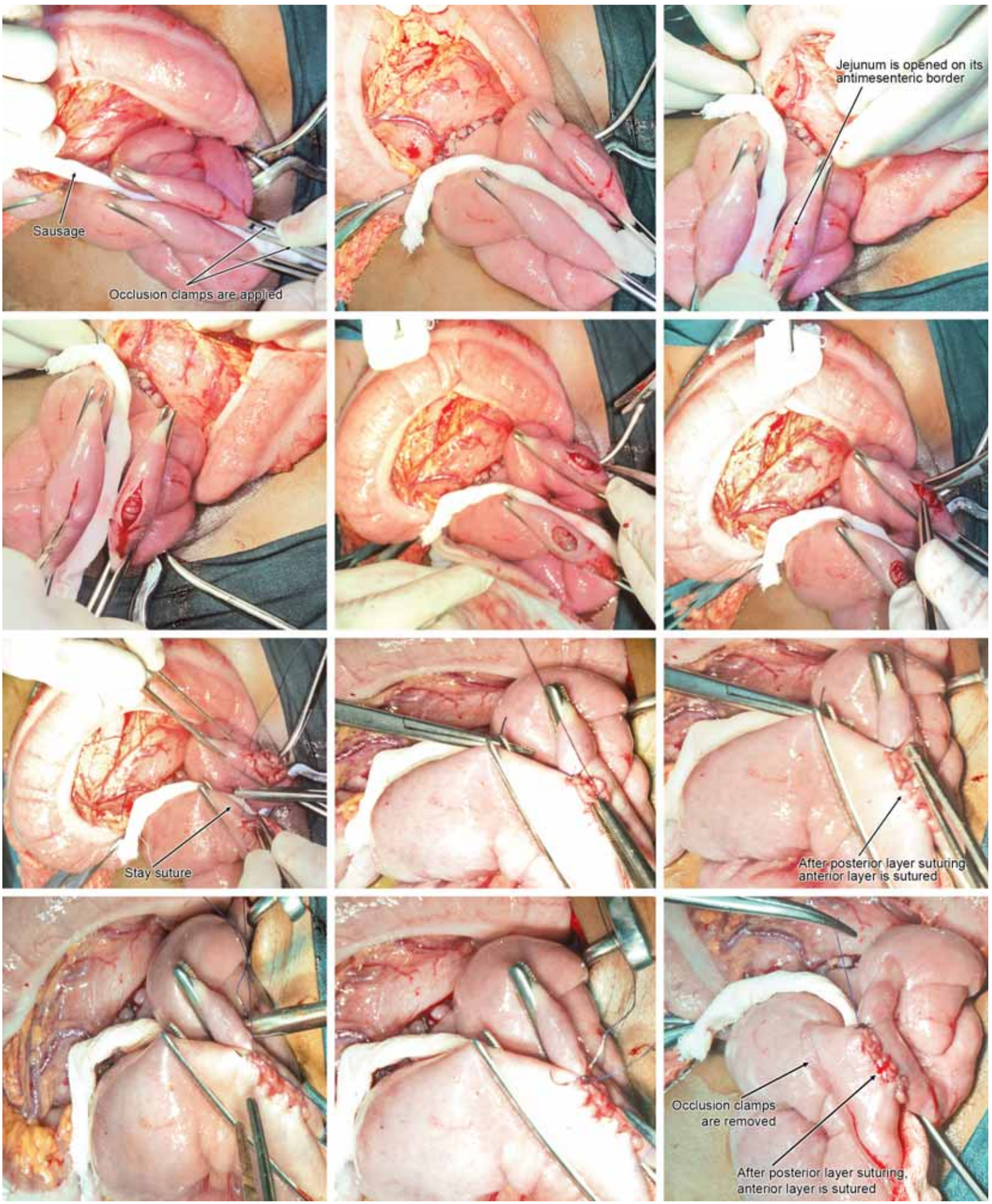
Postoperative Care

Nasogastric tube aspiration is continued for 3-5 days. Once nasogastric tube aspiration reduces to minimum, it is removed. Oral sips are started.

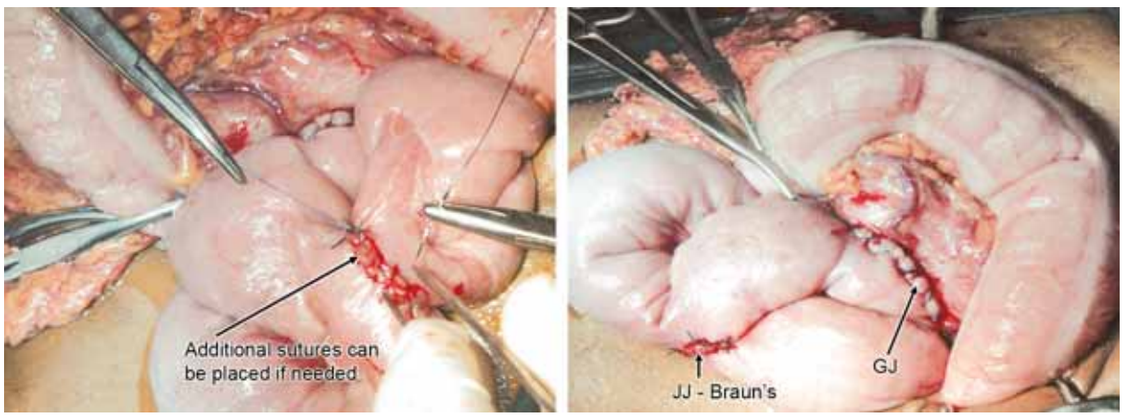
Intravenous fluid is given for first 5 days. Antibiotics may be needed.

Complications

Anastomotic bleeding (1.5%) can occur which is confirmed by blood in the nasogastric tube. It usually subsides in 24 hours. Rarely it may require reopening and placing additional suture at the bleeding point. Leak from the site may occur which again may need reexploration.


Sausage
Occlusion clamps are applied
Jejunum is opened on its antimesenteric border
Stay suture
After posterior layer suturing anterior layer is sutured
Occlusion clamps are removed
After posterior layer suturing, anterior layer is sutured

Figs 20-31(1)



Figs 20-31(2)

Fig. 20-31: Jejunojejunostomy between afferent and efferent loop.

Initial delayed gastric emptying is due to stomal oedema or suture line haematoma which resolves spontaneously. Haematoma is more common in stapled anastomosis as stapler is not entirely haemostatic.

Efferent loop obstruction can cause persistent vomiting. Delayed gastric emptying in spite of adequate anatomical stomal opening is often difficult to manage.

Twist in the mesentery can cause afferent loop obstruction. Afferent limb syndrome can occur if the afferent limb becomes larger than needed; it is due to accumulation of large quantity of bile in the lengthy afferent limb making it as a reservoir which impairs its motility leading to poor afferent loop emptying. This false reservoir empties at time together into the stomach causing bilious vomiting in the morning time.

Antecolic gastroenterostomy shows poorer gastric emptying; causes afferent loop syndrome and volvulus compared to retrocolic type.

Jejunogastric intussusception is rare but definitive complication which occurs in loop (omega) gastrojejunostomy only; not in Roux-en-Y type. In 80% cases efferent limb intussusception occurs; 20% cases afferent; rarely both. It causes acute abdomen pain, haematemesis, tender mass left side of the umbilicus. Contrast X-ray shows coiled spring appearance; gastroscopy is diagnostic. Treatment is surgical resection, doing gastrectomy and Roux-en-Y anastomosis.

VAGOTOMY

Dragstedt in 1940–1942 started vagotomy through thoracic approach. He also later in 1951 postulated that just vagotomy is not sufficient; drainage procedure is essential and truncal vagotomy should be combined with either pyloroplasty or gastrojejunostomy. It used to be the standard surgical therapy for peptic ulcer disease for around 40–50 years. Later selective and highly selective vagotomies became popular. However presently because of the availability of good drugs, surgical therapy is specified mostly for refractory duodenal ulcers, and complications like bleeding and pyloric stenosis. Truncal vagotomy and posterior gastrojejunostomy is more suitable for pyloric stenosis (gastric outlet obstruction) due to chronic duodenal ulcer. Proximal gastric vagotomy/PGV (highly selective vagotomy) is the procedure of choice with refractory ulcers. Grinding, propulsive and retropulsive action of antral mill (antral motility) mainly depend on vagal nerves through their nerves of Latarjet. It is essential to empty the solid food by grinding food into chyme then propelling across the pylorus. Liquid emptying is basically by pressure in the body and fundus of the stomach. Antral mill is weakened permanently by truncal vagotomy. Pyloroplasty is probably done whenever there is bleeding.

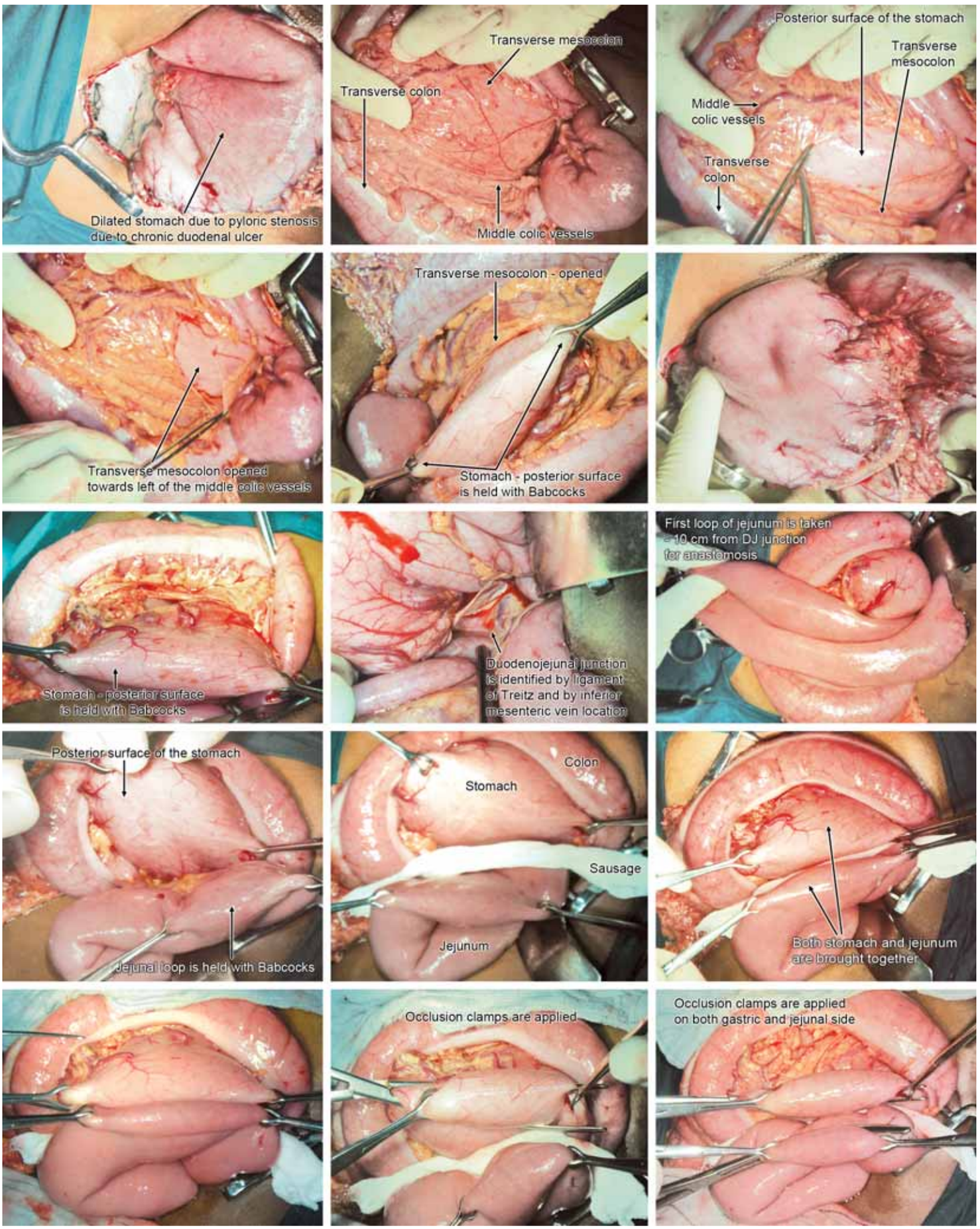
H2 receptor antagonist like ranitidine, should be discontinued 24 hours prior to surgery; Proton pump inhibitors (PPIs) should be discontinued 7 days prior to surgery. It restores the acidity of the gastric lumen which reverses the bacterial colonization of the stomach which is important especially when drainage procedure is undertaken to prevent sepsis.

Truncal Vagotomy

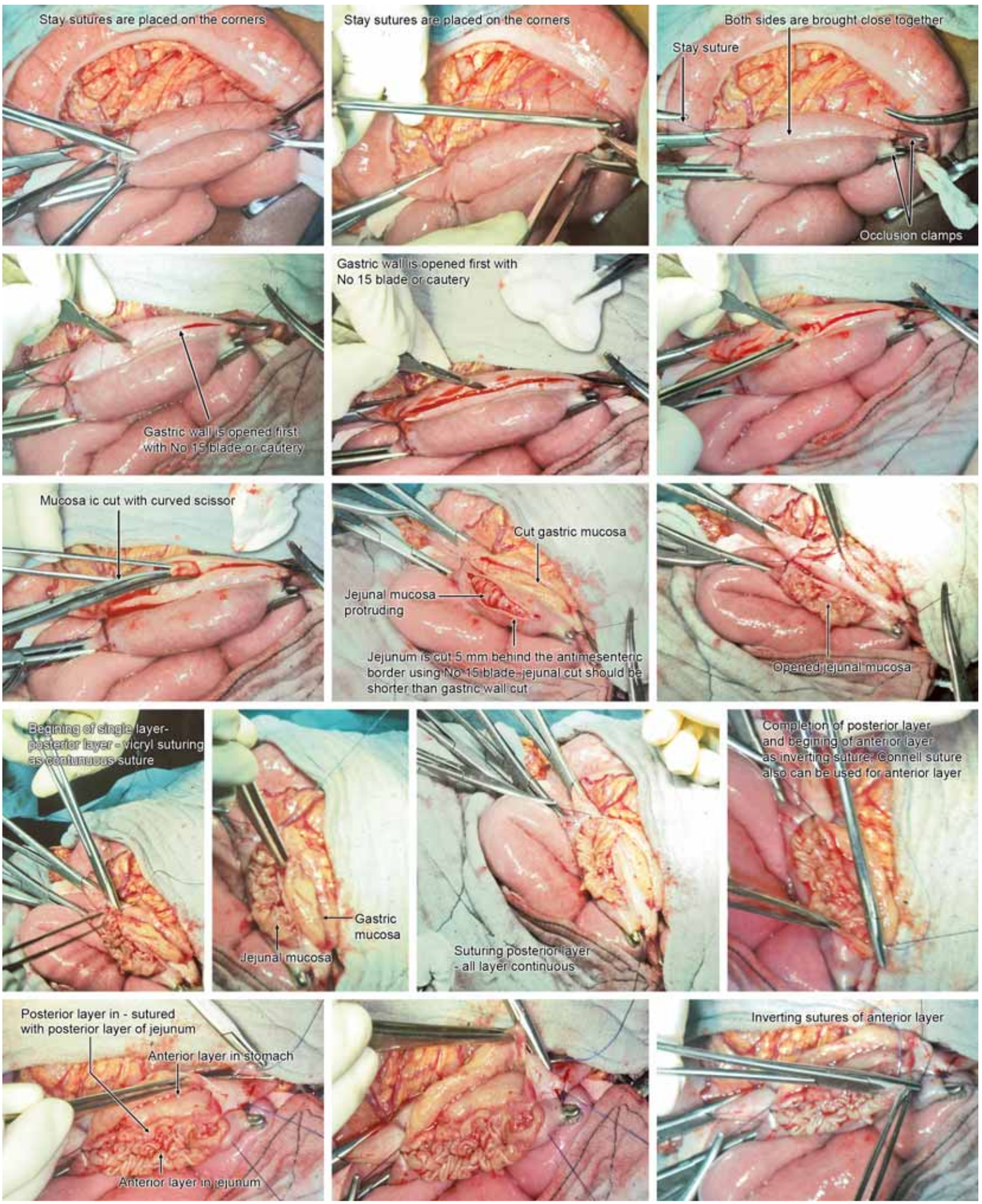
General anaesthesia is used. Nasogastric tube should be placed. Patient is placed in supine head up (reverse Trendelenburg) position. Upper midline incision is placed; often it is necessary to extend 3 cm proximal to xiphoid process and across the umbilicus. Occasionally, excision of the xiphoid process may be needed. In olden days, surgeons were using left upper paramedian incision. Now it is not practiced. Routine exploration is done after laparotomy. Duodenal ulcer is identified with scarring, deformed duodenum and dilated stomach. Cayenne pepper look may be evident on the surface. Head of the pancreas should be examined for possible presence of the gastrinoma, of course it is often difficult to feel on table as lesion may be small. It is better if gastrinoma is suspected to do specific evaluation like serum gastrin estimation and multidetector CT (MDCT) abdomen.

Left triangular ligament is divided if needed, even though it is not necessary always. Inferior phrenic vein which is on the extreme right extent of the ligament should not be injured. Left lobe of the liver is folded towards right to expose the hiatus properly. Self retaining retractor is placed. Assistant is asked to hold the greater curvature of the stomach with wet mop to give traction downwards and towards left gently. This makes vagus taut to feel like string. Peritoneum on the front of the hiatus is incised and opened horizontally to expose the anterior surface of the oesophagus. Dissection begins on the left side of the hiatus. Index finger is passed gently from left side behind the oesophagus towards right side by breaking loose areolar tissue; any small vessels if encountered are fulgurated with bipolar cautery. Nasogastric tube inside oesophagus guides the dissection as well. Posteriorly aortic pulsation can be felt. Gently hepatogastric ligament is incised on the right side to allow index finger to pass and encircle the hiatus; with further blunt, sharp and cautery dissection hiatus is dissected properly. Infant feeding tube or Penrose drain is encircled around hiatus to facilitate the traction. With traction towards left and downwards, hiatus is further dissected posteriorly.

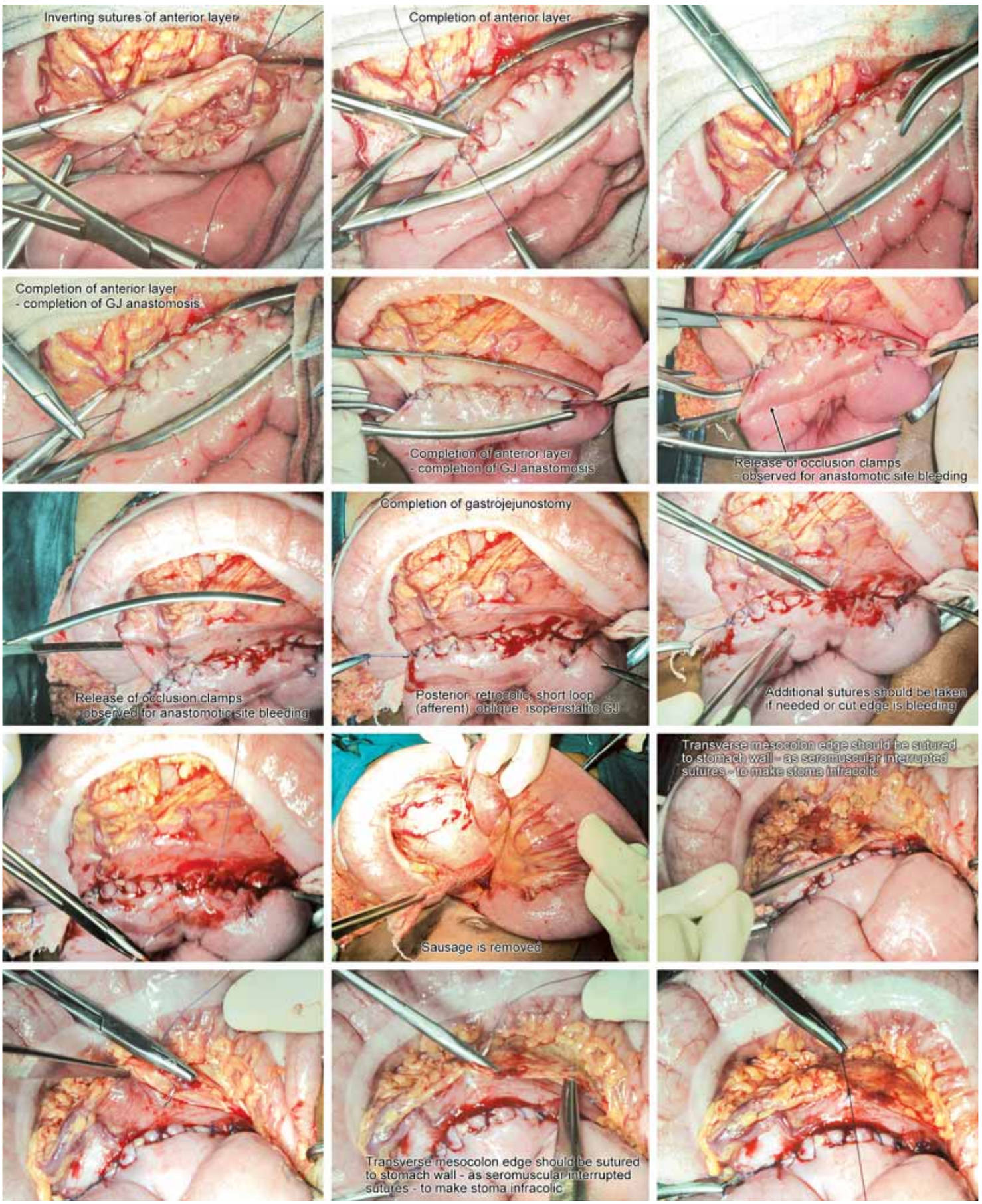
First anterior vagotomy is done. Anterior vagal trunk is felt like string while running finger in front of the oesophagus. Traction on stomach below is continued. Vagus is dissected of the oesophagus using right


Dilated stomach due to pyloric stenosis due to chronic duodenal ulcer
Transverse mesocolon
Transverse colon
Middle colic vessels
Posterior surface of the stomach
Transverse mesocolon
Middle colic vessels
Transverse colon
Transverse mesocolon opened towards left of the middle colic vessels
Transverse mesocolon - opened
Stomach - posterior surface is held with Babcocks
Stomach - posterior surface is held with Babcocks
Duodenojejunal junction is identified by ligament of Treitz and by inferior mesenteric vein location
First loop of jejunum is taken - 10 cm from DJ junction for anastomosis
Posterior surface of the stomach
Jejunal loop is held with Babcocks
Colon
Stomach
Sausage
Jejunum
Both stomach and jejunum are brought together
Occlusion clamps are applied
Occlusion clamps are applied on both gastric and jejunal side

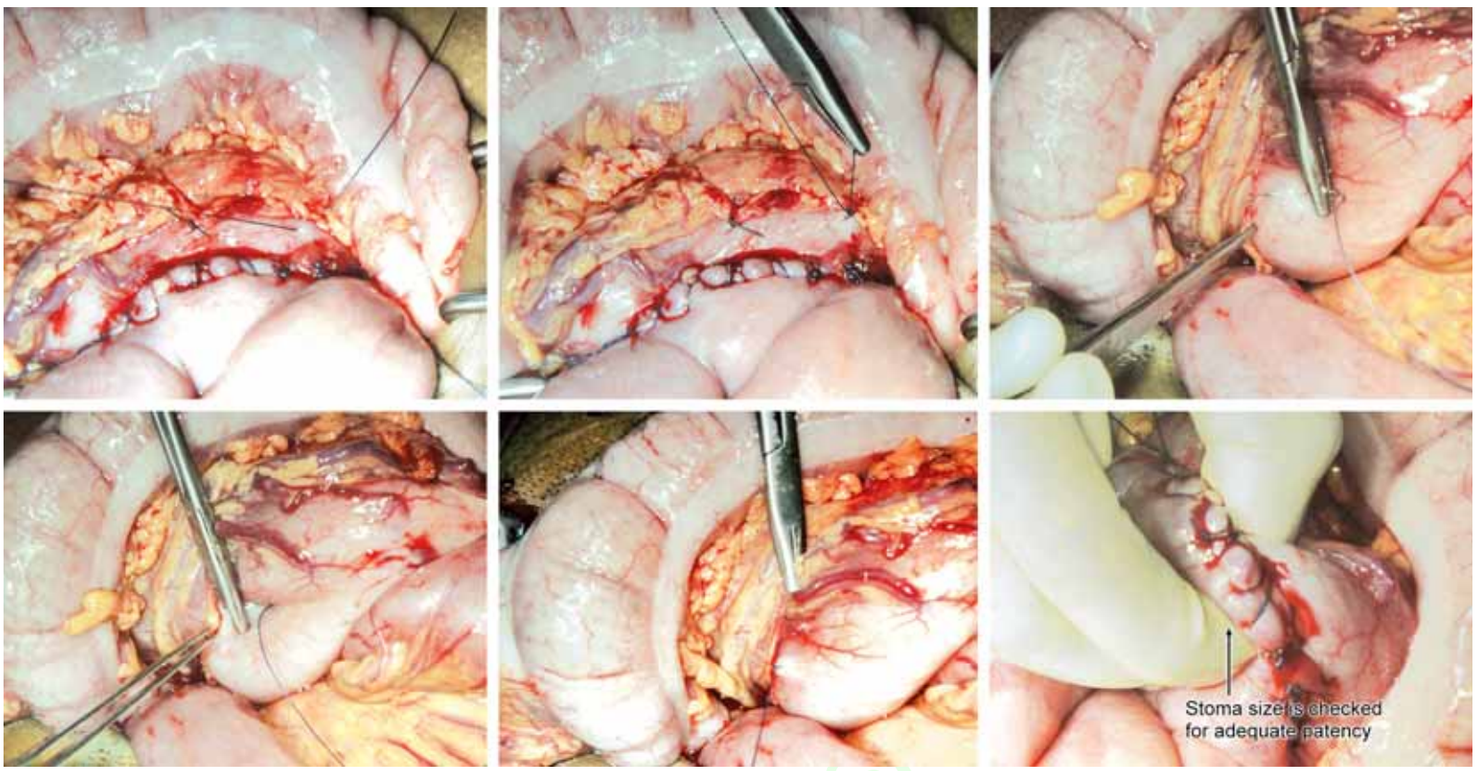
Figs 20-32(1)


Stay sutures are placed on the corners
Stay sutures are placed on the corners
Both sides are brought close together
Stay suture
Occlusion clamps
Gastric wall is opened first with No 15 blade or cautery
Gastric wall is opened first with No 15 blade or cautery
Mucosa ic cut with curved scissor
Cut gastric mucosa
Jejunal mucosa protruding
Jejunum is cut 5 mm behind the antimesenteric border using No 15 blade- jejunal cut should be shorter than gastric wall cut
Opened jejunal mucosa
Begining of single layer- posterior layer - vicryl suturing as continuous suture
Gastric mucosa
Jejunal mucosa
Suturing posterior layer - all layer continuous
Completion of posterior layer and begining of anterior layer as inverting suture. Connell suture also can be used for anterior layer
Posterior layer in - sutured with posterior layer of jejunum
Anterior layer in stomach
Anterior layer in jejunum
Inverting sutures of anterior layer

Figs 20-32(2)


Inverting sutures of anterior layer
Completion of anterior layer
Completion of anterior layer
- completion of GJ anastomosis
Completion of anterior layer
- completion of GJ anastomosis
Release of occlusion clamps
- observed for anastomotic site bleeding
Release of occlusion clamps
- observed for anastomotic site bleeding
Completion of gastrojejunostomy
Posterior, retrocolic, short loop
(afferent), oblique, isoperistaltic GJ
Additional sutures should be taken
if needed or cut edge is bleeding
Sausage is removed
Transverse mesocolon edge should be sutured
to stomach wall - as seromuscular interrupted
sutures - to make stoma infracolic
Transverse mesocolon edge should be sutured
to stomach wall - as seromuscular interrupted
sutures - to make stoma infracolic

Figs 20-32(3)



Figs 20-32(4)

Figs 20-32(1 to 4): Posterior gastrojejunostomy—technique.

angled forceps; any small bleeders should be fulgurated with bipolar forceps. Nerve hook may be used for dissection. About 2-3 cm length of the nerve is dissected. Two long curved haemostats are placed on the dissected nerve. Nerve segment (1cm) is excised between clamps. It should be placed in a bottle for biopsy with anterior vagus as label. Vagal ends are ligated with 2 zero silk suture. Long suture is needed to pass the ligature around. Additional anterior vagal trunks may be present in 40% of individuals and they should be dissected and cut. Small nerve fibres should also be divided. It is done by giving traction to the greater curvature **(Fig. 20-33)**.

Posterior vagotomy is done next. This nerve is more away from the oesophageal wall, unlike anterior trunk. Often it may be on the right crus of diaphragm. Oesophagus is held towards left; on the hiatus towards right, gentle dissection helps to identify it. It is thicker than anterior vagus. It is also similarly clamped, divided and excised (1 cm) and cut ends are ligated with silk. Posterior vagus often is associated with a significant sized vein which if get disrupted can cause bleeding. It is again sent for biopsy in separate bottle. Lower oesophagus for 7 cm is dissected meticulously and all nerve branches are identified and divided. Criminal nerve of Grassi is behind the hiatus; it also should be divided. Nerve fibres along the fundus and angle of His are also dissected and divided. Entire OG junction and lower oesophagus should be cleared of the nerve branches to avoid incomplete vagotomy and so recurrence of ulcer. Posterior vagus is commonly a single trunk unlike anterior vagus. Incidence of additional posterior vagal trunk is only 5%. Communicating trunk to anterior vagus is often present which should also be divided. Missing of posterior vagus is common and intact posterior vagus is one of the common causes of incomplete vagotomy. Posterior vagotomy is done often in different methods. First index finger is passed left of the hiatus behind the OG junction and with traction on the stomach, posterior vagus can be felt as a string like thick structure which is hooked with index finger from left to delineate left side and forward; it is clamped, 1 cm of it is excised and ligated by surgeon or assistant similarly. In another modification, entire hiatal dissection is not necessary. Only right side is dissected to identify the posterior vagus to complete the vagotomy. Coeliac branch is in a constant position as a constant single trunk which is identified close to the left gastric artery; if this branch is traced upwards, posterior vagal trunk is identified. This avoids extensive dissection and prevents complication. Truncal vagotomy should be completed with a drainage procedure like posterior gastrojejunostomy **(Figs 20-34 and 20-35)**.

Note:

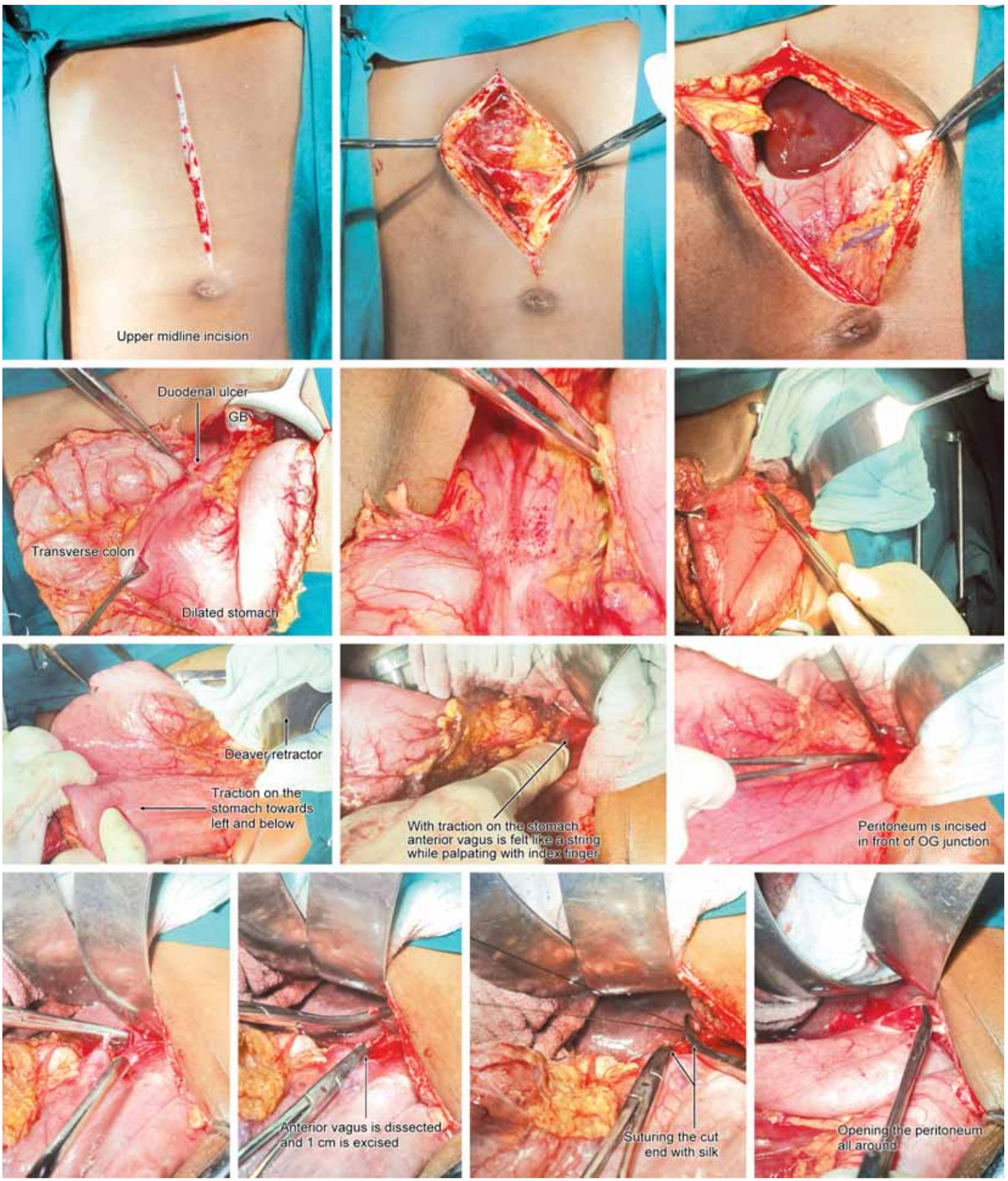
Truncal vagotomy can be done through laparoscopy also. Vagotomy with antrectomy also can be done which reduces the ulcer forming area of the stomach and also reduces the gastrin release (gastrin is released from G cells of the antrum).

Proximal Gastric Vagotomy (PGV)

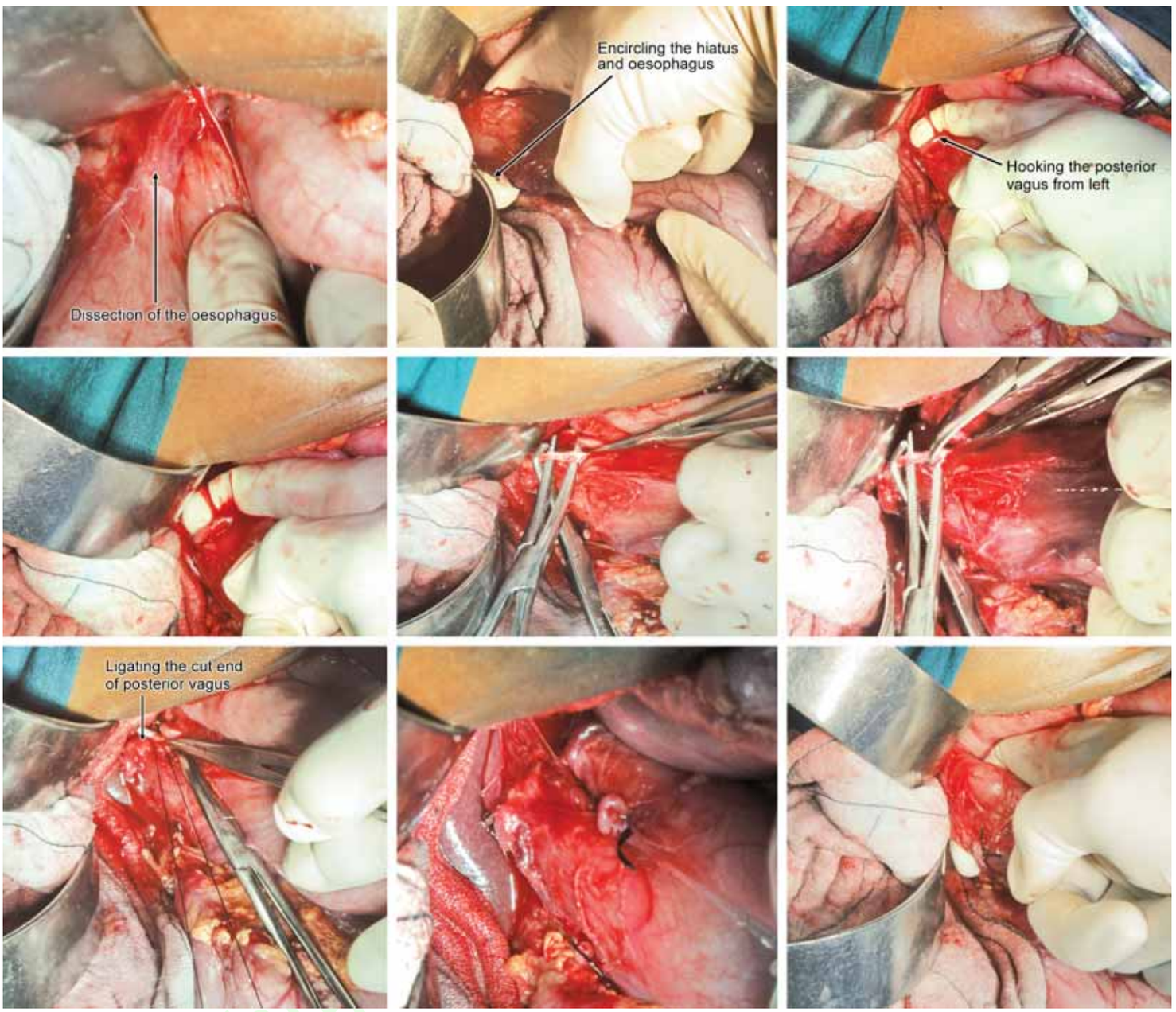
It is also called as parietal cell vagotomy (PCV) or highly selective vagotomy (HSV) or superselective vagotomy. It denervates the supply of cells in fundus and body specifically. Meantime, it preserves antropyloric gastric emptying function. PGV reduces both acid and pepsin secretion. PGV was first described by Amdrup and Johnston in 1969.

Indications

PGV is useful in refractory/intractable duodenal ulcer; repeated recurrences by drug therapy, perforated duodenal ulcer when presents within 24 hours; selected bleeding duodenal ulcers in females. PGV is not useful in gastric outlet obstruction due to duodenal ulcer.


Upper midline incision
Duodenal ulcer
GB
Transverse colon
Dilated stomach
Deaver retractor
Traction on the stomach towards left and below
With traction on the stomach anterior vagus is felt like a string while palpating with index finger
Peritoneum is incised in front of OG junction
Anterior vagus is dissected and 1 cm is excised
Suturing the cut end with silk
Opening the peritoneum all around

Figs 20-33(1)


Dissection of the oesophagus
Encircling the hiatus and oesophagus
Hooking the posterior vagus from left
Ligating the cut end of posterior vagus

Figs 20-33(2)

Figs 20-33(1 and 2): Technique of open truncal vagotomy.

Advantages

It is safer with less than 0.3% mortality. Dumping syndrome or diarrhoea is not known. Antral pump is retained and so drainage procedure is not needed. Basal acid secretion reduces to 80%; maximum acid response to stimuli (pentagastrin) is reduced to 60%. Developing anaemia, tuberculosis, osteoporosis, and carcinoma are not present.

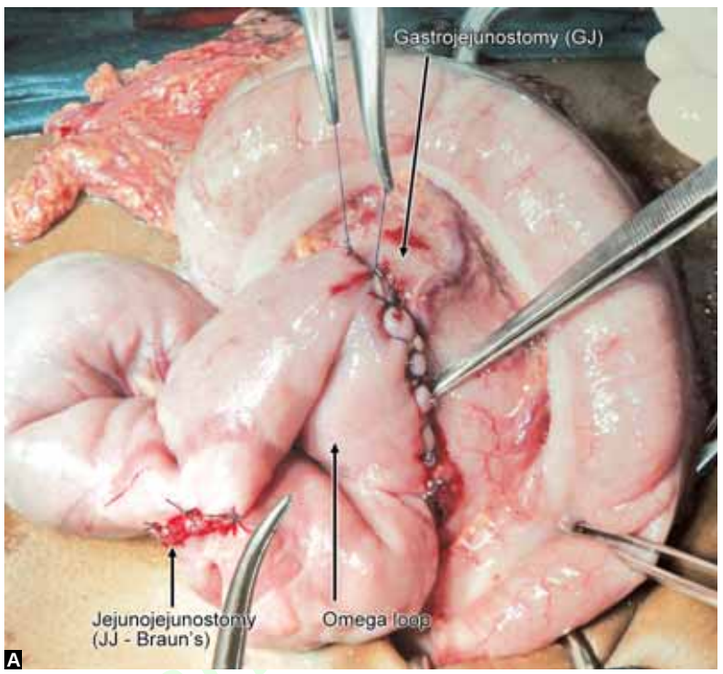
Disadvantages

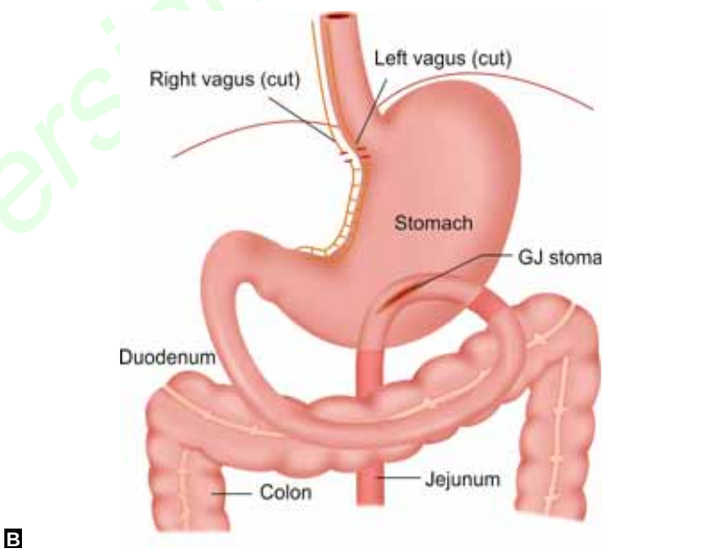
Lesser curve necrosis even though is rare but is a definitive complication. Ulcer recurrence rate is higher which is 10-15%. Dissection on the proximal part along the OG junction, angle of His and distal 7-8 cm of oesophagus is most crucial to prevent recurrence or to avoid failure due to incomplete vagotomy.

Technique

Preparation, position, incision are same as truncal vagotomy. Many surgeons suggest that hiatus should be dissected early with identification and dissection of vagal trunks first. It is probably not necessary or may be an option for individual surgeon. Oesophageal hiatus is mobilised using index finger and encircled with a Penrose or infant feeding tube. Anterior vagal trunk is carefully felt and identified; it is dissected gently and slinged using silk suture material or vascular slings. Similarly posterior vagus is dissected on the right side of the hiatus, and slinged. Greater curvature is mobilised; posterior surface of the stomach is also mobilised. Anterior PGV is done first. Crow's foot is identified. PGV begins from uppermost branch of the crow's foot; if crow's foot is not obvious then at a point of 6 cm from the prepyloric vein of Mayo (pylorus) dissection begins. A stay suture

Fig. 20-34: Barium meal X-ray showing gastric outlet obstruction due to pyloric stenosis due to chronic duodenal ulcer.





Figs 20-35A and B: Posterior, vertical, short loop, retrocolic gastrojejunostomy of Mayo. Vagotomy should be combined with gastrojejunostomy.

using 3 zero silk is placed at this point on the lesser curvature. Lesser omentum where it joins the lesser curve shows three distinct layers, if carefully dissected; first anterior layer gastric branches of anterior vagus; 3rd posterior layer gastric branches of posterior vagus; middle a loose areolar tissue. PGV begins always from distal to proximal. Gastric branches are very closely associated with vessels entering the stomach at lesser curvature, even though their directions are different (vessels are transverse; nerves are oblique). Using a fine haemostat, vessels are clamped, divided and tied using 3 zero silk individually very close to the gastric wall. It is often better to dissect the vessels for adequate length before passing a ligature towards lesser curve side followed by placing a haemostat on the lesser curve side to cut in between. This prevents bleeding and haematoma formation. It is continued up to the OG junction and later extends in front of the oesophagus towards left beyond the angle of His. Haemoclips and cautery should not be used. Haemoclip may slip causing bleeding and preventing further dissection properly. Cautery may transmit the energy along the nerve of Latarjet. Once anterior leaf is dissected and denerved properly, posterior vagotomy begins. Crow's foot in posterior vagus is not identified. Dissection begins 6-7 cm from the pylorus towards proximally along the posterior leaf of the lesser omentum very close to the lesser curvature of the stomach. Devascularisation with denervation is done similarly from below upwards towards OG junction; near OG junction criminal nerve of Grassi is identified which crosses behind the oesophagus. Often stomach is rotated to dissect the posterior part properly; but it is not necessary. One has to remember that stomach wall should not be included in ligatures.

Distal 8 cm oesophagus should be denerved properly and completely. Anterior vagus is gently retracted towards right and all nerve fibres are felt and divided carefully. Often fibres embedded in the oesophageal muscle are also divided; fibres along the angle of His are also divided. Posterior vagus is retracted towards right and OG junction towards left; distal 8 cm of posterior oesophagus is again cleared of all nerve fibres.

Entire lengths of both vagi are dissected completely and both nerves of Latarjet are visualised. Slings and Penrose rain are removed. Lesser curvature of the stomach is imbricated with 3-zero silk suture to prevent the devascularisation, perforation or lesser curve necrosis; it also prevents the nerve regeneration.

Gastroepiploic nerve along with the right gastric and epiploic artery when present should be divided. It is divided at the junction of the right and left gastroepiploic artery. Adding this, is called as extended proximal gastric vagotomy.

Ontable tests (intraoperative) are often used to confirm the completion of vagotomy. *Burge test*; ontable oesophagus and pylorus is closed to convert into a closed system; vagus nerve is electrically stimulated; intragastric pressure is recorded using a manometer; pressure rises in incomplete vagotomy. *Grassi test*; pentagastrin is injected intravenously during intraoperative period; gastrotomy is done; pH of the gastric mucosa is assessed before and after vagotomy; pH is less than 2.5 before, but more than 5.5 after vagotomy.

Complications of Vagotomy

Intraoperative

When left triangular ligament is mobilised more than usual, it may cause injury to the hepatic and phrenic veins causing bleeding.

Splenic injury even though rare can occur while retracting spleen towards left. It is more often seen in enlarged spleen. It can occur also during traction over the greater curvature of the stomach and whenever there are fibrous adhesions between spleen and greater curvature of the stomach.

Oesophageal laceration can occur when hiatus is mobilised from left side with index finger. Laceration usually occurs on the right posterolateral oesophageal wall. Tear should be exposed by rotating the oesophageal wall and is sutured with interrupted silk sutures. Often Nissen's fundoplication wrap may be useful. Nasogastric tube should be kept in situ for 7-10 days postoperatively. Injury is more while doing revagotomy or in patients with any previous upper abdominal surgery.

Other rare but known complications are—pneumothorax; oesophagogastric disruption; distal pancreatic injury; thoracic duct injury.

Early Complications

Gastric atony can occur due to altered gastric pacesetter potential, and normal propagation of peristalsis is altered. Ectopic pacemaker may appear which reduces the normal fundal pacemaker function leading into gastric atony. Atony leads into delayed emptying. Contrast (water soluble) study will show emptying of the gastric content but slowly. Endoscopy reveals widely opened stoma.

Transient dysphagia is seen in 10% of patients. It is due to temporary operative trauma; less commonly due to vagotomy.

Lesser curve necrosis (0.3%) occurs in 72 hours. They present with toxicity and features of perforation. It is initially thought due to devascularisation; but probably, it is due to gastric distension which causes compression on vascular network in already ligated vascular area. It requires reexploration, excision of the necrosed area, until it bleeds and resuturing. Jejunostomy may be required. Gastrectomy may also be needed.

Subphrenic abscess formation due to sepsis can occur. Occasionally infection may spread above to cause dreaded mediastinitis.

Long-term Complications

Twenty percent of truncal, 3% of selective, 1% of proximal gastric vagotomy will develop bowel disturbances like diarrhoea. It is episodic, with urgency of passage of mucus and flatus and stool. Truncal vagotomy can cause severe disabling diarrhoea in 1% of patients. Stasis, hypoacidity with bacterial overgrowth, changes in intestinal villi, altered biliary and pancreatic exocrine function, dysmotility of small bowel are the probable causes. It usually gets controlled with passage of time. Restriction of fluid, carbohydrate and milk products, neomycin, loperamide, codeine, cholestyramine are the treatments for vagotomy diarrhoea. Severe disabling persistent incapacitating diarrhoea (20 times a day stool with incontinence) needs surgical correction. Reverse jejunal interposition is the treatment.

Disruption of crural fibres due to dissection may cause reflux oesophagitis and later stricture formation.

Truncal vagotomy increases the incidence of gallstone formation. Because of hepatic divisions, gallbladder becomes hypotonic; decreased release of cholecystokinin from the duodenum is also the cause for gallstone formation.

PYLOROPLASTY

It is done in case of bleeding duodenal ulcer. Though this bleeding is controlled by various methods. It is also done as part of the procedure in creation of gastric reservoir for oesophageal substitution or bypass, if pyloromyotomy is not undertaken or not possible **(Fig. 20-36)**.

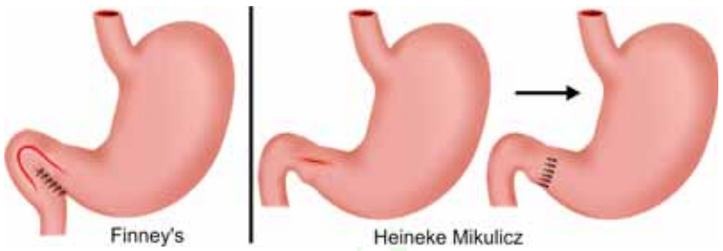


Fig. 20-36: Types of pyloroplasty.

Types of Pyloroplasty

Heineke–Mikulicz pyloroplasty

Upper midline incision is used for laparotomy. Duodenum is mobilised by Kocherisation. Peritoneum is held on the lateral part of the 2nd part of the duodenum and is incised along the margin of the duodenum. Finger dissection further facilitates the mobilisation. Avascular lateral duodenal ligament that runs between duodenum and retroperitoneum is also divided. Curved scissor and cautery can be used for the same. About 5 – 6 cm incision is made along the lower antrum, pylorus and 1st part of the duodenum longitudinally to its entire thickness. Bleeding points are cauterized using bipolar cautery. Opened pyloroduodenotomy wound is closed transversely as full thickness interrupted 3 zero vicryl or silk sutures **(Fig. 20-37)**.

First midpoint suture is placed; then sutures are placed on either side. Once midpoint suture is placed and is held long with a haemostat, remaining sutures are placed from one corner towards middle on either side. Second seromuscular suture is also placed often but it is difficult as it often tears. If there is no tear interrupted, seromuscular sutures can be placed, but it is not mandatory. Omentum is wrapped around it as a secure. Stapling closure also can be done easily using 55–4.8 mm linear stapler.

Emergency Surgical Management of Bleeding Duodenal Ulcer

Bleeding from duodenal ulcer is either from the small vessels in the wall of ulcer crater or due to erosion into the gastroduodenal artery.

Precipitating causes are—alcohol, NSAIDs, steroids, excessive fibrosis and atherosclerotic disease.

Forrest classification of bleeding or bled ulcer

- Ia Spurting and bleeding
- Ib Nonspurting but active bleeding
- IIa Visible vessel with red or blue protrusion or pulsatile pseudoaneurysm
- IIb Nonbleeding ulcer with clot overlying
- IIc Ulcer with haematin base
- III Clean ulcer—no clot, no vessel

Usually posterior duodenal ulcer bleeds; bleeding from small vessels in the wall of ulcer is due to sloughing of the ulcer. It is less severe,

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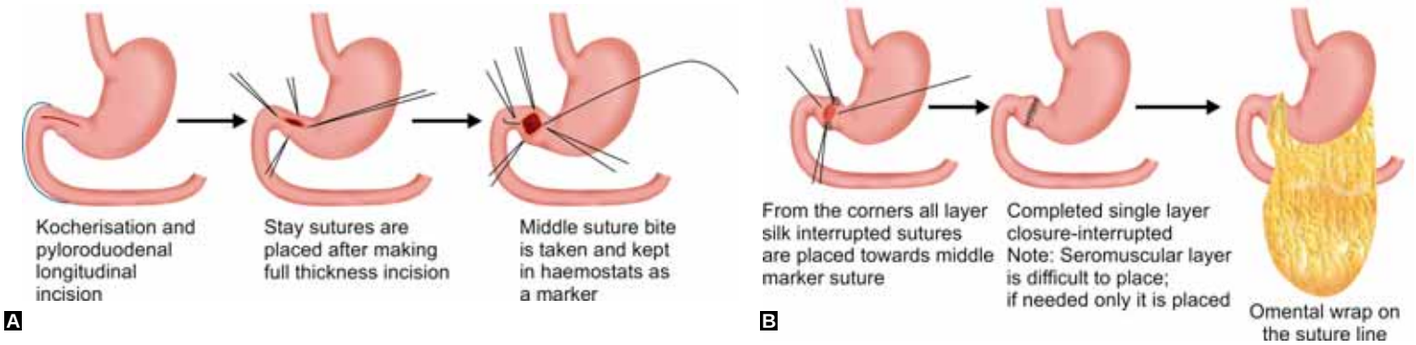
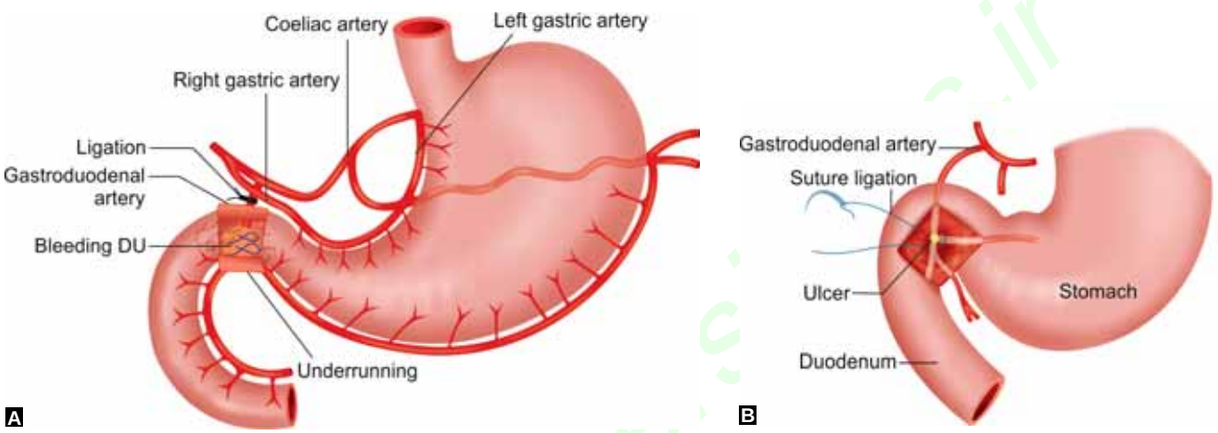

Kocherisation and pyloroduodenal longitudinal incision
Stay sutures are placed after making full thickness incision
Middle suture bite is taken and kept in haemostats as a marker
A
From the corners all layer silk interrupted sutures are placed towards middle marker suture
Completed single layer closure-interrupted Note: Seromuscular layer is difficult to place; if needed only it is placed
Omental wrap on the suture line
B

Figs 20-37A and B: Heineke–Mikulicz pyloroplasty.



Figs 20-38A and B: Bleeding duodenal ulcer is treated by underrunning the ulcer bed or ligating the gastroduodenal artery in two places.

gradual and often well-controlled by conservative treatment. Bleeding from erosion of gastroduodenal artery is severe, torrential and almost always needs early surgical intervention **(Fig. 20-38)**.

Indications for surgical treatment: In spite of conservative treatment, condition of patient deteriorates; bleeding from gastroduodenal artery; recurrent bleeding; elderly patient; if more than 4 units of blood required immediately.

Technique

After laparotomy, adequate Kocherisation is done. Pyloric channel and first part of the duodenum (gastroduodenum) are opened longitudinally, bleeder is identified. Underruning of the bleeding area with 2 zero silk or vicryl is done. Proximal and distal bleeding points are transfixed using 2 zero silk sutures. Deep transverse pancreatic artery which is a deep posterior branch of gastroduodenal artery should be occluded by placing a deep middle transfixing suture in the ulcer bed. If the bleed is from gastroduodenal artery, then it has to be ligated to stop the bleeding. It is done by dissecting above the duodenum where it originates from the common hepatic artery. Aneurysm needle may be used to pass a secure ligature around. Gastroduodenal artery also often needs to be ligated inferiorly to prevent backflow of blood; it is ligated below after defining and dissecting just above the origin of the right gastroepiploic artery. Keeping 5 mm distance from the origin, it is securely ligated with transfixation sutures using 2 zero silk. Opened gastroduodenum is closed by ***Finney's pyloroplasty.*** Truncal vagotomy may be done together, if only the general condition of the patient is good.

Finney's Pyloroplasty (1922)

It is done in bleeding duodenal ulcer and when wide pyloroplasty is needed.

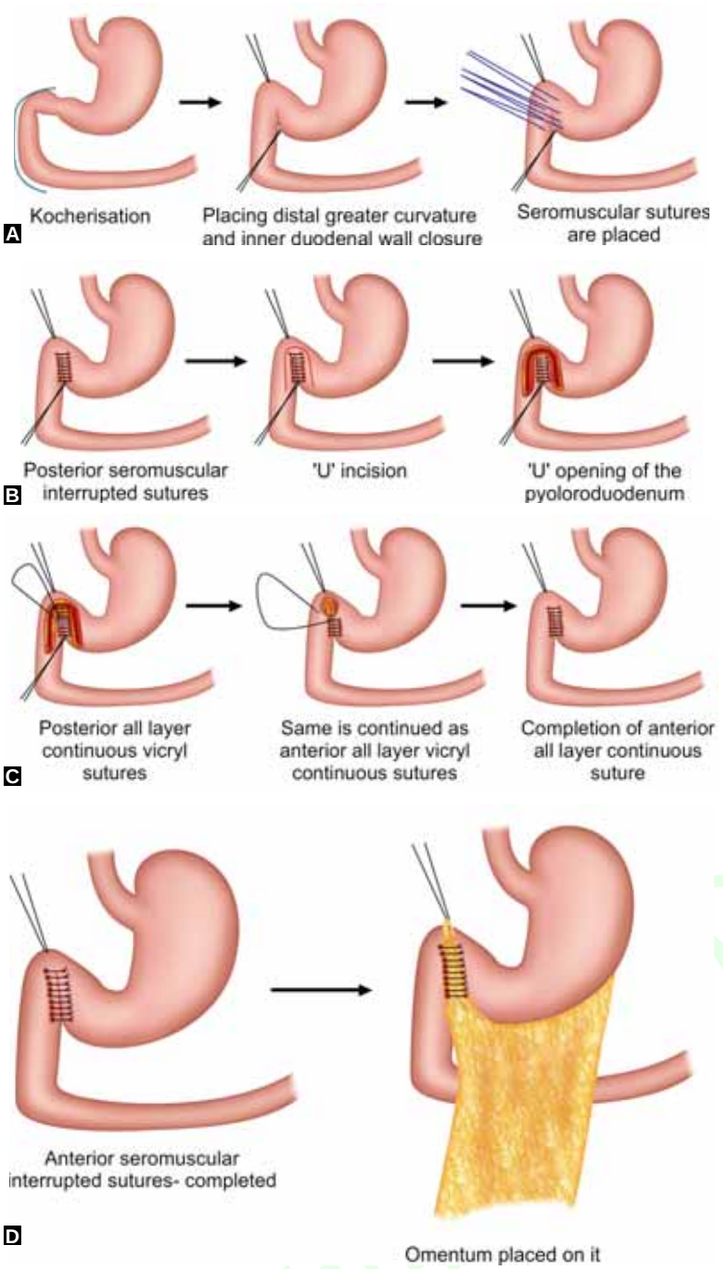
Upper midline incision is used. Kocherisation is done adequately. Junction of the pylorus and first part of the duodenum is held at its upper margin with a Babcock's forceps or stay suture. Distal part of the greater curvature is brought closer to the pancreatic side of the 2nd part of the duodenum. Seromuscular sutures (3 zero silk) are placed between distal part of the greater curvature of the stomach and proximal inner part of the duodenum which are tied either after placing all sutures or individually after placing sutures one by one. A 'U'-shaped incision is made from greater curvature towards proximal duodenum which is deepened to have a full thickness gastroduodenotomy. Inner all layer suturing is done using 3 zero silk or vicryl from upper most apex part of the posterior layer towards downwards direction. Once lowermost part is reached, it is continued in front as anterior all layer continuous Connell sutures from below upwards. Anterior seromuscular interrupted 3 zero silk sutures are placed at the end. It is supported with omental patch. Truncal vagotomy may be added **(Figs 20-39A to D)**.

Complications

Bile leak due to anastomotic dehiscence is possible, especially when pyloroplasty is done in a scarred duodenum. Infection, subphrenic abscess formation, delayed gastric emptying are other complications.

Note:

Kennedy duodenoplasty is similar like pyloroplasty but distal to the pylorus on the proximal part of the first part of the duodenum;


A
Kocherisation
Placing distal greater curvature and inner duodenal wall closure
Seromuscular sutures are placed
B
Posterior seromuscular interrupted sutures
'U' incision
'U' opening of the pyoloroduodenum
C
Posterior all layer continuous vicryl sutures
Same is continued as anterior all layer vicryl continuous sutures
Completion of anterior all layer continuous suture
D
Anterior seromuscular interrupted sutures- completed
Omentum placed on it

Figs 20-39A to D: Finney's pyloroplasty.

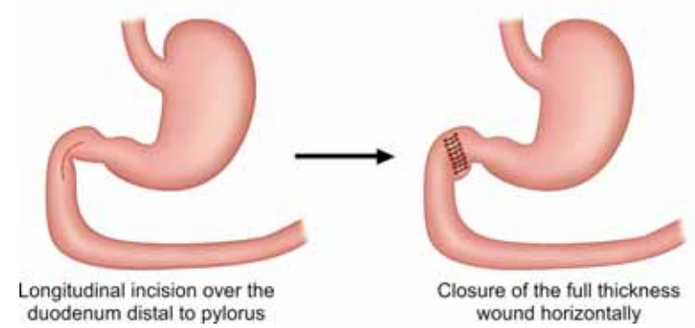


Fig. 20-40: Duodenoplasty is done distal to pylorus (Kennedy).

longitudinal full thickness incision is closed transversely **(Fig. 20-40)**.

Dudd pylorectomy: Here ulcer crater is excised by a diamond-shaped incision along with pyloroplasty.

Antrectomy (hemigastrectomy): Here ulcer bearing area in the stomach is removed and pyloric antrum with either gastroduodenal or gastrojejunal anastomosis is done. It is done in case of recurrent ulcers or in Zollinger Ellison syndrome. It removes the gastrin secreting area (G cells). Antrectomy as a primary procedure is not routinely done for duodenal ulcer.

Gastric mucosal resection (Kirk, 1972): It is done in recurrent ulcers. Here antral mucosa is dissected and removed without ligating vessels externally. It is done after vagotomy. Anterior gastrotomy is done from pylorus 8 cm proximally and 3 cm distally to open entire distal stomach and duodenum. Using pH probe, proximal acid secreting mucosa and distal alkali secreting mucosa is marked at junction. Submucosal injection of 1 in 2,00,000 saline with adrenaline is injected around 300-500 ml. it distends and separates the mucosa and also prevents bleeding. Onto this mucosa, only circumferential incision is made at the pylorus junction and mucosa proximal is dissected off from the submucosa like tube for 8 cm. Proximal part is also transected circumferentially. Small bleeders are fulgurated using bipolar cautery. Mucosal edges proximal and distal are brought together using 3 zero vicryl sutures continuously taking bites deeply up to muscular layer.

GASTRECTOMY

Removal of the part or entire stomach surgically is called as gastrectomy. It can be antrectomy (hemigastrectomy), partial (65%), subtotal (80%), total or radical (nodal clearance) gastrectomy.

Gastrectomy reconstruction can be Billroth I or Bilroth II type. Billroth I is gastroduodenostomy; Billroth II is gastrojejunostomy.

Professor Hans Theodor Billroth did first gastrectomy with gastroduodenostomy in 1881 **(Figs 20-41 to 20-43)**.

Gastrectomy with Billroth I Methods of Anastomosis

Classical Bilroth I operation is partial gastrectomy with gastroduodenostomy with closure of lesser curve and anastomosis at greater curvature side. Horsley, von Haberer–Finney, von Haberer, Schoemaker, Kocher are different Billroth I modifications.

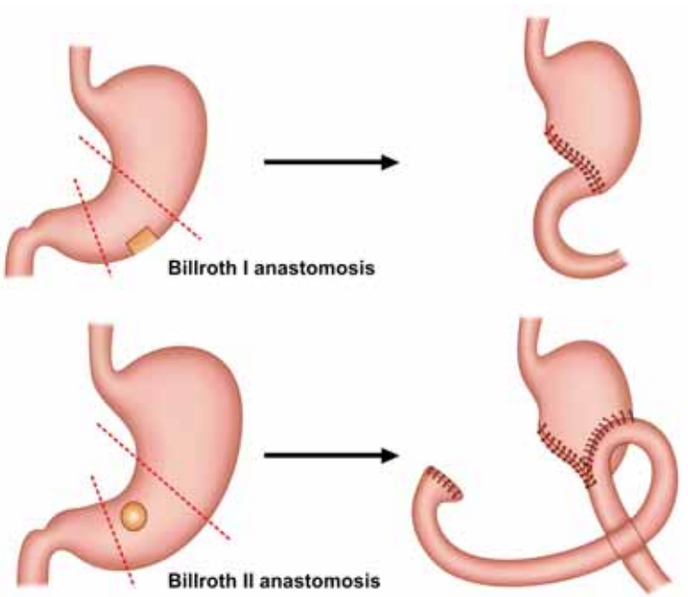


Fig. 20-41: Billroth I and II anastomosis after gastrectomy.

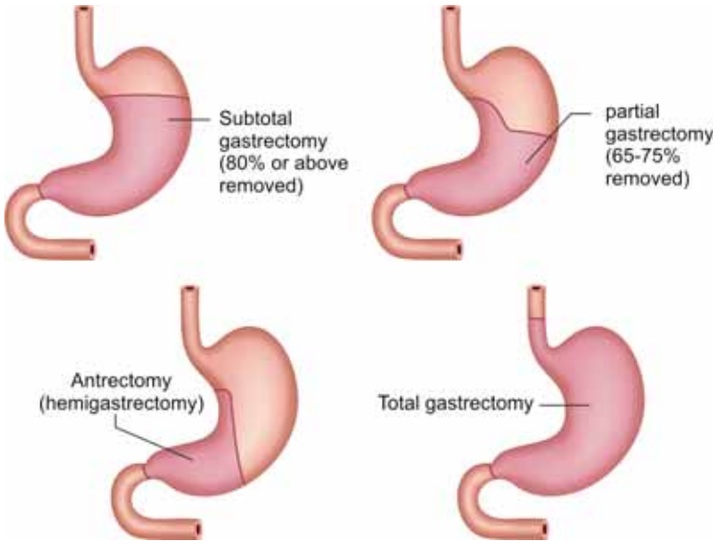


Fig. 20-42: Anatomical meanings of hemigastrectomy, partial, subtotal and total gastrectomies.

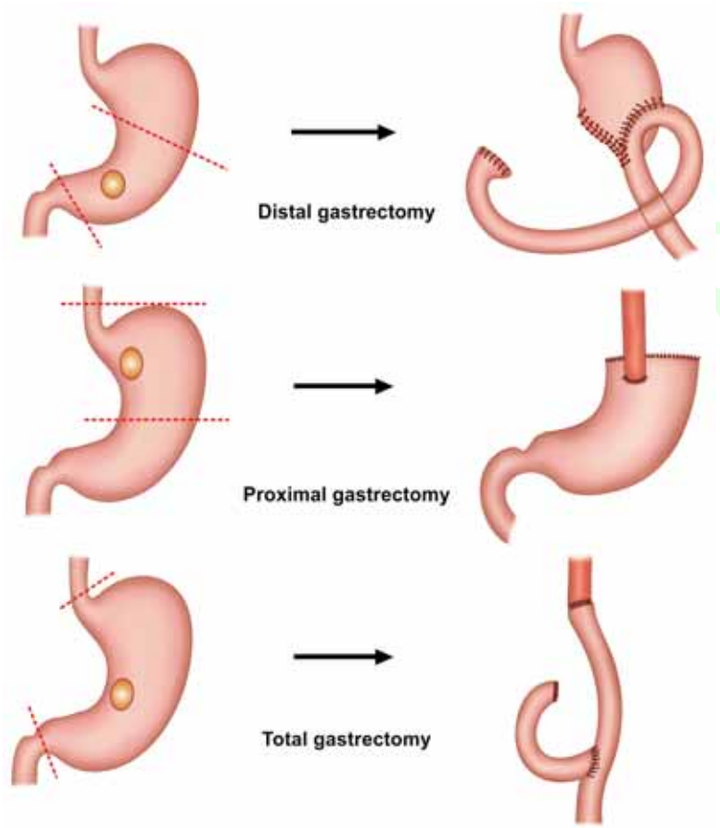


Fig. 20-43: Technical meanings of distal, proximal and total gastrectomies. Proximal gastrectomy is done rarely now; probably done in OG junction growths only; even there, total gastrectomy is preferred by many.

Preparation

Gastroscopy and adequate biopsy are must; CT abdomen to detect additional pathology; adequate hydration; electrolyte management; evaluation of cardiac and respiratory systems are needed. Nasogastric tube and urinary catheter should be passed. Preoperative/perioperative antibiotics are a must as once stomach is opened, field gets contaminated.

Indications

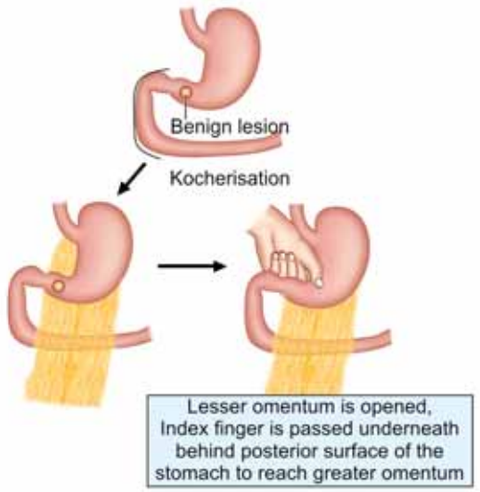
Partial gastrectomy with Billroth I procedure is done in benign gastric ulcer (proved by endoscopic biopsy), benign tumour of the distal stomach, trauma to distal stomach, recurrent or bleeding duodenal ulcer, if pyloroplasty is not feasible. In carcinoma distal stomach, Billroth I anastomosis is usually not done as recurrence in bed when it occurs will cause obstruction due to encasement of the relapsed (local) tumour; whereas in Billroth II gastrojejunostomy, stoma recedes upwards and leaves away from the gastric bed and also omentum and colon interposes between gastric bed and stoma.

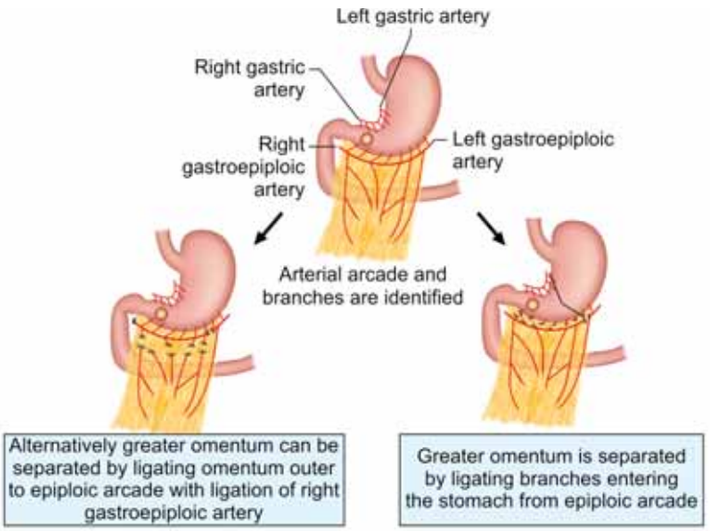
Technique

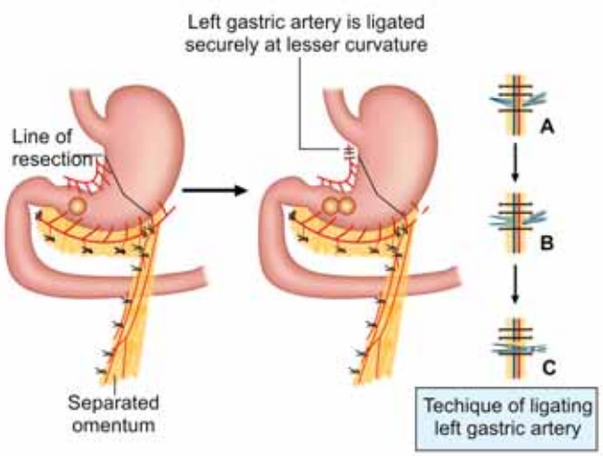
Patient is in supine head up position. General anaesthesia/epidural are given. Abdomen is approached through upper midline incision extending down towards left of the umbilicus. Abdomen is explored for any additional findings. Gastric ulcer area is felt for its location and adhesion. Self retaining retractor is placed. If initially benign gastric ulcer ontable is doubtfully malignant then a gastrotomy is done well away proximally and four quadrant biopsies are done and sent for frozen section biopsy and proceeded further accordingly.

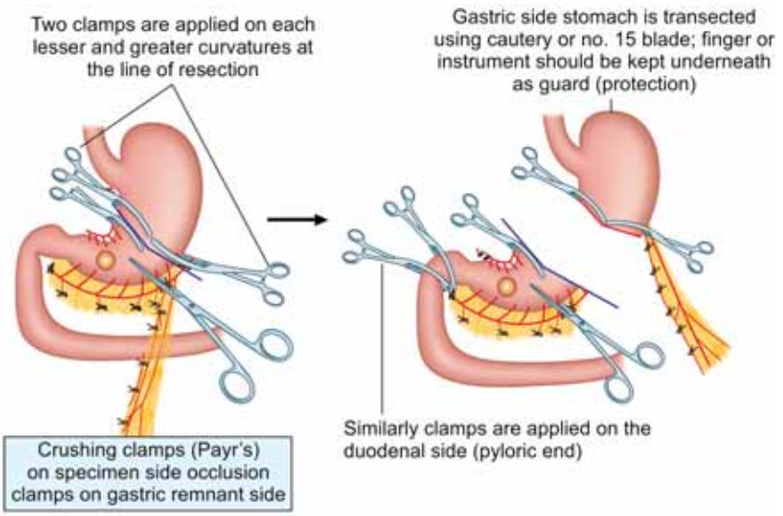
For a benign condition, there is no need to remove the omentum. Kocherisation is done adequately. Gastrohepatic ligament (lesser omentum) is opened using index finger and gently posterior wall of the stomach is separated using finger dissection; if there are adhesions, these are released after release of greater omentum under direct vision. Greater omentum is clamped with two haemostats, divided and ligated sequentially between greater curvature and gastroepiploic arcade; alternatively bipolar cautery or ligaseal or harmonic scalpel (energy sources) can be used to free the greater omentum on the resecting part of the stomach (like in mobilisation of greater omentum in omentoplasty); alternatively, many advocate ligation of the greater omentum outer to the gastroepiploic arcade. Energy sources can be used for the same (harmonic). Right gastroepiploic artery is retained if arcade is retained. Once greater curvature is freed of the omentum, posterior surface of the stomach is easily seen by everting it; if any adhesions are present, these should be divided either with sharp dissection using scissor or cautery or harmonic scalpel. These adhesions if forced with finger for release will cause troublesome bleeding. Dissection close to the origin of the right gastroepiploic vessels should be done with care as small multiple veins may get torn causing bleeding. Middle colic vessels are very close and care should be taken not to injure them; especially middle colic artery if injured will cause transverse colon ischaemia. Middle colic vein joins right gastroepiploic vein which joins the portal vein or superior mesenteric vein. Middle colic vein may be ligated if need arises **(Fig. 20-44)**.

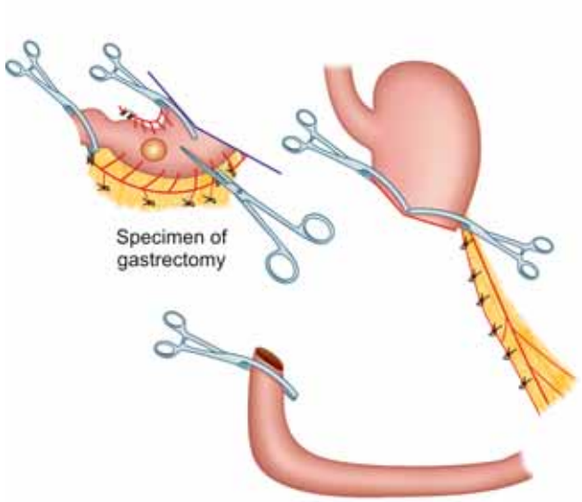
Left gastric vessels are ligated usually at midpoint of OG junction and pylorus along the lesser curvature. Left gastric vessels are clamped together; two haemostats (medium or large) proximally and one distally are applied; it is divided in between proximal and distal (keeping right angled forceps underneath) using number 15 blade or fine scissor. Proximal part is once transfixed with silk and another ligated. Distal part is also ligated using silk. One should confirm that there is bleeding or loosening of the ligature. Often alternatively, left gastric vessels are dissected using right angle forceps for 1.5 cm and ligature is passed and ligated both proximally (2 or 3) and distally (one) and divided in between; lengthy ligature ends are held traction during division. But it is now practiced that left gastric artery and vein are individually dissected, isolated and ligated separately, but it is technically difficult. Left gastric vein is caudal to artery. Few more

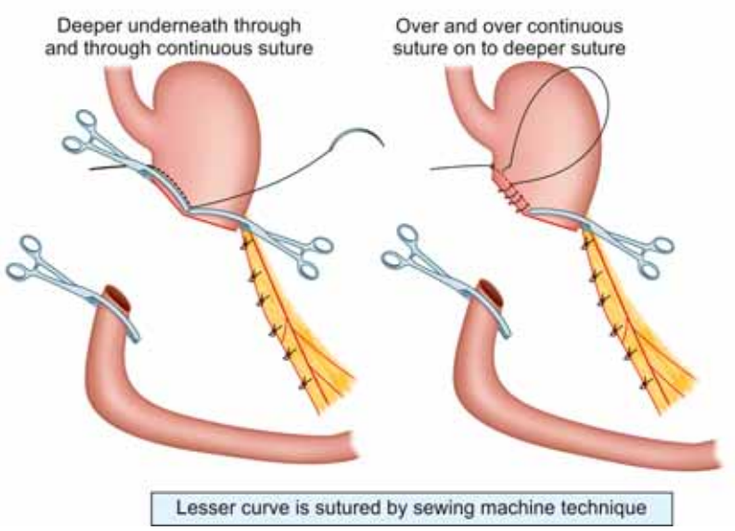

Benign lesion
Kocherisation
Lesser omentum is opened, Index finger is passed underneath behind posterior surface of the stomach to reach greater omentum


Left gastric artery
Right gastric artery
Right gastroepiploic artery
Left gastroepiploic artery
Arterial arcade and branches are identified
Alternatively greater omentum can be separated by ligating omentum outer to epiploic arcade with ligation of right gastroepiploic artery
Greater omentum is separated by ligating branches entering the stomach from epiploic arcade

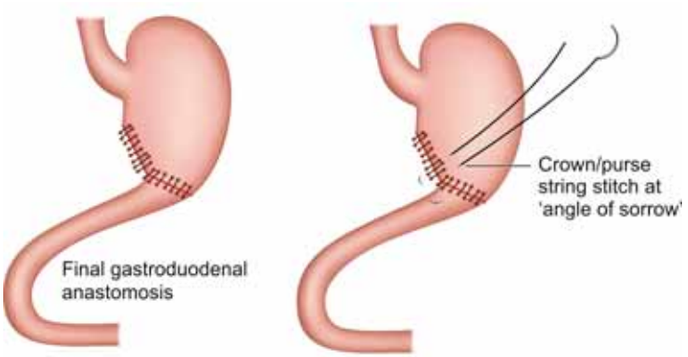

Left gastric artery is ligated securely at lesser curvature
Line of resection
A
B
C
Separated omentum
Techique of ligating left gastric artery


Two clamps are applied on each lesser and greater curvatures at the line of resection
Gastric side stomach is transected using cautery or no. 15 blade; finger or instrument should be kept underneath as guard (protection)
Crushing clamps (Payr's) on specimen side occlusion clamps on gastric remnant side
Similarly clamps are applied on the duodenal side (pyloric end)


Specimen of gastrectomy


Deeper underneath through and through continuous suture
Over and over continuous suture on to deeper suture
Lesser curve is sutured by sewing machine technique

Figs 20-44(1)



Figs 20-44(2)

Figs 20-44(1 and 2): Gastrectomy with Billroth I anastomosis—technique. It is usually done for benign lesions.

small vessels along the lesser curve at this point are also ligated and divided. Remaining gastric stump is supplied by the ascending branch of left gastric artery, left gastroepiploic and short gastric arteries. Similarly left gastroepiploic vessels (commonly two veins will be present at this level) are ligated along the greater curvature side at the point of resection of the stomach.

Nasogastric tube is palpated and pulled out proximally away from the line of applying clamps and line of division. One occlusion clamp is applied along the lesser curvature towards middle of the stomach directed downwards from lesser curve side; another applied horizontally from greater curvature side towards middle of the stomach. Large Payr's clamp is applied or (two Kocher's clamps or Parker Kerr crushing clamps) on the specimen side below. Stomach is transected in between, leaving clear margin on the proximal side; transection is done using number 15 blade from lesser curve towards greater curve with keeping finger or flat instrument behind as a guard to prevent inadvertent injury to deeper structures. Cautery can be used for the division. Antral mucosa should be completely removed.

Distal part is lifted upwards to visualise the posterior aspect. Small vessels between pancreas and stomach are cauterised or ligated and divided. Right gastric artery on the upper margin of the pylorus is dissected, ligated and divided. Other vessels in the lesser curve are also ligated and divided. Often instead of single right gastric artery, there will be leash of right gastric vessels which are ligated and divided. An occlusion clamp is applied on the 1st part of the duodenum after mobilizing duodenum for 1.5–2.0 cm. Duodenum is dissected gently using bipolar and finger. A Kocher's clamp is applied on the distal part of the specimen; duodenum is divided similarly using number 15 blade. Duodenal clamp is removed once to inspect its mucosa for completion of removal of entire antral mucosa; finger is passed inside to feel for orifice of duct of Santorini and ampulla of Vater (which is 7 cm from the pylorus). Care should be taken not to injure the bile duct. If duodenal division is done within gastroduodenal artery level (not beyond) then it is less likely that pancreatic ducts are injured. Bleeding from the cut edge of the duodenum should be adequate. If greater omentum is mobilised outer to the epiploic arcade by dividing fat and vessels of the greater omentum, then right gastroepiploic artery is to be ligated close to pancreas and where it enters the duodenal lower margin and greater curvature. There is rare chance of loss of omental viability by ligating both right and left gastroepiploic arteries; in such situation, omental excision can be added. Right gastroepiploic vessels can be ligated divided as a bulk (mass tie) between proximal two and distal one ligatures; but present practice is identifying vessels individually and dissecting and ligating.

Alternatively duodenal part of the dissection and ligating of right gastric artery and separation from the pancreas, clamping and dividing the duodenum can be done first, later lifting the specimen upwards, forwards and towards left. Left gastric and left gastroepiploic vessels are addressed. Stomach is similarly transected between clamps.

Lesser curve oblique clamp is held upwards; using 2 or 3 zero silk or vicryl, this part of the lesser curve is closed using sewing machine suturing technique. Here from the lesser curve end, needle bite is taken underneath the occlusion clamp and tied outside; tail end is held with a haemostat; continuous bites are taken underneath the clamp from lesser curve side towards the tip of the clamp as through and through running sutures; once this suture is reached up to the tip of the clamp, clamp is released; knot is tied to the last loop of the suture material; it is continued as over and over continuous suture towards the tail end of the suture material at lesser curve where it is tied with knot. Interrupted seromuscular layer suturing (Lembert) is also done on this layer.

During mobilisation and dissection of stomach, care should be taken to protect spleen, pancreas, duct of Santorini, common bile duct, middle colic artery. Duodenal mobilisation should not go beyond the gastroduodenal artery. Adhesion between pancreas and stomach distally is most crucial; care should be taken not to pull the stomach and do blunt dissection; instead sharp or bipolar cautery dissection should be done. Clamps used should be ellipsoidal and after applying compression should be uniform on the bowel. Clamp steadies the gut, prevents spillage, prevents oozing from the cut edges of the stomach and duodenum. Straight clamps even though commonly used are more damaging than ellipsoidal. These occlusion clamps when applied on your finger and after locking it, should not be painful.

Billroth I gastroduodenal anastomosis is done. Posterior interrupted silk stay sutures are placed; later tied after taking all bites. Posterior all layer through and through vicryl continuous suture is done from lesser curve end towards greater curve end; bites are taken at 3-5 minutes interval at 3-5 mm from the cut edges; locking is done once in 3 or 4 bites to prevent purse string and for haemostasis. Same is continued as anterior all layer through and through sutures towards lesser from greater curve. Connell sutures can be placed to invert the mucosa. In lesser curve, it is sutured tail end of the suture material. Anterior seromuscular interrupted silk sutures are placed afterwards. *Angle of sorrow* (***Jammerecke***) is angle where lesser curve end meets the sutured upper duodenal end. It should be reinforced with *crown stitch/ purse string stitch/ triple seromuscular stitch*. Bite (seromuscular) is taken from anterior gastric wall to posterior gastric wall and from posterior duodenal wall towards anterior duodenal end and tied with a knot. Often this stitch alternatively can be taken prior to completion of the suturing of the angle of sorrow which is kept untied and tied only at the end. Patency of lumen is confirmed by admitting the tip of the thumb. Usually nasogastric tube is negotiated across gastroduodenal stoma. Tube drain may be kept and is removed after 5-7 days.

Note:

Stapler can be used for closure of lesser curvature.
Present concept is gastroduodenostomy should be performed without clamps to avoid tension.
In olden days for suturing inner layer, *Moynihan atraumatic straight intestinal needle* were used (not now). They were used with hand for suturing.

Tanner's method: Twin gastroenterostomy clamps (Lane's) can be used for anastomosis by applying their blades on both duodenal and gastric sides.

Pauchet's operation/maneuver is used in high gastric ulcer with distal stomach lifted upwards to visualise the ulcer bearing area on the lesser

curvature and tongue-like piece of lesser curve containing ulcer is excised and immediately sutured.

In a high lesser curve ulcer where access is difficult especially in obese individual, lesser curve can be created without application of the clamp. Here suturing begins from lower part of the proposed lesser curve, continuous sutures are applied upwards as '*open climbing*' technique until lesser curve end is reached. It is often guided by nasogastric or orogastric tube.

In von Haberer method, reefing and purse string is done to lower greater curvature part of the cut end of the stomach so that it is buried to avoid angle of sorrow.

In Schoemaker modification, entire lesser curve and antrum are removed; new lesser curve is created by hand suturing or stapling device.

In Horsley's modification, duodenum is anastomosed to lesser curve end of the stomach.

In von Haberer Finney's modification, opened entire cut end of the stomach is sutured to the side of the mobilised 2nd part of the duodenum with closure of the duodenal stump.

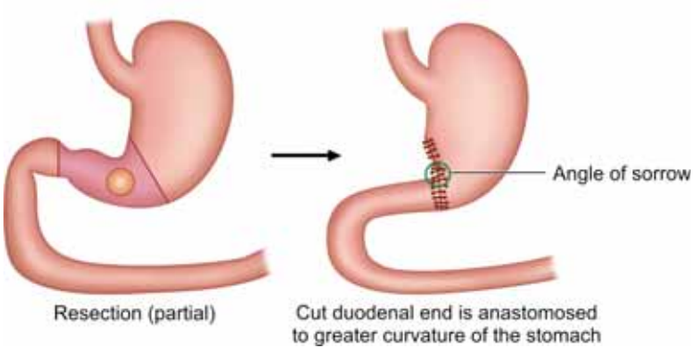


Fig. 20-45: Gastrectomy with Billroth I anastomosis.

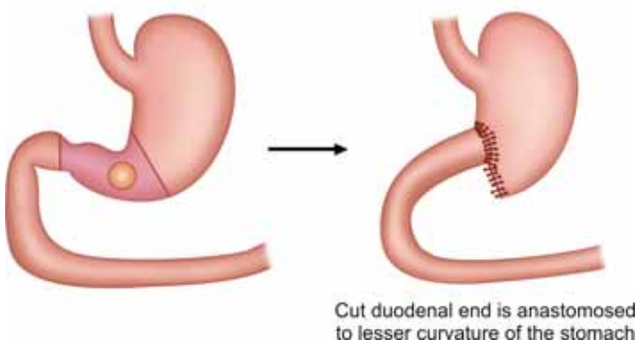


Fig. 20-46: Gastrectomy with Horsley's modification of Billroth I anastomosis.

In Maingot's modification of von Haberer Finney's technique, duodenal stump is not closed; but its end is given a cut on its inner part (like a Cheatle's cut in small intestine) to widen the duodenal stoma which is anastomosed to the lower cut end of the stomach towards greater curvature after suturing lesser curvature.

Pylorus preserving Billroth I procedure and vagus preserving Billroth I procedures are advocated in Japan for early gastric cancers **(Figs 20-45 to 20-51)**.

Postoperative care

Nasogastric aspiration is done for 5 days. Then oral sips are started. Respiratory exercise, early mobilisation and Deep vein thrombosis (DVT) prophylaxis should be given. Antibiotic coverage, fluid and electrolyte management, observations are mandatory. Drain is removed in 5-7 days.

Complications

Stomal oedema, gastric paresis, stomal obstruction, anastomotic dehiscence and bile leak, sepsis, subphrenic abscess formations are known complications.

Gastrectomy with Billroth II Methods of Anastomosis

It is partial/subtotal gastrectomy with closure of the duodenal stump and achieving the continuity by doing gastrojejunostomy. Billroth first did this procedure on 1885 January 15. It was anterior antecolic gastrojejunostomy. So many modifications were done at a later period on this. Kronlein (1887); Von Eiselsberg (1889), Braun (1892); Roux

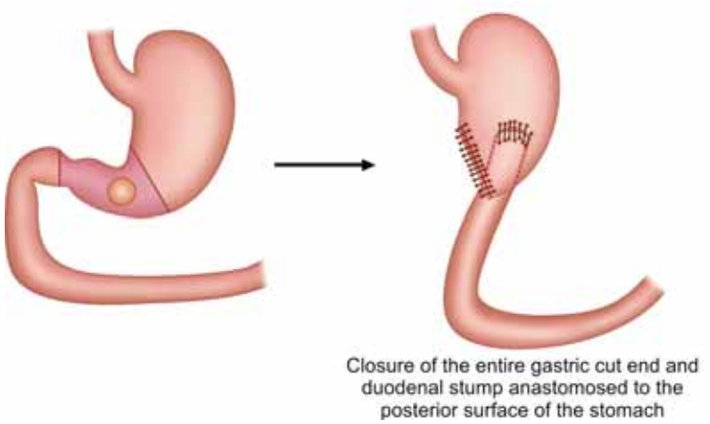


Fig. 20-47: Gastrectomy with Kocher's modification of Billroth I anastomosis.

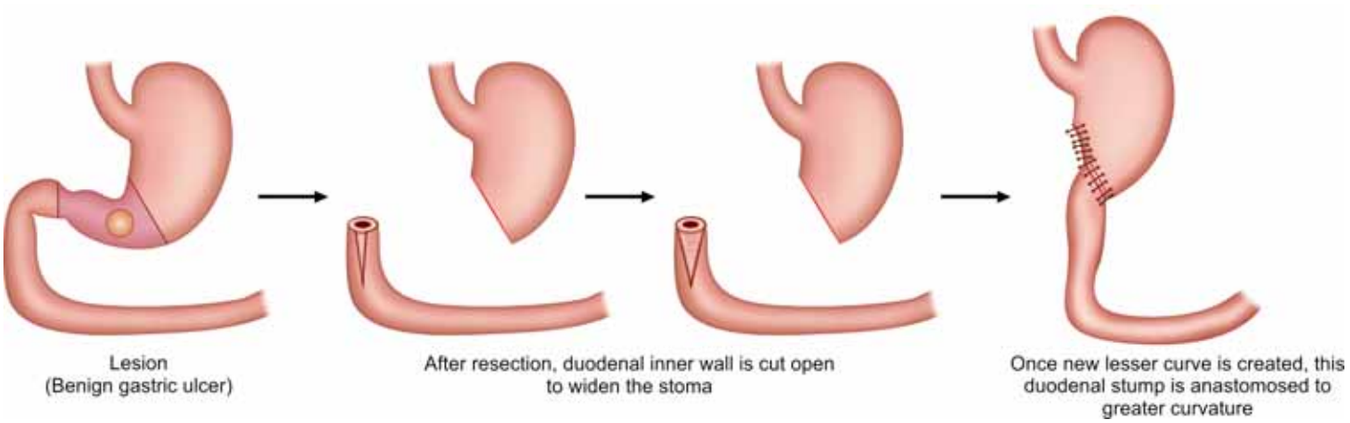

Lesion
(Benign gastric ulcer)
After resection, duodenal inner wall is cut open
to widen the stoma
Once new lesser curve is created, this
duodenal stump is anastomosed to
greater curvature

Fig. 20-48: Gastrectomy with Maingot's modification of Billroth I anastomosis.

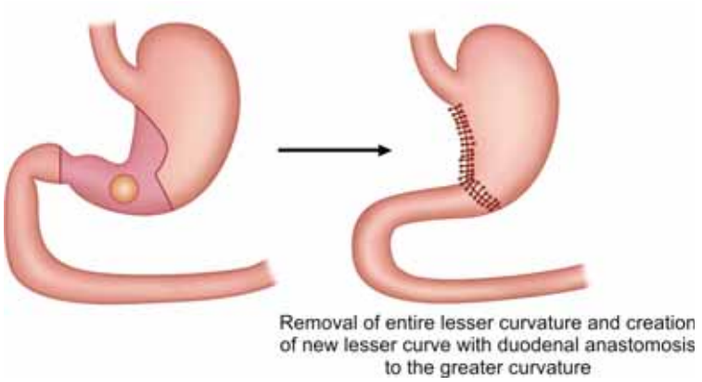

Removal of entire lesser curvature and creation
of new lesser curve with duodenal anastomosis
to the greater curvature

Fig. 20-49: Gastrectomy with Schoemaker's modification of Billroth I anastomosis.

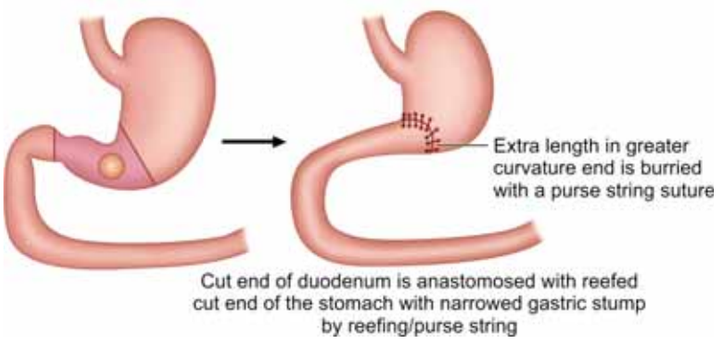

Extra length in greater
curvature end is burried
with a purse string suture
Cut end of duodenum is anastomosed with reefed
cut end of the stomach with narrowed gastric stump
by reefing/purse string

Fig. 20-50: Gastrectomy with von Haberer modification of Billroth I anastomosis.

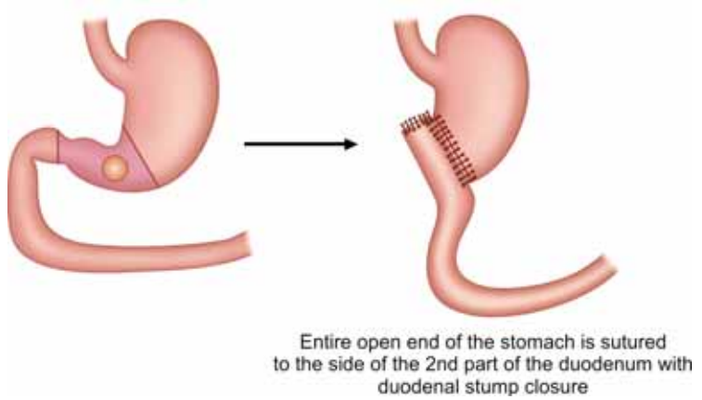


Fig. 20-51: Gastrectomy with von Haberer Finney's modification of Billroth I anastomosis.

(1893); Reichel (1908; Polya (1911); Hofmeister–Finsterer (1914); Balfour (1917); Moynihan (1923) are different modifications.

Indications

Gastric ulcer where Billroth I is not possible; carcinoma pylorus and antrum as a radical or palliative procedure; recurrent ulcers; trauma to distal stomach and duodenum are different indications.

Preparation

Gastroscopy and biopsy are a must; CT abdomen to stage the tumour; adequate hydration; electrolyte management; evaluation of cardiac and respiratory systems are needed. Nasogastric tube and urinary catheter should be passed. Preoperative/perioperative antibiotics are a must as once stomach is opened, field gets contaminated.

Technique

After doing laparotomy through midline incision, thorough exploration of the abdomen is done for secondaries in liver, omentum, transverse colon, mesocolon, pancreas, primary tumour fixity, resectability, operability, nodal status etc are assessed. Operability means amenable for radical cure. Resectability means even though advanced, primary tumour which is not fixed posteriorly can be removed. Resection of growth (partial gastrectomy) is the best palliation even though it is advanced. In a fixed nonresectable tumour, palliative anterior gastrojejunostomy or Devine's exclusion procedure can be done to relieve vomiting due to gastric outlet obstruction by the tumour **(Fig. 20-52)**.

Kocherisation is usually not necessary for Billroth II anastomosis; if at all needed, only limited Kocherisation should suffice.

For benign lesions, technique of mobilisation is same as detailed above in Billroth methods. For confirmed carcinoma distal stomach, mobilisation is different. Greater omentum is separated from the colon along the avascular plane completely. Greater omentum is included in the specimen. Omental bursa is carefully separated from the transverse mesocolon and pancreatic bed. Care should be taken not to injure middle colic artery. Ligation and division of individual vessels using 3 zero silk or bipolar cautery or ligaseal or harmonic scalpel may be used as techniques to achieve this.

Right gastroepiploic vessels, right gastric artery, descending branch of left gastric artery (left gastric vascular pedicle) and left gastroepiploic vessels are ligated doubly and divided. Gastric remnant attains its blood supply through short gastric vessels and ascending branch of left gastric artery—which are sufficient enough. Retrogastric dissection is carried out carefully meticulously using bipolar cautery and sharp dissection (never blunt dissection). Duodenal part is mobilised from the pancreatic bed for 2 cm by rotating stomach upwards. Occlusion clamp is applied on the duodenal side at 1st part of the duodenum. Payr's crushing clamp is applied on the gastric side; duodenum is cut in between using no. 15 blade with right angled forceps or flat instrument behind. Good bleeding from the cut edge should be ensured from the duodenal stump, otherwise duodenal leak may occur at later period. If tissue is not healthy, edge is trimmed until it bleeds properly.

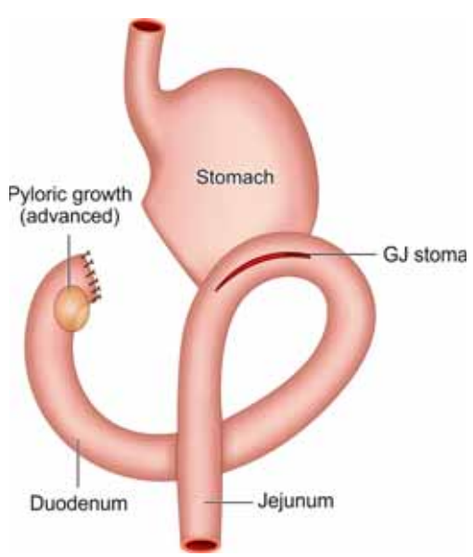


Fig. 20-52: Devine's exclusion procedure.

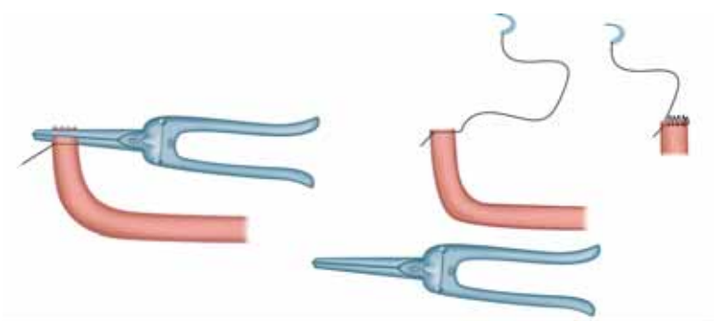
Duodenal stump closure

Duodenal stump closure is an important step. It is done by different methods.

Using 2 zero or 3 zero vicryl or silk from superior to inferior part *sewing machine technique* closure is done; here continuous bites alternatively from right and left sides are taken underneath the occlusion clamp close to it to reach the inferior margin; then clamp is gently released, suture is looped and tightened; same suture material is again passed as over and over suture on the previous suture to reach the superior part and is tied to the tail end with secure knot. If needed, few additional interrupted sutures are placed. There is usually space, and length of the stump is not present to place interrupted Lembert sutures to bury/invert the duodenal stump. Often anterior part of the stump is buried on the prepancreatic fascia with interrupted vicryl sutures to secure the stump further **(Fig. 20-53)**.

Alternatively, clamp placed on the duodenal stump is gently lifted; loose over and over vicryl suture loops are placed from superior margin of the stump towards inferior margin under and over the clamp which is held loosely; clamp is loosened and gently removed by sliding and traction off the duodenal stump; suture is pulled tight. Then purse string thin small seromuscular suture is placed around the stump to invert it. A third layer purse string is placed to invaginate the stump completely (*Tanner's method*). Or Lembert seromuscular suture can also be placed using silk **(Fig. 20-54)**.

Open closure of the duodenal stump without applying the clamp using Connell suture is also practiced. Second layer of mattress silk suture is also required **(Fig. 20-55)**.



Suture material (vicryl or silk) is passed underneath the occlusion clamp alternatively on both sides without looping over the clamp from superior margin to inferior margin; clamp is released and suture is tightened and continued as over and over continuous suture on the stump to reach back to superior margin and is tied to the tail end to complete the closure of the stump

Fig. 20-53: Closure of duodenal stump using sewing machine technique.

Both inner and outer layers are closed using interrupted 3 zero or 2 zero silk sutures also considered safer.

Stapler closure of duodenal stump is safer and saves time with a good apposition. Usually there is no need to invaginate stapler line **(Fig. 20-56)**.

Catheter duodenostomy: It prevents build up of intraduodenal pressure and sutured stump will not distend. It is done in difficult duodenal stump and when doubt is there about the integrity of the stump. Usually lateral duodenostomy is done. Prior to closure of the duodenal stump, right angle clamp is passed into the lumen and 3 mm incision is made at lateral wall in 2nd part of duodenum on its tip; 14 Foley's catheter is passed into the duodenum. Duodenotomy around the catheter is closed by purse string vicryl/silk suture; and is also fixed to abdominal wall and brought out of abdominal wall through a stab incision and fixed to skin. It is usually kept for 10 days. Catheter is irrigated with 5-10 mL of warm normal saline. On 10th day catheter is partly withdrawn to the adjacent of the duodenum; if drainage after low suction becomes less than 100 mL it is gradually removed step by step in 2 days. In case if duodenal stump is impossible to close then catheter duodenostomy is done directly across the stump and is closed around it **(Fig. 20-57)**.

Nissen – Cooper technique: When there is fibrotic ulcer crater (benign) which could not be mobilised and removed, it is left in place on the surface of the pancreas and duodenum, if could not get adequate length, stump should be sutured to the ulcer crater itself in three layers. First layer is from anterior and anterolateral duodenal margin to the distal end of the fibrotic edge of the ulcer crater; 2nd layer is interrupted silk sutures between seromuscular duodenal wall to the proximal edge/lip of the ulcer crater; 3rd layer often is used to appose onto the thickened peripancreatic tissue. It is not done nowadays.

Bancroft Plenk operation: It is done when there is scarred duodenum which cannot be dissected or mobilised; 7.5 cm proximal to pyloric sphincter, circular seromuscular incision is made in the antrum. Muscular tube is dissected off from the mucosa circumferentially up to the pyloric sphincter; entire mucosa is made like tube; seromuscular purse string is placed at the pyloric sphincter excluding antral mucosal tube. Antral mucosa tube is cut and included in the gastrectomy specimen. Duodenal stump is further invaginated over seromuscular purse string suture. It is not done nowadays.

Lahey's method: Here in difficult distal stump, common bile duct is opened; Bake's dilator is passed to identify the duct during duodenal stump mobilisation and closure. Bile duct is closed with T tube.

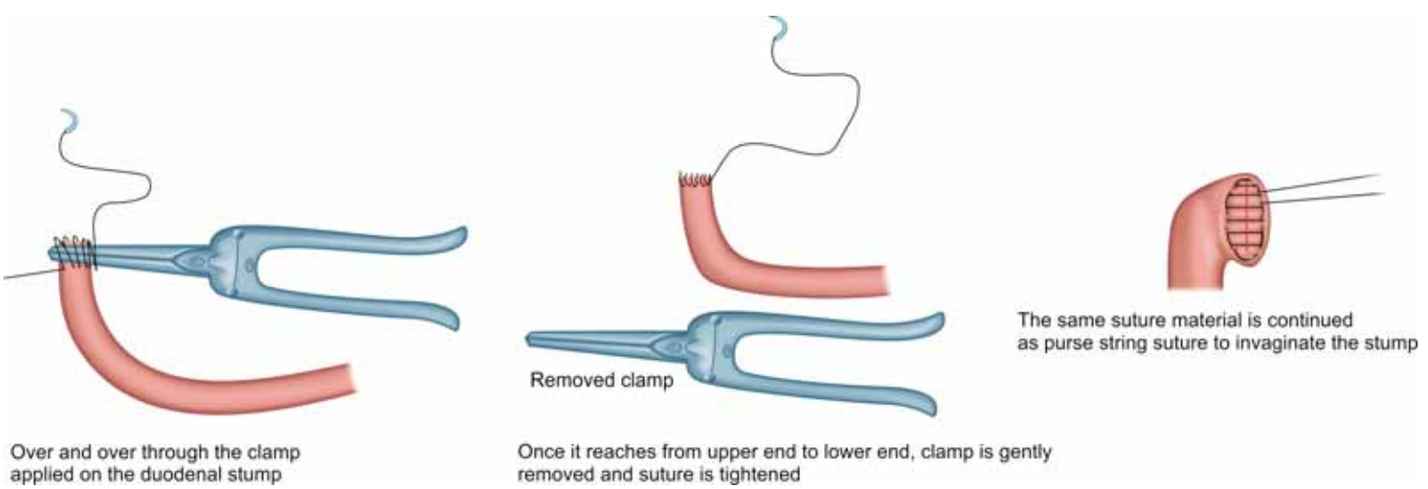
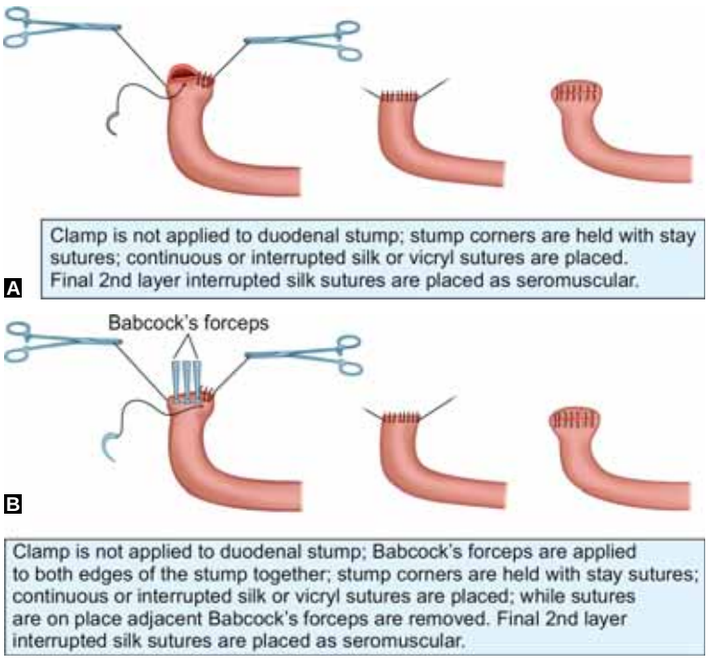

Removed clamp
The same suture material is continued as purse string suture to invaginate the stump
Over and over through the clamp applied on the duodenal stump
Once it reaches from upper end to lower end, clamp is gently removed and suture is tightened

Fig. 20-54: Duodenal closure by Tanner's method.


A
Clamp is not applied to duodenal stump; stump corners are held with stay sutures; continuous or interrupted silk or vicryl sutures are placed. Final 2nd layer interrupted silk sutures are placed as seromuscular.
Babcock's forceps
B
Clamp is not applied to duodenal stump; Babcock's forceps are applied to both edges of the stump together; stump corners are held with stay sutures; continuous or interrupted silk or vicryl sutures are placed; while sutures are on place adjacent Babcock's forceps are removed. Final 2nd layer interrupted silk sutures are placed as seromuscular.

FigS 20-55A and B: Technique of stump closure of duodenal stump without using occlusion/crushing (Payr's clamp).

Fig. 20-56: Stapler duodenal closure.

Completion of gastrectomy and Billroth II anastomosis

Distal end of the specimen (duodenal side) is held upwards and towards left to visualise anatomy posteriorly. Descending branch/ left gastric artery is identified and ligated after proximal two secure ligatures. Left gastroepiploic vessels are ligated. Gastric remnant derives its blood supply from the oesophageal branches of inferior phrenic artery, short gastric arteries, proximal gastric branches of the left gastric artery (in 65% partial gastrectomy left gastric artery is ligated distally unlike in subtotal (75 - 80%/4/5th) gastrectomy wherein left gastric artery is ligated at its origin).

Stomach is fully drawn upwards on to the abdominal wound. Duodenojejunal junction is identified in similar way through ligament of Treitz and inferior mesenteric vein. First loop of the jejunum is taken making afferent loop of about 15-20 cm. Lengthy afferent or efferent loop may stand behind gastric remnant causing obstruction. Antecolic or retrocolic approach may be used; antecolic is preferred than retrocolic, as if stomal ulcer develops chances of penetration or formation of the gastrojejunocolic fistula is higher in retrocolic. However different surgeons prefer different approaches. If retrocolic then loop is brought through the transverse mesocolon left of the middle colic artery. Occlusion clamps applied on the lesser curve, on the greater curve and on the jejunal loop. Alternatively twin clamp can be applied. Posterior seromuscular sutures are placed using continuous or interrupted (seromuscular) silk sutures. This suture line runs through the entire length of the stomach curvature and selected loop of the jejunum from greater curvature towards lesser curve. Alternatively only greater curvature side of the stomach is sutured at the stomal length of around 4-5 cm. Crushing Payr's clamp is placed on the specimen side of the stomach. Specimen is cut between occlusion clamps and crushing clamp. Anterior flap of the gastric edge is kept longer than posterior flap. Lesser curve is closed using continuous 2 or 3 zero vicryl sutures as standard sewing machine technique or over and over two layer closure. Earlier placed continuous silk seromuscular suture is continued on the created lesser curve from edge of the lesser curve towards apex of the new lesser curve kept carefully for later continuation over the stoma. One should confirm that jejunum is properly placed with antimesenteric margin properly aligned otherwise oblique anastomosis can cause stomal obstruction at afferent or efferent level. Around 4 cm length of the jejunum is

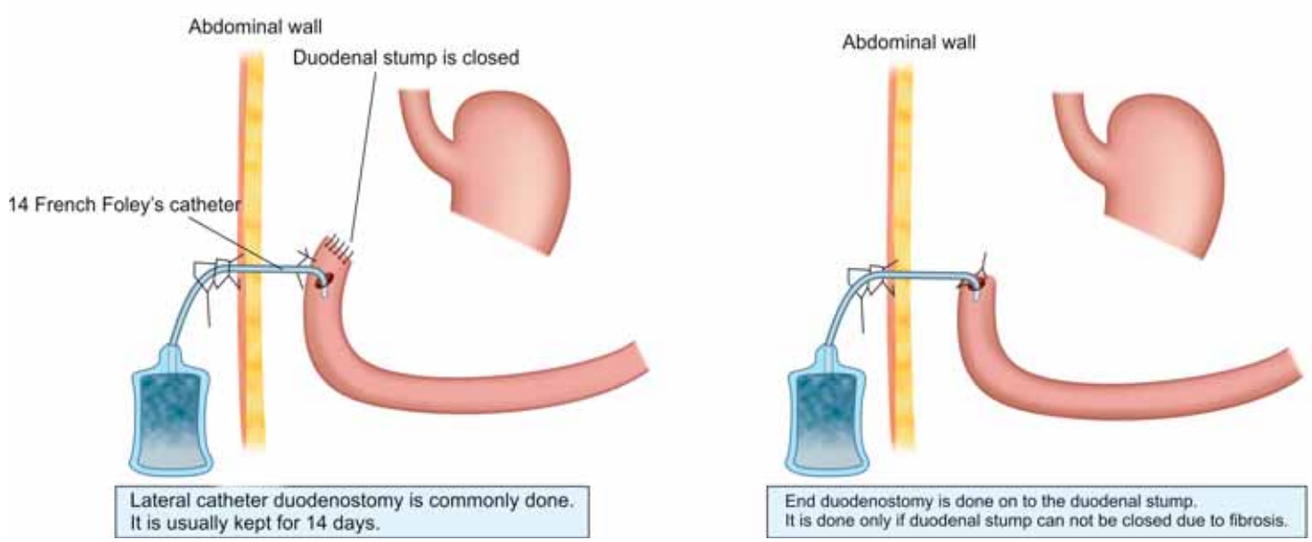

Abdominal wall
Duodenal stump is closed
14 French Foley's catheter
Lateral catheter duodenostomy is commonly done. It is usually kept for 14 days.
Abdominal wall
End duodenostomy is done on to the duodenal stump. It is done only if duodenal stump can not be closed due to fibrosis.

Fig. 20-57: Catheter duodenostomy used to decompress the duodenal stump.

opened on the greater curvature (left) side. Posterior all layer through and through continuous sutures are placed using vicryl from greater curvature side towards lesser curve angle; it is continued as anterior layer all layer suture (using Connell suture) to reach greater curvature again and tied with a knot. Anterior seromuscular continuous suture is placed as a continuation of the already placed seromuscular suture on the new lesser curve, thus completing the anastomosis. Clamps are removed. Nasogastric tube should be passed across the stoma along the efferent limb. Any bleeders if present are secured with transfixation. Adequacy of the stoma is checked.

In order to prevent enterogastric bile reflux, jejunojejunostomy is done between afferent and efferent limbs—*Braun's enteroenterostomy*. This prevents bile reflux but diverts bile only partially unlike in *Roux-en-Y anastomosis which is more ulcerogenic.*

Ligatures at all four main vessel sites are observed for its security. Subphrenic spaces are sucked out and cleaned. Duodenal stump closure is observed. Abdomen is closed in layers after placing a tube drain.

Postoperative Care

Nasogastric tube aspiration; observation of vitals, drain site and urinary catheter; respiratory monitoring.

Nasogastric tube is removed in 5 days; oral sips started; drain removed in 7 days.

Note:

Antecolic is said to be better than retrocolic after gastrectomy and Billroth II anastomosis. However both are used all over equally.

Valve is found to be not helpful during anastomosis **(Fig. 20-58)**.

Single layer closure is universally accepted now as far as Billroth II anastomosis.

When placing afferent loop towards greater or lesser curv, it will not make much difference as far functioning of the stoma is considered. Moynihan's placing afferent loop towards greater curvature has gained popularity. Different modifications are shown in figures **(Figs 20-59 to 20-67)**.

Distal Gastrectomy with Roux-en-Y Anastomosis

Cesar Roux, Swiss surgeon from Lausanne described Roux-en-Y anastomosis in 1897. Jejunum is transected 20 cm from duodenojejunal junction; distal cut part of the jejunum is brought upwards towards gastric remnant and anastomosed; proximal cut end is anastomosed to distal cut part of the jejunum 45 cm from its cut margin to maintain the continuity.

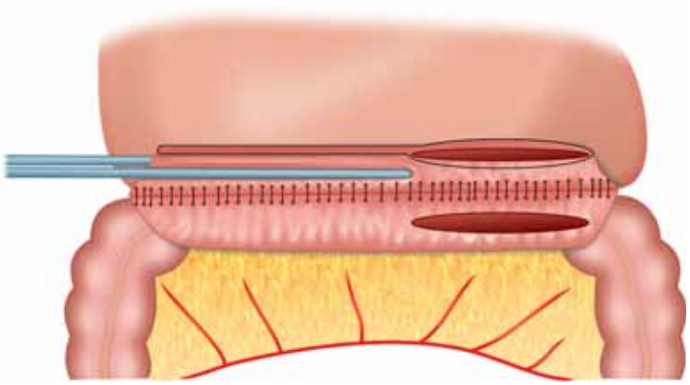


Fig. 20-58: Valved gastrojejunostomy.

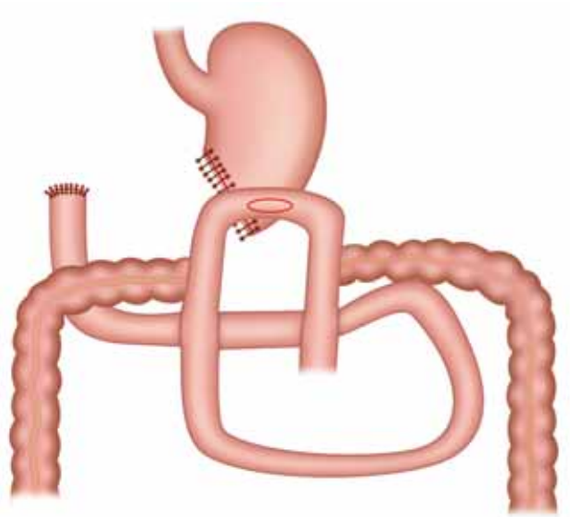


Fig. 20-59: Gastrectomy with classical Billroth II anastomosis.

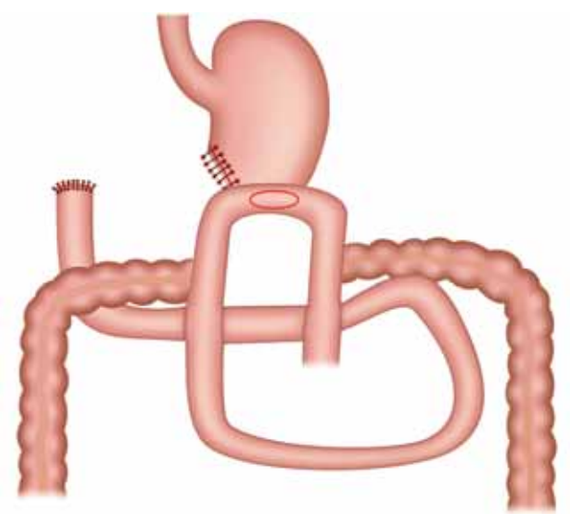


Fig. 20-60: Gastrectomy Voneiselsberg modification of Billroth II anastomosis.

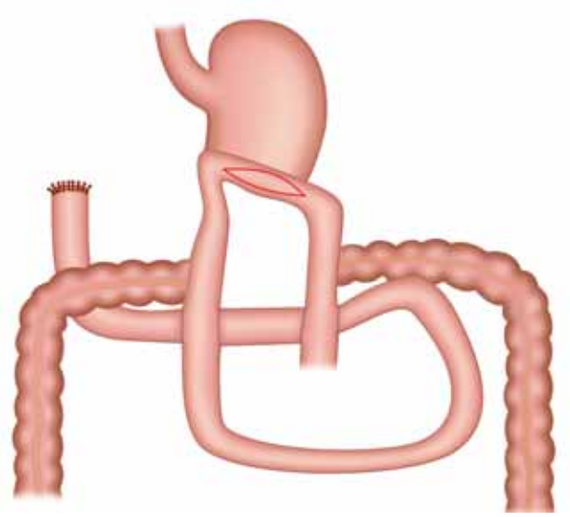


Fig. 20-61: Gastrectomy Kronlein modification of Billroth II anastomosis.

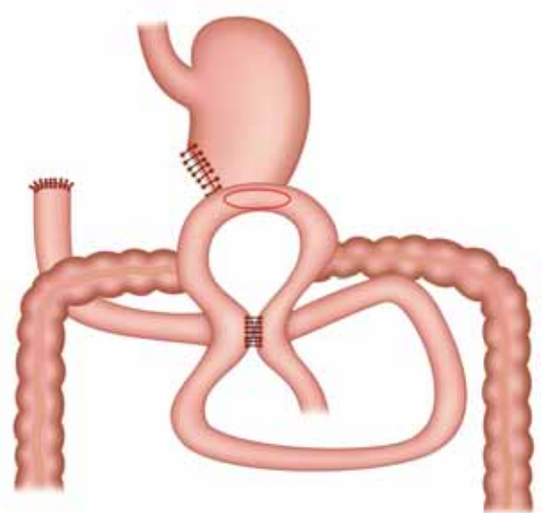


Fig. 20-62: Gastrectomy Braun modification of Billroth II anastomosis.

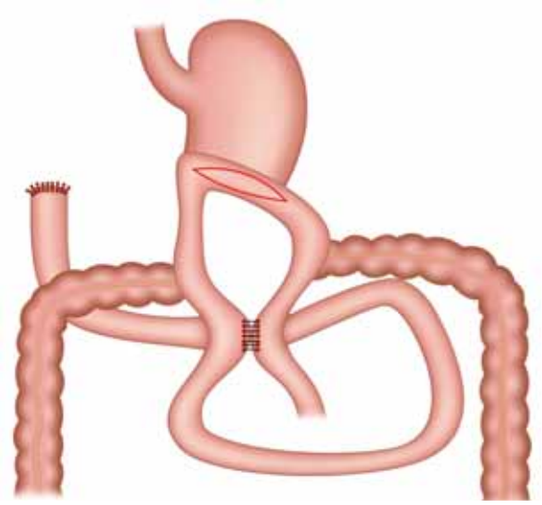


Fig. 20-63: Gastrectomy Balfour modification of Billroth II anastomosis.

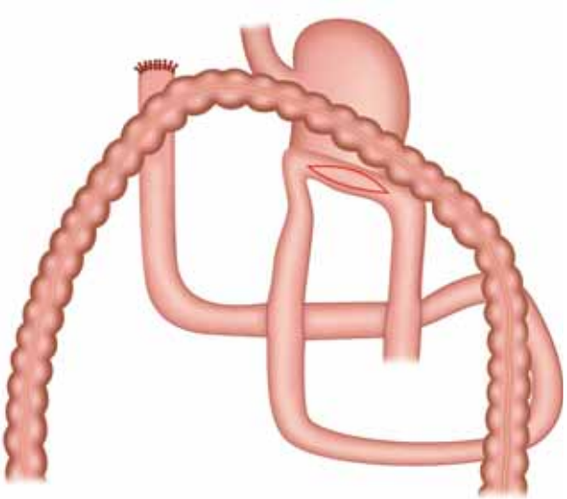


Fig. 20-64: Gastrectomy Reichel and Polya modification of Billroth II anastomosis.

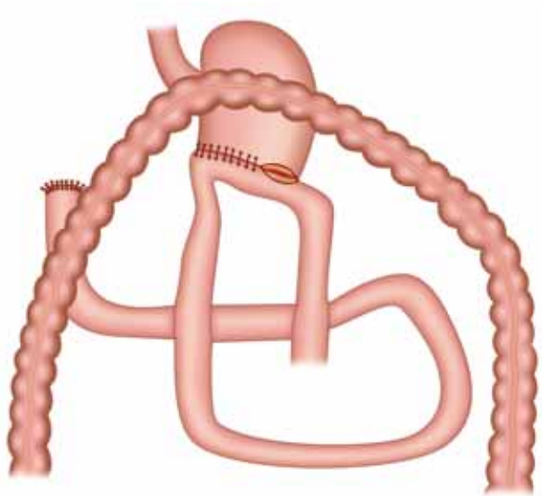


Fig. 20-65: Gastrectomy Finsterer Hofmeister modification of Billroth II anastomosis.

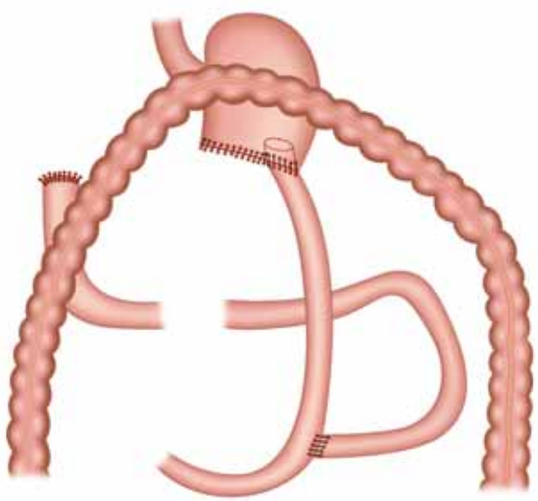


Fig. 20-66: Gastrectomy Roux modification of Billroth II anastomosis.

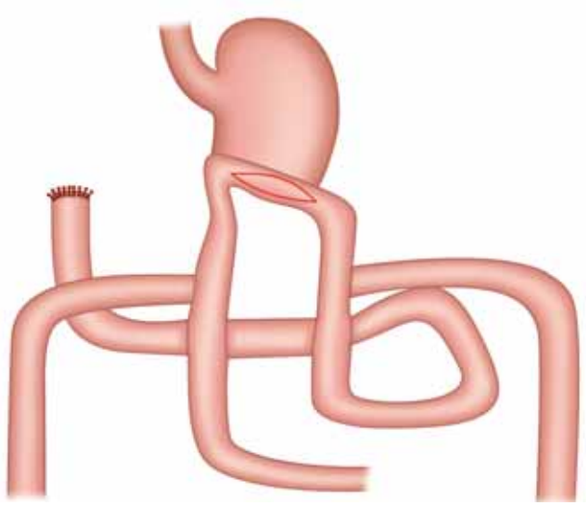


Fig. 20-67A: Gastrectomy Moynihan modification of Billroth II anastomosis.

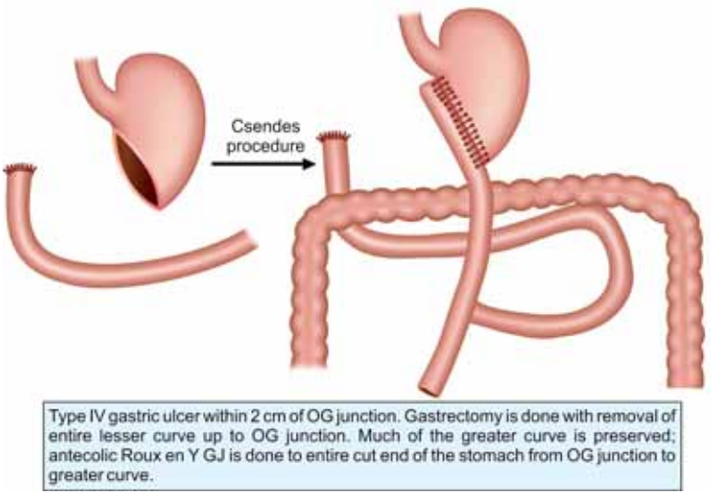

Csendes
procedure
Type IV gastric ulcer within 2 cm of OG junction. Gastrectomy is done with removal of entire lesser curve up to OG junction. Much of the greater curve is preserved; antecolic Roux en Y GJ is done to entire cut end of the stomach from OG junction to greater curve.

Fig. 20-67B: Csendes procedure – with gastrectomy, Roux en Y antecolic GJ to entire cut end of stomach

Indications

Early gastric cancer is a good option but with lymph node dissection. Gastrointestinal stromal tumour (GIST) and leiomyoma are other indications. It has been opined by many that Roux-n-Y anastomosis should be reserved to only subtotal gastrectomy with less gastric remnant. But presently proved that Roux-n-Y anastomosis is better; but Roux syndrome and gastric stasis are the major drawbacks.

Advantages

It shows very less enterogastric reflux and lower incidence of *H. pylori* infection. Gastritis and dumping is less in Roux-en-Y.

Disadvantages

Development of stomal ulcers; gallstone formation; technically additional anastomosis; endoscopic access to ampulla of Vater is lost or difficult; Roux stasis syndrome (25%, inadequate jejunal limb peristalsis).

Technique (Fig. 20-68)

Under general anaesthesia with head up position laparotomy is done with upper midline incision. Thorough exploration of the peritoneal cavity is done. Greater omentum is separated from the transverse

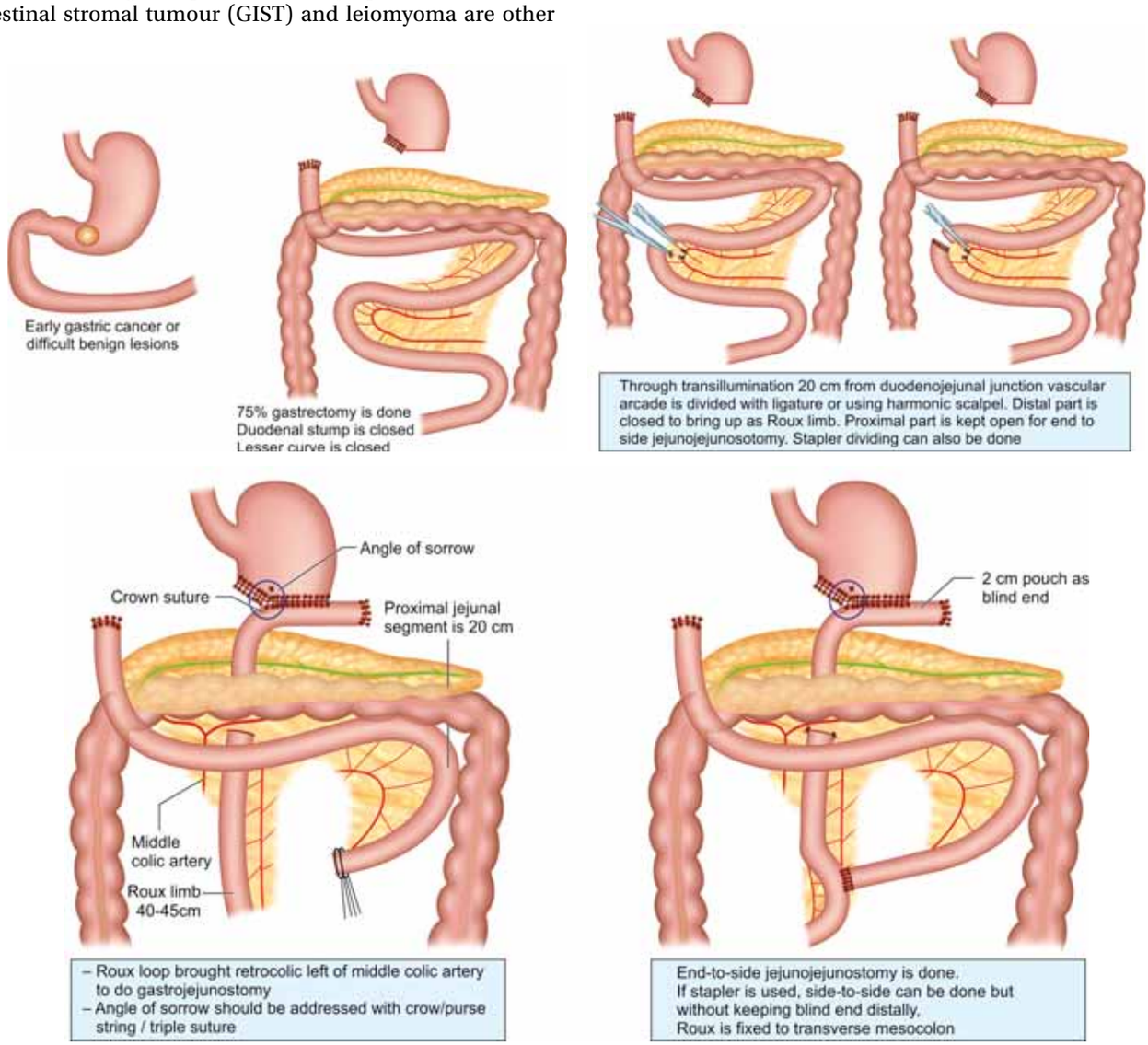

Early gastric cancer or
difficult benign lesions
75% gastrectomy is done
Duodenal stump is closed
Lesser curve is closed
Through transillumination 20 cm from duodenojejunal junction vascular arcade is divided with ligature or using harmonic scalpel. Distal part is closed to bring up as Roux limb. Proximal part is kept open for end to side jejunojejunosotomy. Stapler dividing can also be done
Angle of sorrow
Crown suture
Proximal jejunal
segment is 20 cm
Middle
colic artery
Roux limb
40-45cm
– Roux loop brought retrocolic left of middle colic artery to do gastrojejunostomy
– Angle of sorrow should be addressed with crow/purse string / triple suture
2 cm pouch as
blind end
End-to-side jejunojejunostomy is done.
If stapler is used, side-to-side can be done but without keeping blind end distally,
Roux is fixed to transverse mesocolon

Fig. 20-68: Roux-en-Y anastomosis after subtotal gastrectomy.

colon through avascular lane using scissor or cautery. Middle colic artery should be taken care of. While using cautery, care should be taken not to transmit heat to adjacent colon which may be dangerous. Lesser omentum is divided. Omental bursectomy is done by peeling of the omental layer from the superior part of the transverse mesocolon and in front of the pancreas. Line of proximal resection is marked; descending branch of left gastric artery and vein are ligated securely and divided; branch of left gastroepiploic artery along the arcade is ligated and divided. Stomach is transected using linear stapler device at two levels to create lesser curve and to achieve Roux-en-Y gastrojejunostomy. This can be done by applying pairs of clamps on each part and dividing in between using number 15 blade or cautery. Clamp distal to the resected line with the distal stomach is lifted upwards and towards right to expose posterior aspect of the stomach and duodenum in front of the pancreas. All adhesions between distal stomach and pancreas are divided with cautery or harmonic scalpel. Right gastroepiploic and right gastric arteries are ligated and divided. Right gastric artery may be like leashes of vessels often. Duodenum is mobilised up to the gastroduodenal artery level, not beyond. Small vessels entering the proximal duodenum should be tackled using bipolar cautery. Duodenum is transected using stapler. It can also be transected between two clamps and can be closed by hand suturing. Specimen is removed. Lymph node dissection is also carried out along with gastric mobilisation in case of distal gastric cancer.

Ligament of Treitz is identified; 20 cm from the duodenojejunal junction jejunal loop is selected for mobilisation. Through transillumination, vascular arcades are ligated along the mesentery to get adequate length of the distal jejunum. Jejunum is divided after ligating vascular arcade. It is better to ligate this arcade using 3 zero silk; but harmonic scalpel may be sufficient. About 40-45 cm of Roux limb is selected at distal part of the jejunum which is brought upwards towards gastric remnant. It can be brought retrocolic commonly or antecolic. It is passed through an opening in the transverse mesocolon towards left of the middle colic artery. Stapler line in the gastric remnant is removed partly for 4 cm on the greater curvature side; jejunum is opened on the antimesenteric border 2 cm proximal to the terminal end for 4 cm using cautery. Two layer anastomosis using outer continuous or interrupted silk and inner all layer vicryl sutures. Alternatively single layer continuous vicryl or silk can also be used. Angle of sorrow at the junction with the lesser curve also should be addressed with crown/triple suture. Stoma is confirmed using fingers. Continuity of gut below is maintained by end-to-side jejunojejunostomy after removing the stapler line (side-to-side also can be done wherein stapler line need not be removed). Roux jejunal loop is fixed to the transverse mesocolon with interrupted sutures to prevent herniation.

Nasogastric tube is gently negotiated across gastrojejunostomy stoma distally which acts as a stent. Pedicles, duodenal stump, anastomotic lines are checked again. Suction is done in surgical field. Mop counting is confirmed. Tube drain is placed. Abdomen is closed in layers **(Fig. 20-69)**.

Postoperative Care

Nasogastric tube is removed in 72 hours. Oral sips started and later solid food.

Drain is removed in 5 days.

Complications

- Gastroparesis.
- Dumping syndrome.
- Roux stasis syndrome.
- Afferent loop syndrome.
- Other complications.

Subtotal Gastrectomy with D2 Dissection

Subtotal gastrectomy is still an acceptable reasonable option as it is less morbid with better quality of life than total gastrectomy with equivalent survival rate. But when subtotal gastrectomy is not possible or microscopic margin clearance is doubtful then total gastrectomy is better option, especially when tumour is large occupying almost entire lesser curve or 75% of the stomach or tumour of the body of the stomach. Microscopic margin clearance is most important deciding factor, along with lymph node involvement which should be less than five. Even when there is microscopic clearance but if lymph nodes are positive in more than 5 nodes, then there is no benefit as far as prognosis is considered.

D2 gastrectomy includes—removal of stomach with growth, omental bursa, greater and lesser omentum, anterior layer of mesocolon, anterior pancreatic capsule, D2 lymphadenectomy. D2 dissection is better than D1 dissection of lymph nodes.

Presently newer staging for dissection is practiced in Japan—D1, D2, D3, D4, depending on levels of lymph nodes cleared ('D' for dissection). D1 or D2 dissections are commonly done.

D1 is done when nodes are N0. It is removal of nodes along the lesser and greater curves and pylorus (Group I: Stations 3-6).

D2 is done when nodes are N1. Here nodes like left gastric/common hepatic/splenic/retropancreatic are removed. Splenic nodes can be cleared with or without splenectomy along with removal of tail of pancreas. Here node stations 1-11 are removed. Stations 12-18 are not removed. Average 27 nodes are removed.

D3 is done when nodes are N2. Nodes removed for clearance are hepatoduodenal, nodes along mesentery, middle colic (1-16 stations). Average 43 nodes are removed.

D4 is *not commonly advocated*. It is removal of stations 1-18.

D1—involvement of group I lymph nodes.

D2—involvement of group I and II lymph nodes.

D3—involvement of group I, II and III lymph nodes.

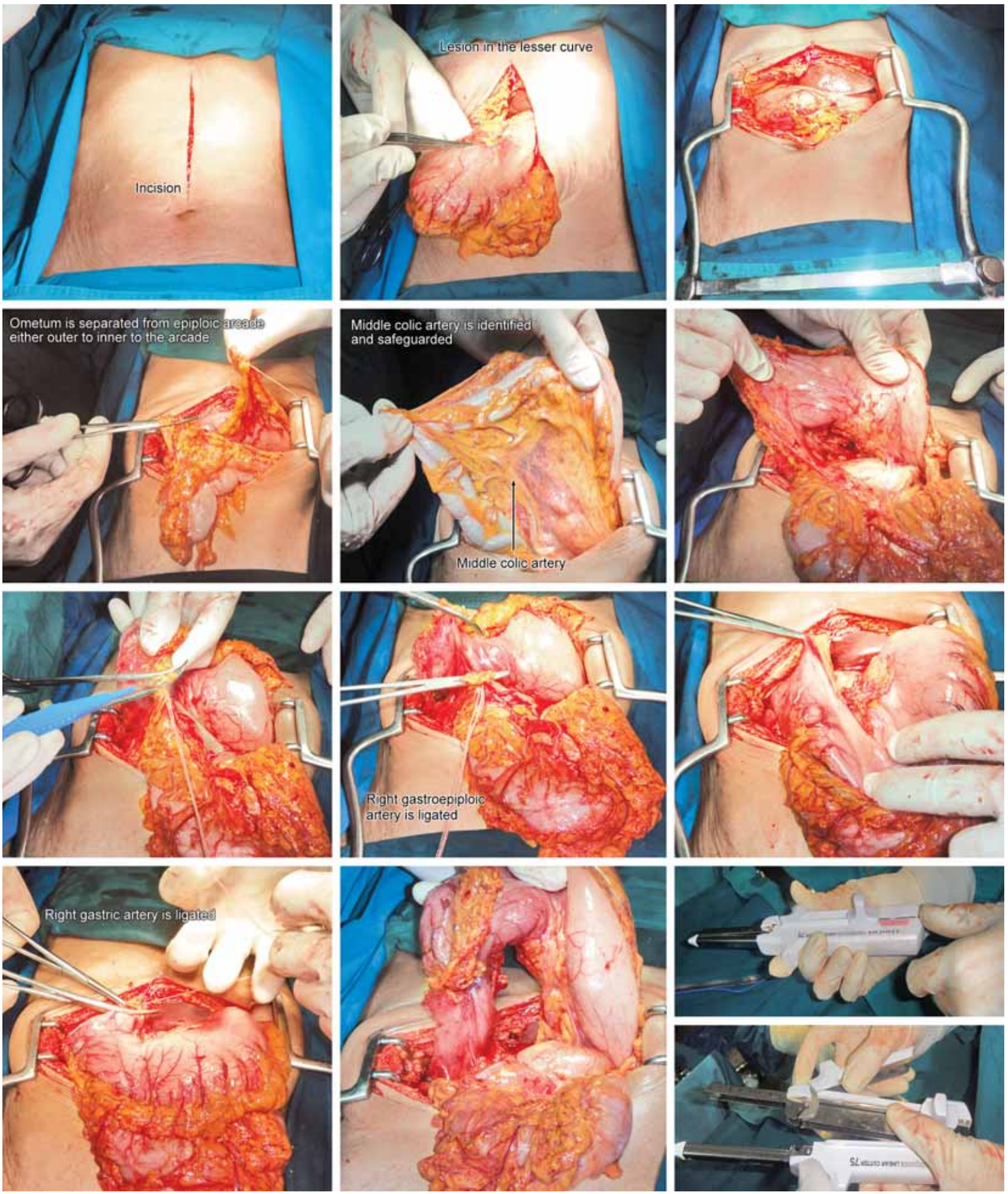
D4—involvement of group I, II, III and para-aortic nodes.

Note:

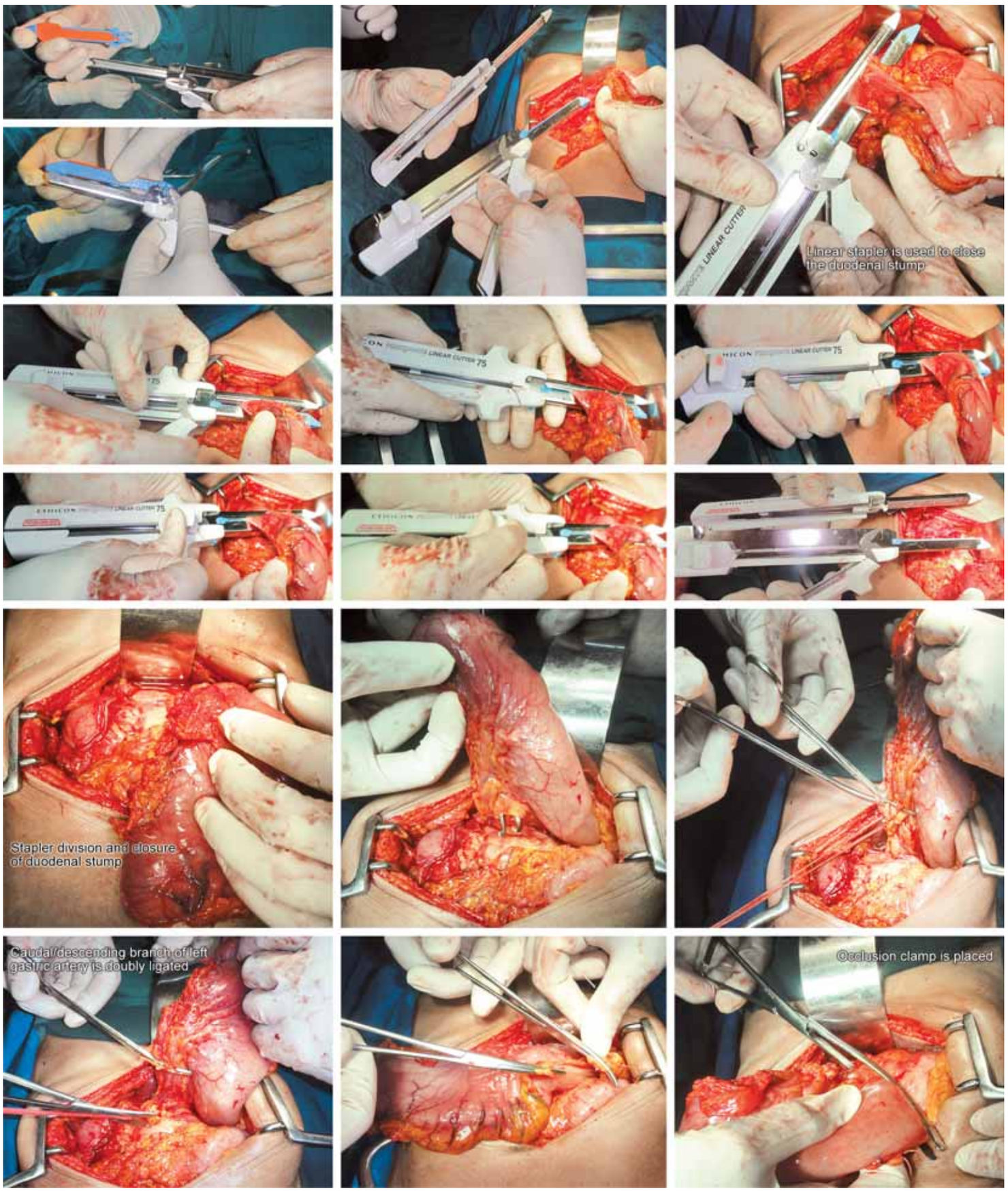
All lymph nodes are numbered differently as 'stations' or 'echelons.' *D1 gastrectomy* is clearance of perigastric nodes; *D2 gastrectomy* is clearance of nodes along major vessel trunks—along coeliac and splenic arteries. D2 is always better than D1.

Lymph node stations in gastric carcinoma (Japan)—18 stations are there:

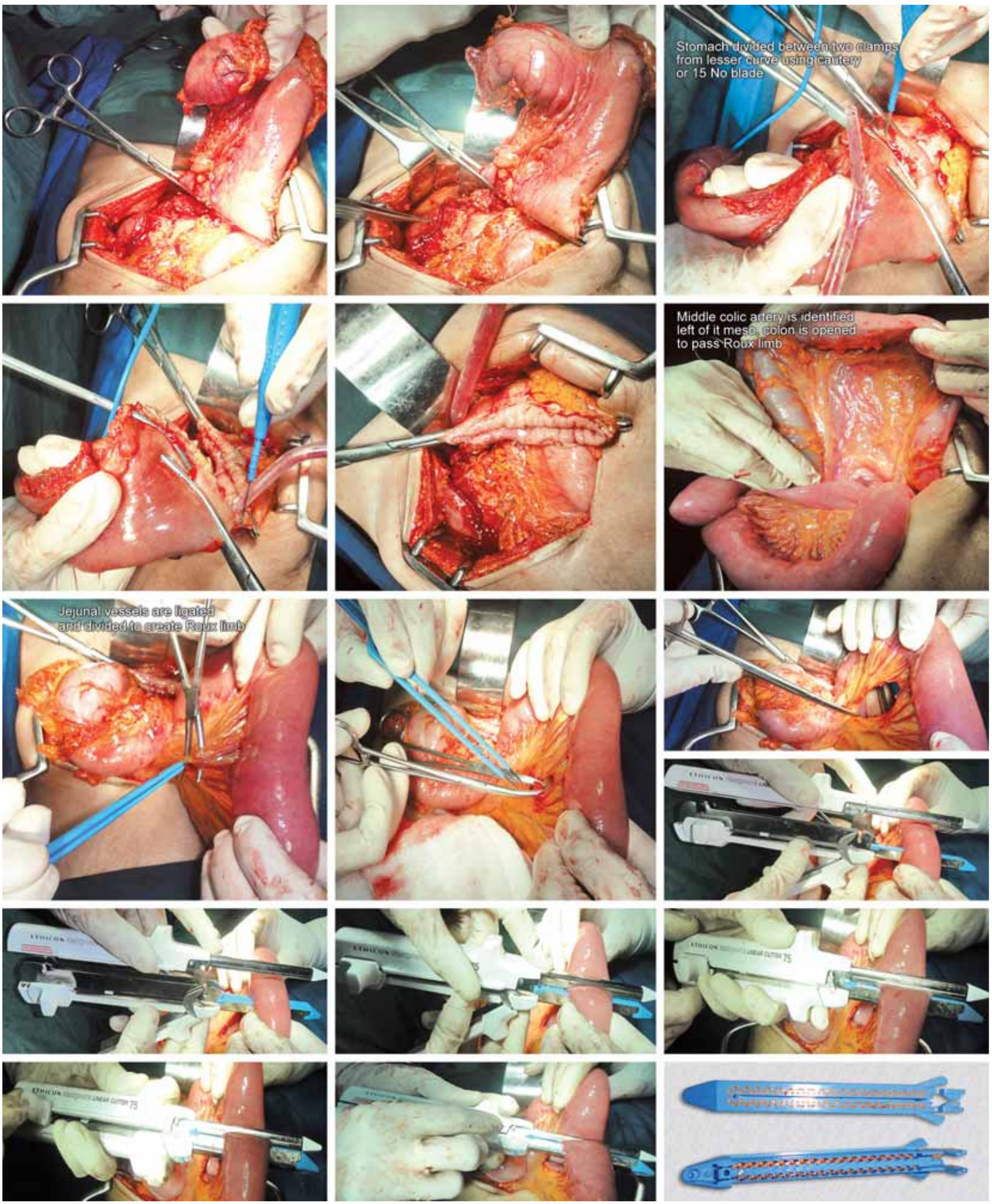
1. Right cardiac
2. Left cardiac
3. Nodes along the lesser curvature
4. Nodes along the greater curvature
   a. Along short gastric vessels—4sa
   b. Along left gastroepiploic vessels—4sb
   c. Along right gastroepiploic vessels—4sc
5. Suprapyloric nodes
6. Subpyloric nodes
7. Along left gastric artery
8. Along common hepatic artery
9. Along coeliac axis
10. At splenic hilum
11. Along splenic artery


Incision
Lesion in the lesser curve
Ometum is separated from epiploic arcade either outer to inner to the arcade
Middle colic artery is identified and safeguarded
Middle colic artery
Right gastroepiploic artery is ligated
Right gastric artery is ligated

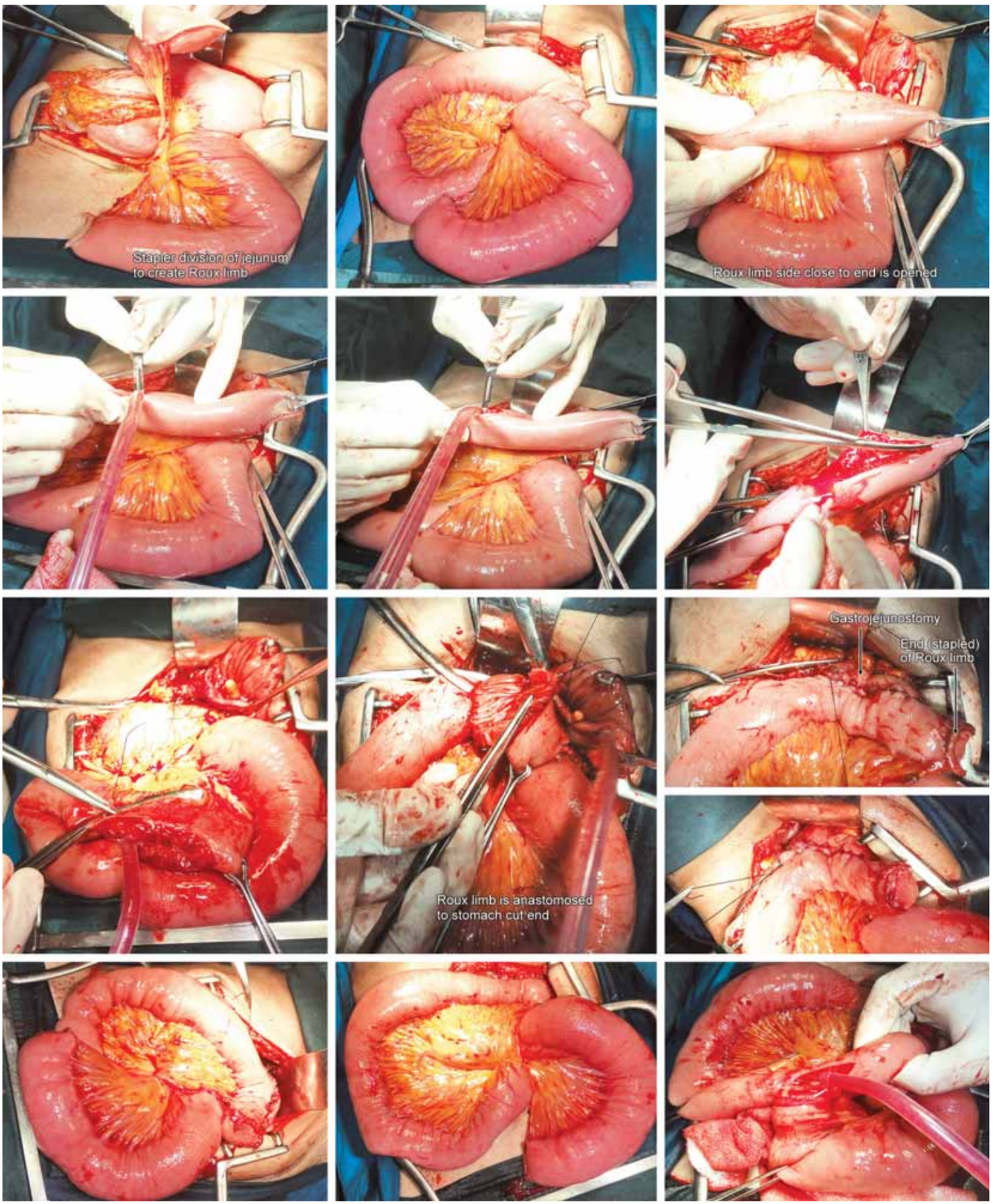
Figs 20-69(1)


Linear stapler is used to close the duodenal stump
Stapler division and closure of duodenal stump
Caudal/descending branch of left gastric artery is doubly ligated
Occlusion clamp is placed

Figs 20-69(2)


Stomach divided between two clamps from lesser curve using cautery or 15 No blade
Middle colic artery is identified left of it mese, colon is opened to pass Roux limb
Jejunal vessels are ligated and divided to create Roux limb

Figs 20-69(3)


Stapler division of jejunum to create Roux limb
Roux limb side close to end is opened
Roux limb is anastomosed to stomach cut end
Gastrojejunostomy
End (stapled) of Roux limb

Figs 20-69(4)

Figs 20-69(5)

Figs 20-69(1 to 5): Gastrectomy with Roux-en-Y gastrojejunostomy.

12. At hepatoduodenal ligament
13. Retroduodenal lymph nodes
14. At root of mesentery
15. Around middle colic artery
16. Para-aortic nodes
17. Around lower oesophagus
18. Supradiaphragmatic

TNM STAGING edition 7th 2010

Tumour – T
- Tx – tumour cannot be assessed
- T0 – no evidence of tumour
- Tis – carcinoma in situ, intraepithelial tumour without invasion
- T1a – invades lamina propria or muscularis mucosa
- T1b – invades submucosal
- T2 – invades muscularis propria
- T3 – invades subserosal connective tissue without invasion of visceral peritoneum or adjacent structures
- T4a – invades serosa/visceral peritoneum
- T4b – invades adjacent structures

Nodes – N
- Nx – cannot be assessed
- N0 – no nodal spread
- N1 – 1-2 regional nodes
- N2 – 3-6 regional nodes
- N3a – 7-15 regional nodes
- N3b – 16 or more nodes

Metastases – M
- M0 – no distant spread
- M1 – distant spread present

Contd...

First tier nodes: Nodes within 3 cm from primary tumour (stations 1-6)—N1 (old TNM).

Second tier nodes: Nodes in main and intermediate arterial trunk (stations 7-11)—N2 (old TNM).

Contd...

Staging
- 0 – Tis N0 M0
- IA – T1 N0 M0;
- IB – T1 N1 M0/T2 N0 M0
- IIA – T1 N2 M0; T2 N1 M0; T3 N0 M0
- IIB – T1 N3 M0; T2 N2 M0; T3 N1 M0; T4a N0 M0
- IIIA - T2 N3 M0; T3 N2 M0; T4a N1 M0
- IIIB - T3 N3 M0; T4a N2 M0; T4b N0-1 M0
- IIIC – T4a N3 M0; T4b N2-3 M0
- IV: Any T Any N M1

- Stage I, II,II: Locoregional disease
- Stage IV: Systemic disease

Japanese Classification of Gastric Carcinoma (JCGC)

It includes following principles:
- Basic rules for clinical, surgical, pathological, and final features
- Specific rules for histology
- Gastric biopsy specimen group classification
- Chemo RT response

Nodal spread as per JCGC:
- Nx – Nodes unknown/cannot be assessed
- N0 – No nodal spreads
- N1 – Group I nodes only involved
- N2 – Group II nodes are involved but not group III
- N3 – Group III nodes are involved

Birmingham staging

1 – Confined to mucosa/muscularis propria
2 – Muscularis/serosal involvement
3 – Nodal spread
4a – Residual disease; 4b – Metastatic disease

Third tier nodes: Nodes at stations 12-18 (para-aortic and above)—N3 (old TNM).

Note: 15 lymph nodes must be removed for adequate staging of nodes

Technique

Preparation is same as other gastrectomy. But CT scan and other modalities of evaluation in relation to secondaries and lymph node status should be done thoroughly.

Under general anaesthesia, laparotomy is done through lengthy upper midline incision which is extended below across the umbilicus. Head up position is preferred (reverse Trendelenburg).

Greater omentum is mobilised from the transverse colon through avascular plane. Anterior leaf of the peritoneum of the transverse mesocolon and peritoneum over the anterior surface of the pancreas is removed (omental bursectomy). Need for omental bursectomy is controversial. Omentum is dissected from splenic flexure of colon and inferior pole of the spleen to expose the tail and body of the pancreas. Left gastroepiploic vessels are divided at their origin from splenic vessels. Short gastric vessels are also ligated and divided. Energy sources like harmonic scalpel are of great use in such situation.

Right gastroepiploic vein is carefully dissected; bleeding is common here as many fragile tributaries are present. Right gastroepiploic vein after being joined by the middle colic vein forms gastrocolic vein which is short and joins the superior mesenteric vein. Right gastroepiploic vein is ligated at its joining junction. If tear and bleeding occur, gastrocolic trunk vein or middle colic vein can be ligated (middle colic artery should be safeguarded). Superior mesenteric vein is dissected in its front, medial and lateral aspects to clear lymph node stations. Right gastroepiploic artery is dissected at its origin from the gastroduodenal artery. Tissues with lymph nodes in front of the head of pancreas and behind the pylorus are cleared.

Gastrohepatic ligament is dissected. Aberrant hepatic artery if present should be preserved. Hepatoduodenal ligament is opened. Common hepatic artery, proper hepatic artery, right gastric artery, gastroduodenal arteries are identified and dissected to remove fat lymph nodes adjacent to it. Right gastric artery is ligated and divided at its origin. It usually arises from proper hepatic artery; but as variation, it can arise from gastroduodenal artery. Small vessels are common in this area which cause troublesome bleeding; so bipolar cautery or harmonic scalpel are better to be used. Kocherisation is needed for proper nodal clearance in relation to duodenum.

Duodenum is transected using stapler in similar way as mentioned earlier. Stapler is ideal; otherwise duodenum is cut between clamps and duodenal stump is closed by one of the suitable methods discussed earlier.

D2 lymphadenectomy is done. It begins by removing fat and lymph nodes lateral to the proper hepatic artery; tissues in front of the portal vein, superior border of the pancreas, in front and behind the common hepatic artery; left gastric vein (coronary vein) is ligated where it joins the portal vein which courses behind the lesser curvature; tissues along and above the splenic artery are also cleared. Coeliac axis is identified; nodes in front of it are cleared; left gastric artery is dissected, doubly ligated and divided and nodes along its origin are cleared. Lymph nodes along the right side of the OG junction along the crura of diaphragm and anterior surface of the abdominal oesophagus (lower 3 cm of abdominal oesophagus should be cleared). Dissection continues along the splenic artery and posterior surface of the stomach. Dissection is continued towards splenic hilum, if nodes are suspiciously involved. Splenectomy is not necessary **(Fig. 20-70)**.

Gastric division is done as *subtotal gastrectomy* (75-80%) by dividing the stomach 2 cm distal to OG junction along lesser curve and 5 cm distal along the greater curvature. Straight occlusion clamp is placed along the greater curvature towards remnant side and along lesser curve obliquely to create lesser curve. Crushing (Payr's) or Kocher's clamps are placed towards specimen side. Stomach is cut using no. 15 blade. Specimen is placed in orientation grid. Intraoperative frozen section biopsy is done to confirm the clearance at margins. Stapler device can be used to divide the stomach at two places. Usually lesser curvature part is transected with stapler. Stomal part is cut with knife between clamps.

Reconstruction is done by omega loop gastrojejunostomy with Braun jejunojejunostomy (ideally antecolic but retrocolic can be used) or Roux-en-Y gastrojejunostomy. Angle of sorrow/angle of death is addressed with crown/purse string/triple suture to stabilise the angle. Nasogastric tube is negotiated into efferent or Roux limb. Feeding jejunostomy may be required. Tube drain is placed. Even though gastric remnant is small, it maintains the OG junction function and remnant acts as small but significant reservoir.

TOTAL GASTRECTOMY

Removal of entire stomach (with cardia, distal oesophageal tube and cuff of duodenum) with nodal clearance may be the oncologically right surgery for carcinoma stomach. Palliative total gastrectomy, even though is done, often is doubtful about its advantages.

Connor did first total gastrectomy in 1884. Brigham, Richardson, Moynihan, Ravitch, etc started doing total gastrectomy.

Indications

Carcinoma involving most of the lesser curvature, carcinoma of body or proximal part of the stomach are probably the indications.
Preoperative preparations are same as subtotal gastrectomy.

Technique

Under general anaesthesia with double lumen, endotracheal tube is used. Patient is positioned supine with left chest upwards in case if extension is needed at a later period. Entire chest and abdomen are cleaned and draped. Upper midline incision with provision for extension into the thorax or bilateral subcostal incision or left upper oblique incision towards left chest wall or left thoracoabdominal incision is used. Lengthy incision is preferred to achieve good exposure **(Fig. 20-71)**.

Procedure is almost same as for subtotal gastrectomy. Mobilisation of the greater omentum from the transverse colon, infrapyloric dissection with ligation of right gastroepiploic vein and artery; suprapyloric dissection with ligation of right gastric artery at its origin and removing fat and lymph nodes along these vessels; duodenal transection; dissection along the cardia and lower oesophagus with clearance of all lymph nodes; ligation of left gastric artery at its origin; left gastric vein is ligated at its joining with the portal vein. Nodes along the splenic artery up to the hilum are cleared. Splenectomy is usually not indicated; but if inevitable arises then should be done. Lymph nodes along the crus of the diaphragm and coeliac artery are removed. Vascular clamp is applied at the line of resection of the lower

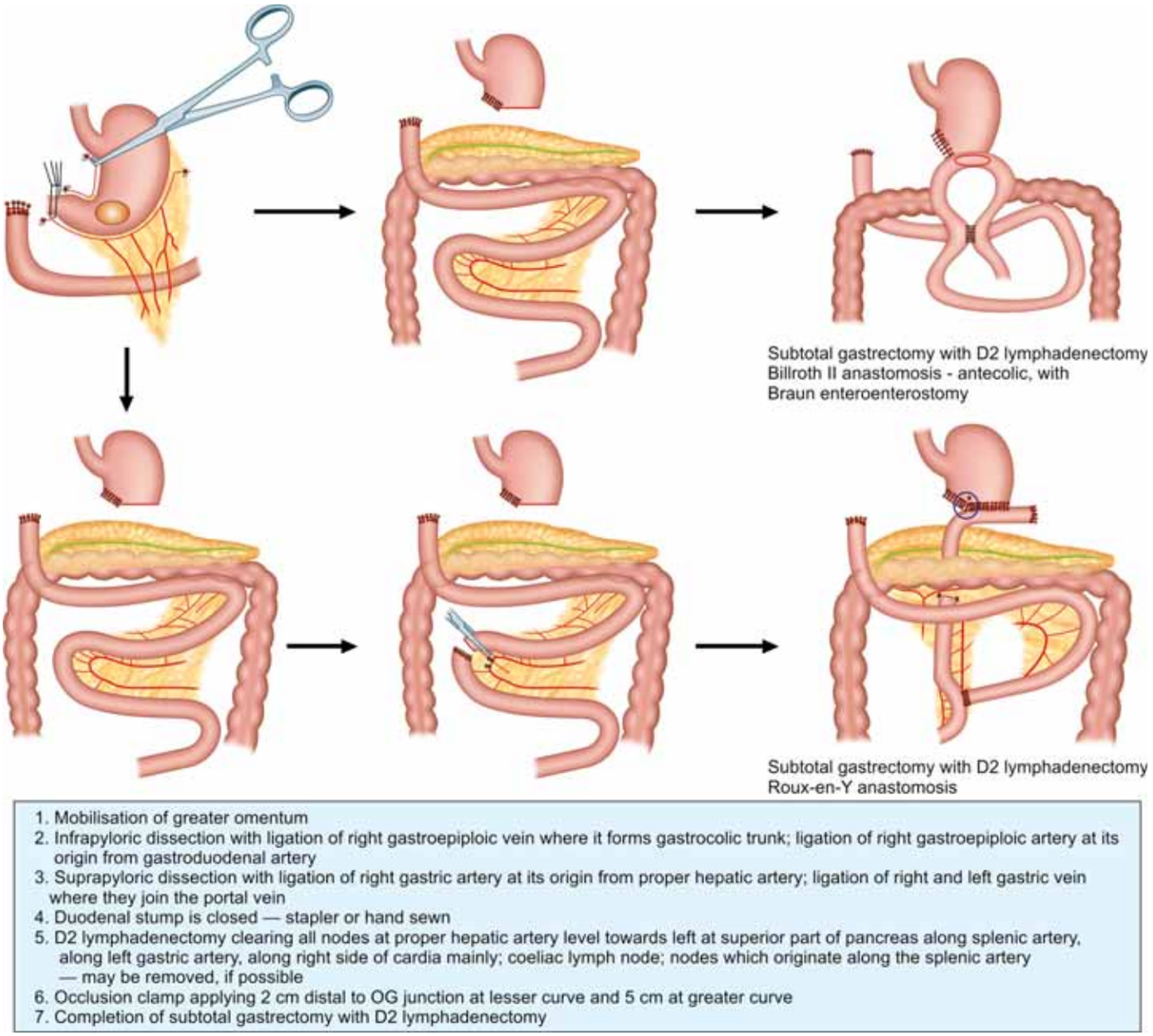

Subtotal gastrectomy with D2 lymphadenectomy
Billroth II anastomosis - antecolic, with
Braun enteroenterostomy
Subtotal gastrectomy with D2 lymphadenectomy
Roux-en-Y anastomosis
1. Mobilisation of greater omentum
2. Infrapyloric dissection with ligation of right gastroepiploic vein where it forms gastrocolic trunk; ligation of right gastroepiploic artery at its origin from gastroduodenal artery
3. Suprapyloric dissection with ligation of right gastric artery at its origin from proper hepatic artery; ligation of right and left gastric vein where they join the portal vein
4. Duodenal stump is closed — stapler or hand sewn
5. D2 lymphadenectomy clearing all nodes at proper hepatic artery level towards left at superior part of pancreas along splenic artery, along left gastric artery, along right side of cardia mainly; coeliac lymph node; nodes which originate along the splenic artery — may be removed, if possible
6. Occlusion clamp applying 2 cm distal to OG junction at lesser curve and 5 cm at greater curve
7. Completion of subtotal gastrectomy with D2 lymphadenectomy

Fig. 20-70: D2 lymphadenectomy with subtotal gastrectomy.

oesophagus 3 cm proximal to the OG junction. With crushing clamp on specimen side, specimen is removed.

Reconstruction is done by Roux-en-Y oesophagojejunostomy. Roux limb should be 40-45 cm. Oesophagojejunostomy should be end-to-side. Nasogastric tube should be passed across the oesophageal stoma. Distal jejunojejunostomy is done at 20 cm from the duodenojejunal junction. End-to-side anastomosis is done. If stapler resection of the loop was done earlier then side-to-side anastomosis is done.

COMPLICATIONS OF GASTRIC SURGERIES

Early Complications

Intragastric haemorrhage occurs usually from anastomotic site. It is identified by blood in the nasogastric tube. If it is mild, it can be left alone as it will subside in a day or two. If it is severe then patient develops shock with tachycardia and hypotension. Blood transfusion is required. If persists such patient needs relaparotomy, identification of bleeding point from the anastomotic site and secure suturing of the area using silk or vicryl. Occasionally bleeding can occur from the existing ulcer (duodenal ulcer) which usually subsides once acid level comes down and ulcer starts healing.

Extragastric haemorrhage occurs either from slipping of ligatures of left gastric/right gastric or epiploic arteries. Bleeding can occur from pancreatic bed, omental site or organs like spleen or liver. Nasogastric tube will not show the blood. Signs like shock, palor and low haemoglobin confirms the diagnosis, blood transfusion, relaparotomy and addressing the bleeding area accordingly is needed.

Duodenal blow out/duodenal stump leakage occurs in Billroth II anastomosis. It occurs in 5th-7th postoperative period commonly. Incidence is 3-5%. It is due to duodenal fibrosis, poor blood supply of the stump, pancreatitis, infection, raised intraduodenal pressure. It can also occur if there is obstruction at afferent limb of the loop Billroth II anastomosis without Braun enteroenterostomy. Leak causes sudden pain, tachycardia and initial sepsis; but gradually gets localised. Conservative treatment usually is sufficient. Additional feeding jejunostomy, creation of jejunojejunostomy between afferent and efferent loops usually is sufficient **(Fig. 20-72)**.

Leak from the Billroth I anastomosis is due to partial disruption of the anastomosis, probably few sutures have disrupted. Usually subsides gradually on its own. If it causes leak it is problematic.

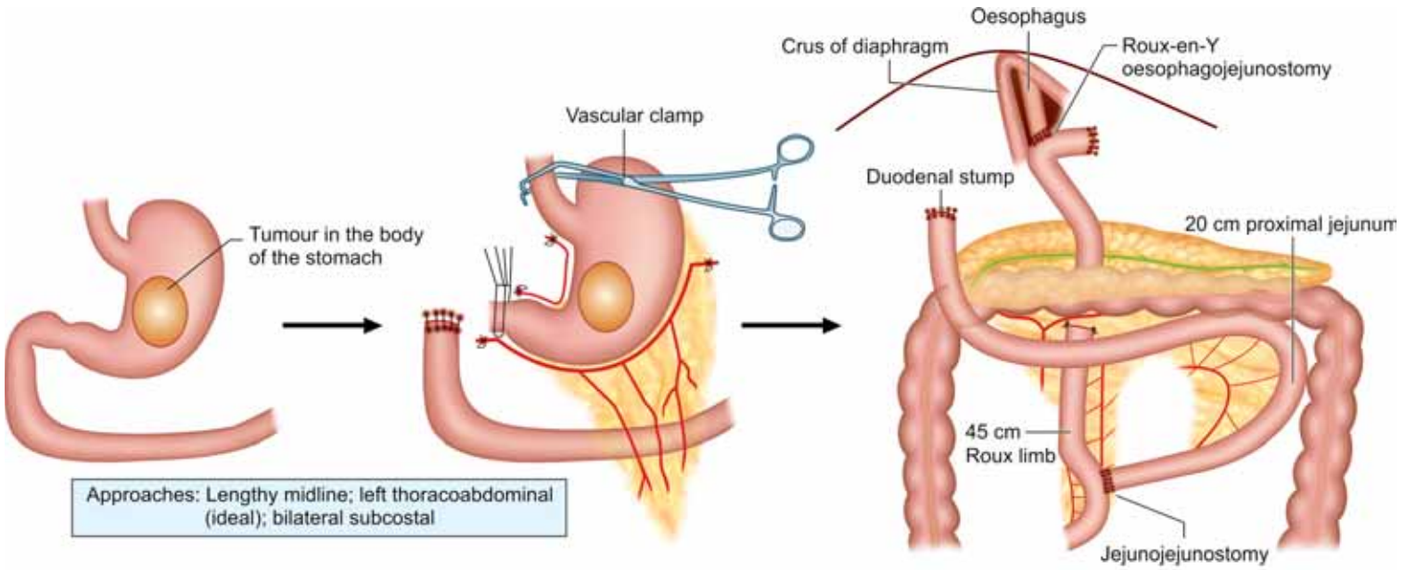

Oesophagus
Crus of diaphragm
Roux-en-Y oesophagojejunostomy
Vascular clamp
Duodenal stump
Tumour in the body of the stomach
20 cm proximal jejunum
45 cm Roux limb
Jejunojejunostomy
Approaches: Lengthy midline; left thoracoabdominal (ideal); bilateral subcostal
1. Mobilisation of greater omentum
2. Infrapyloric dissection with ligation of right gastroepiploic vein where it forms gastrocolic trunk; ligation of right gastroepiploic artery at its origin from gastroduodenal artery
3. Suprapyloric dissection with ligation of right gastric artery at its origin from proper hepatic artery; ligation of right and left gastric vein where they join the portal vein
4. Duodenal stump is closed — stapler or hand sewn
5. D2 lymphadenectomy clearing all nodes at proper hepatic artery level towards left at superior part of pancreas along splenic artery, along gastric artery, along both sides or cardia mainly right side; coeliac lymph nodes; ligation of left gastric artery at its origin; ligation of the left gastroepiploic artery and posteror gastric artery which originates from splenic artery
6. Vascular clamp applying 3 cm proximal to OG junction to the oesophagus
7. Completion of total gastrectomy

Fig. 20-71: Total gastrectomy with oesophagojejunostomy—Roux-en-Y anastomosis.

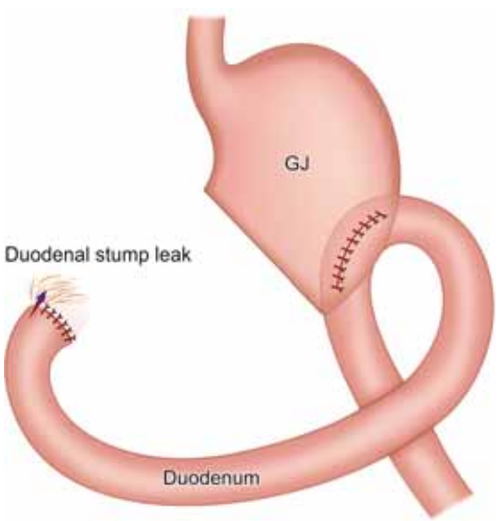


Fig. 20-72: Duodenal blow out after gastrectomy with Billroth II anastomosis.

Gastrografin study provides a clue for leak. In such situation, relaparotomy is needed. Omental patch over the suture site with a drain placement is often sufficient. Occasionally needs conversion of Billroth I to Billroth II anastomosis. Feeding jejunostomy is needed.

Disruption of gastrojejunostomy is usually seen after Billroth II anastomosis; occasionally occurs after simple gastrojejunostomy also. It needs CT study/gastrografin study, reopening and omental patch if it is small. Often needs conversion to Roux-en-Y anastomosis. Disruption of pyloroplasty needs gastric resection.

Stomal obstruction: Stomal obstruction is due to stomal oedema; afferent loop obstruction; herniation of afferent or efferent limbs; kinking and adhesions at efferent loop level; afferent or efferent loop interposition behind the gastric remnant (herniation into lesser sac). Gastroduodenostomy obstruction if persists (Billroth I) for more than 10 days then it needs intervention by relaparotomy. It is not possible to dismantle the gastroduodenostomy stoma as it will cause leak. It is better to leave it like that and bring a gastrojejunostomy as antecolic in the gastric remnant. Stomal oedema usually subsides over the period of time. Thirty percent of stomal obstruction when persists need relaparotomy. Release of kinking and adhesions, correction of internal herniations of afferent or efferent or both limbs; conversion into alternate procedures like Billroth II or Roux-en-Y or adding one more gastrojejunostomy to gastric remnant are alternatives used.

Afferent loop obstruction: It is due to long afferent loop. Afferent loop is usually taken as 8-10 cm for posterior and 15 cm for anterior gastrojejunostomy. Roux-en-Y anastomosis eliminates afferent loop. Long afferent loop causes kinking of the loop at its junction with anastomosis which leads into duodenal obstruction. This leads into duodenal blow out in case of Billroth II anastomosis. Long afferent loop also can lead into twist, internal herniation, jejunogastric intussusception. All these lead into closed loop obstruction proximally in the duodenum raising intraduodenal pressure exceeding pancreatic duct pressure, abdominal pain, vague tender mass in the abdomen, raised total count and serum amylase mimicking acute pancreatitis. But in reality, there is enormous dilatation of the loop and duodenum which needs immediate laparotomy and surgical decompression or diversion. *Afferent loop obstruction cannot be diagnosed by endoscopy.* *Surgical treatment*: If loop is viable on laparotomy then creation of

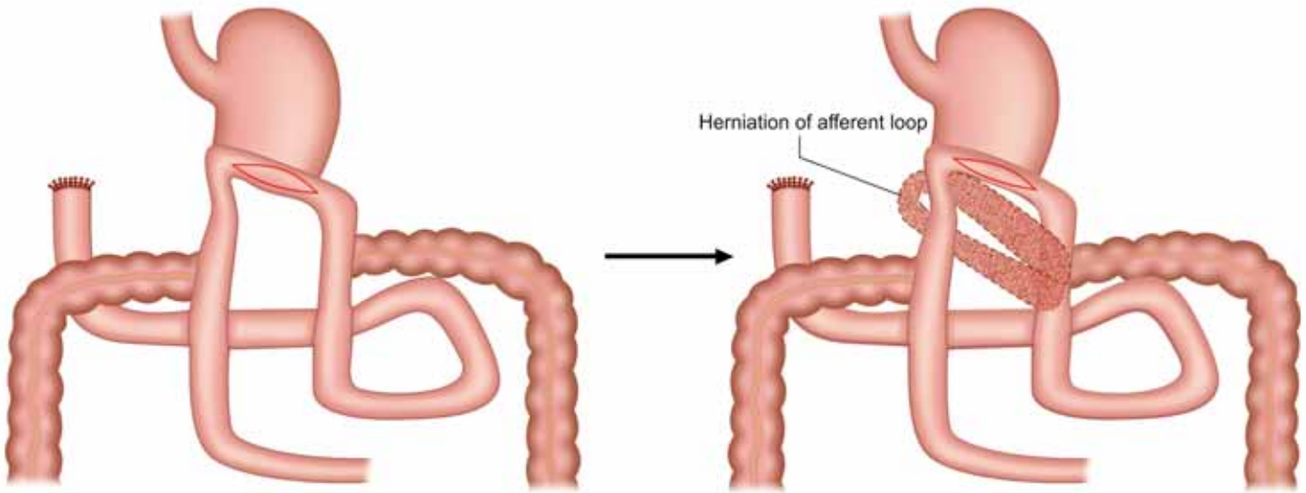


Fig. 20-73: Afferent loop obstruction occurs due to long afferent loop which may herniate or twist or kink.

jejunojejunostomy between dilated afferent and normal efferent limb is suffice. Otherwise resection, dismantling the gastrojejunostomy and creation of Roux-en-Y anastomosis is needed **(Fig. 20-73)**.

Jejunal loop herniation after Billroth II anastomosis can occur as early complication or as late complication also. Herniation occurs in either afferent or efferent loop or both. If afferent loop is short, efferent loop will herniate; if afferent loop is long then afferent loop will herniate behind the gastrojejunostomy or efferent loop. Both loops if fixed to posterior parietal structures, it can be prevented. Relaparotomy is needed; hernia is reduced; mesentery is closed; if needed, afferent, loop is shortened and Roux-en-Y anastomosis is done.

Gastric remnant necrosis occurs in gastrectomies in which left gastric artery is ligated at its origin or splenectomy is also undertaken which compromises the blood supply of the gastric remnant. Gastric remnant after ligation of the left gastric artery maintains the viability through branch from left inferior phrenic artery. As a known variation, if inferior phrenic artery arises from left gastric artery which is already been ligated at its origin, gastric remnant necrosis is most likely to occur. Entire or part of the gastric remnant goes for necrosis leading to acute peritonitis features with coffee ground vomitus which needs immediate surgical intervention. Condition is diagnosed by MDCT abdomen. If part of the gastric remnant is necrosed then resection of that part and creating Roux-en-Y gastrojejunostomy is done; viability of remaining stomach should be adequate. If entire gastric remnant is involved which often may extend to distal oesophagus, then gangrenous part is resected with dismantling of the anastomosis; lower oesophagus is formed into a tube ostomy; cervical oesophagostomy is also done.

Intraabdominal abscess is not uncommon. It can be subphrenic abscess, pelvic abscess, interloop abscess; it can be single or multiloculated. CT abdomen is diagnostic. Higher generation antibiotics, percutaneous drainage or Open surgical drainage is needed **(Fig. 20-74)**.

Postoperative pancreatitis can occur (2-5%). It is usually not due to trauma but due to close proximity. But can occur while dissecting the pancreas in front, while removing the pancreatic capsule. It is treated conservatively. Postoperative jaundice is known to occur after gastric surgeries. It may be due to pancreatitis, anastomotic leak (bile gets absorbed from peritoneal cavity); haemolysis, sepsis, injury to bile duct, cholangitis, anaesthesia toxicity.

Common bile duct injury and injury at ampulla of Vater is uncommon but can occur. It is difficult to manage. Duodenum is opened; common bile duct is exposed; opened duodenum is sutured to head of the pancreas over the disrupted part as a coverage ostomy. T-tube drainage and stenting of ducts on table are other options. Isolated jejunal loop harvested from distal to existing anastomosis can be sutured to the head of the pancreas on to disrupted area. Second Roux loop can be taken to suture to the area **(Fig. 20-75)**.
Omental infarction, stress ulceration, inadvertent gastroileostomy are rare complications.

Late Complications

Alkaline reflux gastritis is commonest postgastrectomy late problem. Bile, pancreatic and duodenal juice is injurious to gastric mucosa. Reflux gastritis can occur in Billroth II (commonly), Billroth I, gastrojejunostomy alone when done and, pyloroplasty. Burning epigastric pain, bilious vomiting, anaemia, bleeding from the stomach are the features. Endoscopy with biopsy is diagnostic which shows oedema and friability of gastric mucosa. There will be acute and chronic inflammation with decrease in parietal cell mass but increase in mucus secreting cells. Prokinetic drugs may help. Measurement of bile acid in fasting gastric aspirate is useful. Surgical treatment is conversion to Roux-en-Y anastomosis; if patient has had pyloroplasty or gastrojejunostomy (after vagotomy) alone, then antrectomy and Roux-en-Y anastomosis to be done as Roux-en-Y perse is ulcerogenic. Many patients may have additionally reflux oesophagitis. Antireflux surgery may be needed in these patients.

Delayed gastric emptying can occur in any type of the gastric bypass. It is probably alteration in the gastric pacemaker activity. In these patients, endoscopy shows normal stoma **(Fig. 20-76)**.

Dumping syndrome can be early or late.

Early dumping syndrome is due to loss of pyloric sphincter mechanism allowing rapid passage of food across the duodenum or proximal jejunum causing vasomotor and gastrointestinal disturbances. It causes palpitation, sweating, increased bowel movements and borborygmi, colicky pain, tachycardia, hypotension, hypovolaemia, vomiting and diarrhoea. There is rapid passage of food. It is common (10%) and more severe type. It occurs in 30-60 minutes of eating. It is a primary disorder of carbohydrate metabolism. Initial transient hyperglycaemia prevents further absorption of glucose, which in turn draws fluid from the bowel wall by high osmolarity resulting in increased intestinal activity, resulting diarrhoea, and fall in blood pressure. Radionuclide studies show rapid emptying from

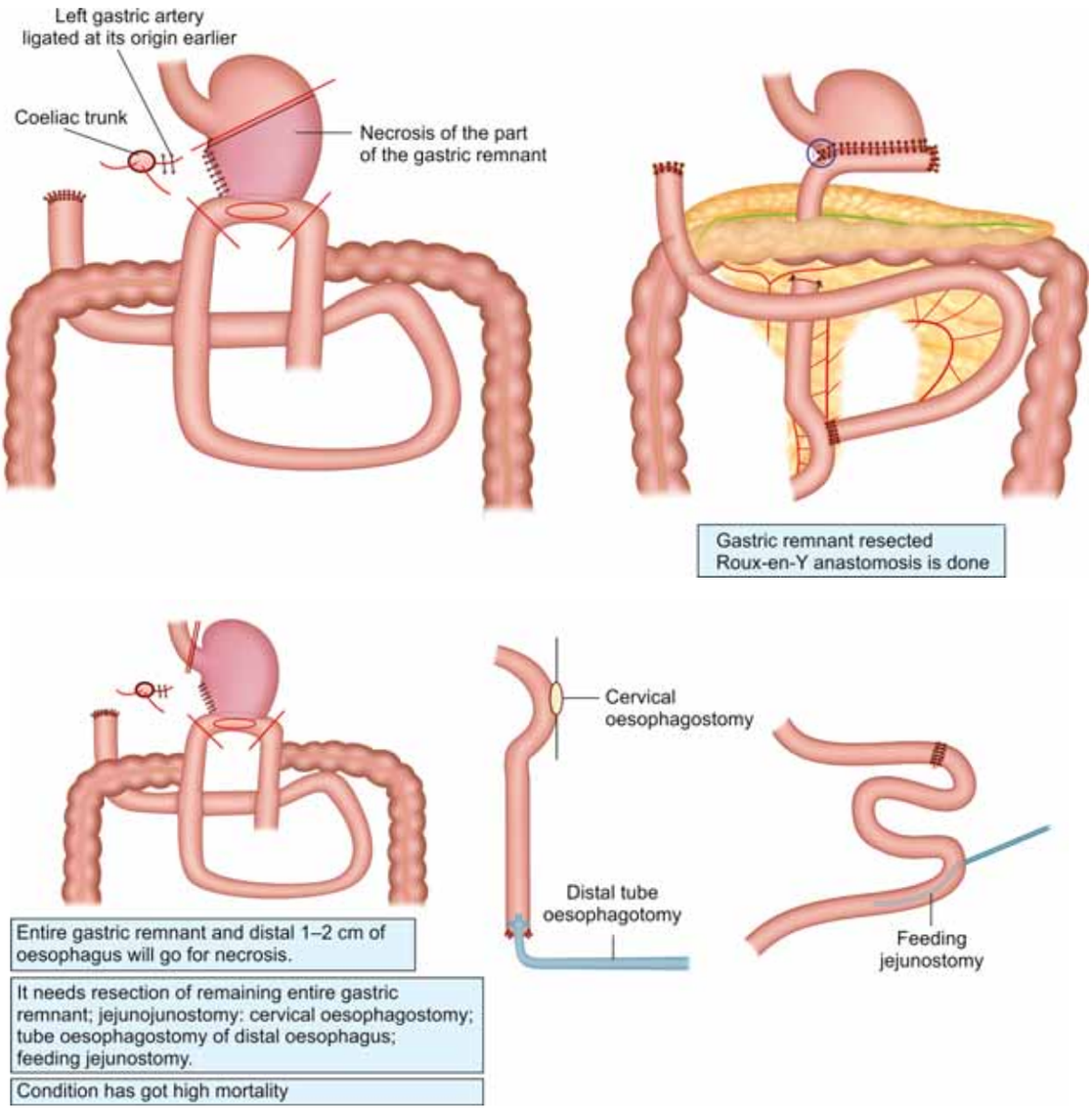


Fig. 20-74: Gastric remnant necrosis. It is managed by resection of necrosis nonviable part and remaining part is anastomosed with jejunum as Roux-en-Y with feeding jejunostomy. If entire gastric remnant is disrupted then it is managed by cervical oesophagostomy, distal tube oesophagostomy and feeding jejunostomy. Later once patient recovers from shock and sepsis, after 3 months, colonic bypass is required.

the stomach; if patient is asked to drink 100 mL of 50% glucose in water, it will show the early symptoms. In late dumping syndrome, 3 hours after intake of 50% glucose in 100 ml of water will show drop in blood sugar below 50 mg% with concomitant raise in plasma insulin level. Treatment is small, that includes dry food, frequent food intake, avoiding carbohydrate diet, octreotide 100 microgram before food subcutaneously; surgical treatment may be required if patient looses weight, develops anaemia, symptoms persist. Surgical treatment is conversion into Roux-en-Y anastomosis or interposition of 25 cm of proximal jejunal segment as isoperistaltic (*Henley's loop*) between stomach and duodenum or jejunum itself. Vagotomy should be completed in these patients. Poth's double limb pouch is better and satisfactory than Henley's loop. Ulcer formation in the pouch/loop, stasis, obstruction are the problems. Triple limb pouches have also been tried. All these pouches have been tried along with Roux-en-Y anastomosis. Antrectomy is a must if Roux limb is planned. Ligidakis modification of Hunt Lawrence pouch has also been tried. Similar like Henley's loop interposition but loop is reversed during interposition gives better result. Ligidakis pouch is said to provide normal pouch motility, required delayed gastric emptying, without any pouch dilatation and stasis **(Figs 20-77 and 20-78)**.

Late dumping syndrome is of less severe type (5%). It is due to initial hyperglycaemia-induced insulin release which in turn causes hypoglycaemia 2-3 hours after meals. Diarrhoea and boborygmi are not present. Features of hypoglycaemia occur 2 hours afterwards with tremor, fatigue, nausea, sweating, and drowsiness. It is a reactive hypoglycaemia. Symptoms are relieved by glucose but aggravated by exercise. Treatment is reduced carbohydrate meal; increased protein diet; small intake of glucose between meals. Usually surgical correction is not needed for late dumping syndrome.

Dumping may be associated with postvagotomy diarrhoea. It is corrected by Roux-en-Y anastomosis and creating short jejunal reversal loop 100 cm distal to the ligament of Treitz. Dumping

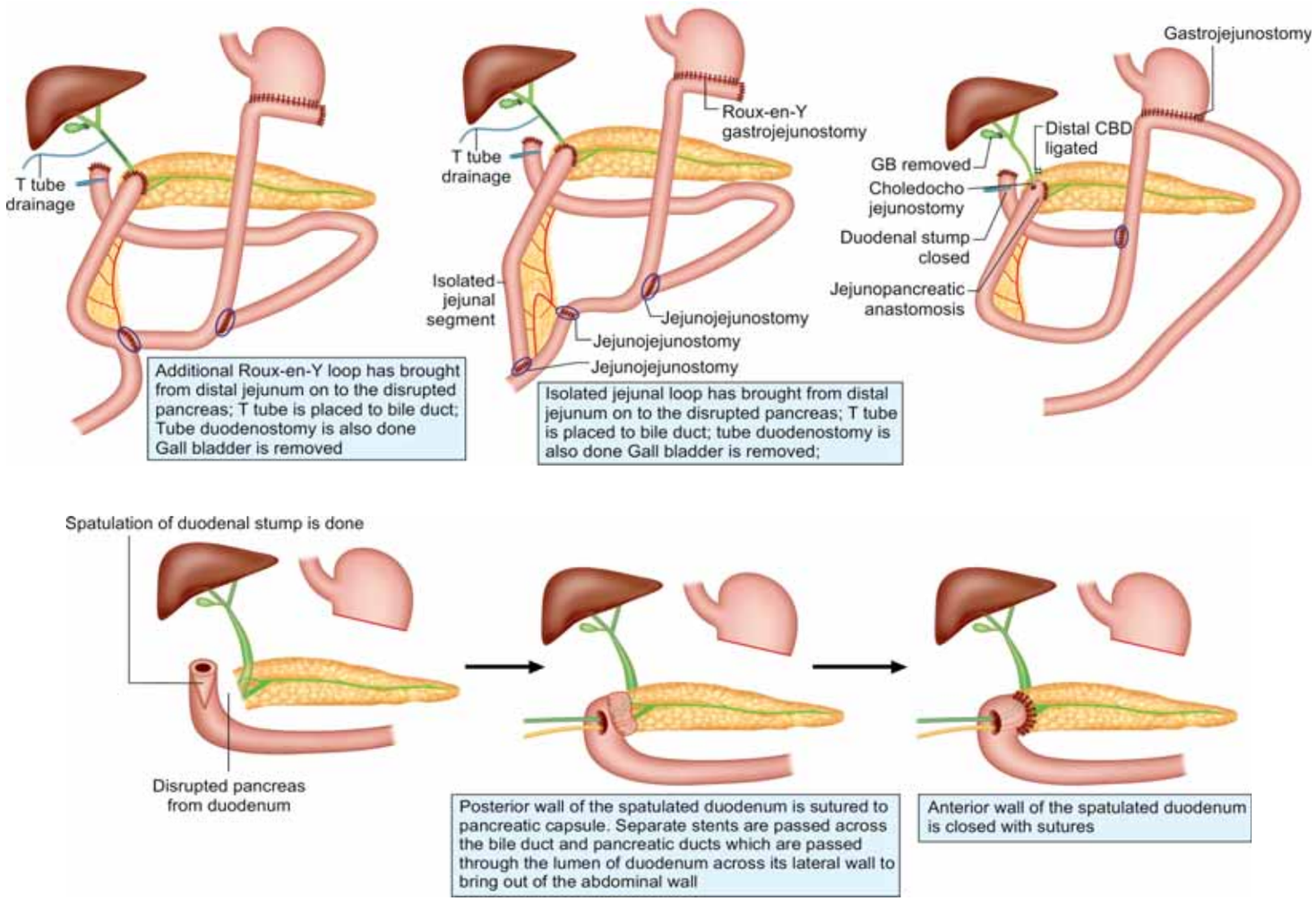

T tube drainage
Additional Roux-en-Y loop has brought from distal jejunum on to the disrupted pancreas; T tube is placed to bile duct; Tube duodenostomy is also done Gall bladder is removed
T tube drainage
Roux-en-Y gastrojejunostomy
Isolated jejunal segment
Jejunojejunostomy
Jejunojejunostomy
Jejunojejunostomy
Isolated jejunal loop has brought from distal jejunum on to the disrupted pancreas; T tube is placed to bile duct; tube duodenostomy is also done Gall bladder is removed;
Gastrojejunostomy
Distal CBD ligated
GB removed
Choledocho jejunostomy
Duodenal stump closed
Jejunopancreatic anastomosis
Spatulation of duodenal stump is done
Disrupted pancreas from duodenum
Posterior wall of the spatulated duodenum is sutured to pancreatic capsule. Separate stents are passed across the bile duct and pancreatic ducts which are passed through the lumen of duodenum across its lateral wall to bring out of the abdominal wall
Anterior wall of the spatulated duodenum is closed with sutures

Fig. 20-75: Different procedures used for duodeno pancreatic disconnection.

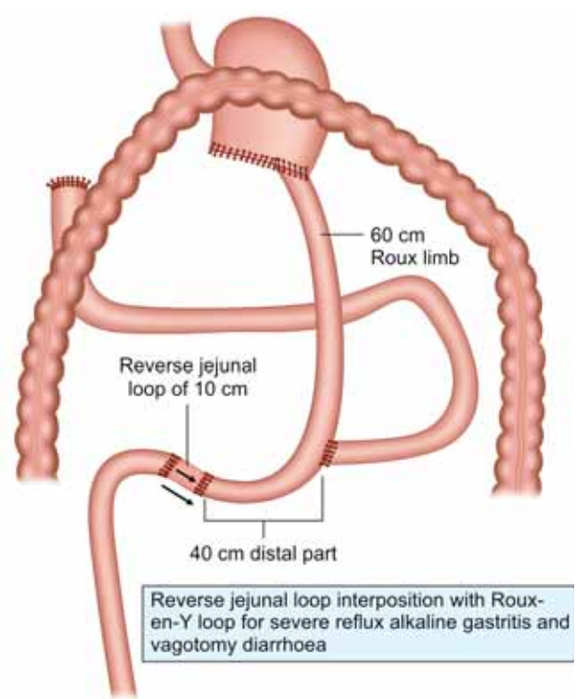

60 cm Roux limb
Reverse jejunal loop of 10 cm
40 cm distal part
Reverse jejunal loop interposition with Roux-en-Y loop for severe reflux alkaline gastritis and vagotomy diarrhoea

Fig. 20-76: Reverse jejunal loop interposition with Roux-en-Y loop is done for severe alkaline gastritis and vagotomy diarrhoea.

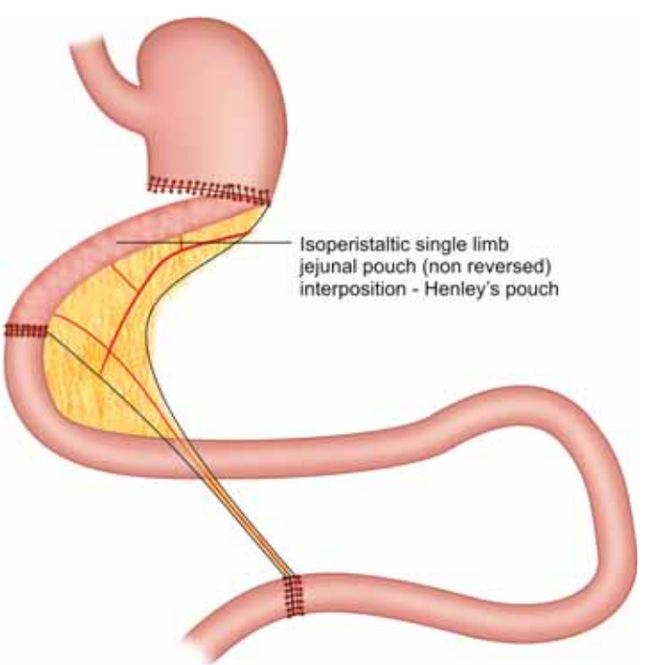


Fig. 20-77: Henley's isoperistaltic jejunal loop interposition (non reversed). It does not give good results compared to reversed jejunal loop interposition.

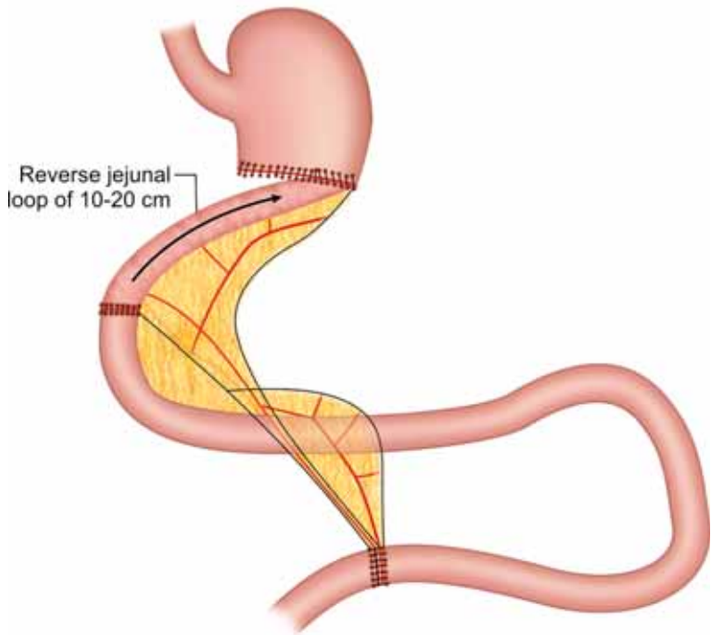


Fig. 20-78: Reverse jejunal interposition is better than isoperistaltic.

may be associated with reflux gastritis. It is treated with Roux-en-Y anastomosis. Occasionally dumping, reflux gastritis and vagotomy diarrhoea may be associated together. It is treated by Roux-en-Y anastomosis, creation of short reversed jejunal segment distal to the 40 cm end-to-side anastomosis.

Recurrent ulcer: Recurrent ulcer after vagotomy with drainage procedure is treated with antral resection and completion vagotomy. Recurrent ulcers due to Zollinger Ellison syndrome is treated with total gastrectomy with Roux-en-Y anastomosis.

Small gastric remnant syndrome: It is due to reduced gastric reservoir. Patient develops abdominal discomfort by taking food and so restricts caloric diet. Gastric reservoir function is increased by doing different pouches using jejunum. Hunt Lawrence or Tanner Roux 19 pouches are often used **(Figs 20-79 to 20-84)**.

Malabsorption, gastric remnant bezoar formation, motility problems are also known to occur. Gastric remnant bezoar is common in

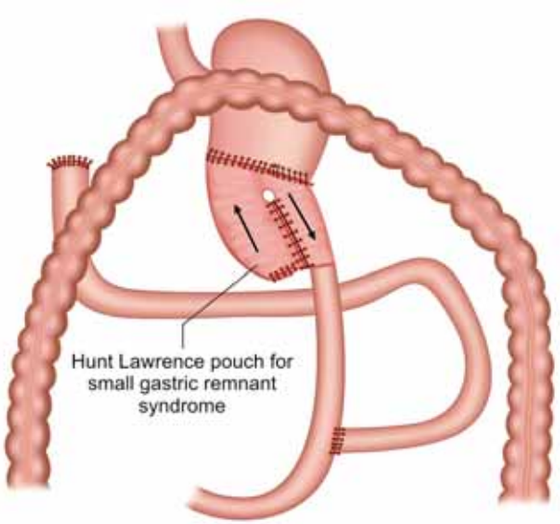


Fig. 20-79: Hunt Lawrence pouch as a reservoir for small gastric remnant.

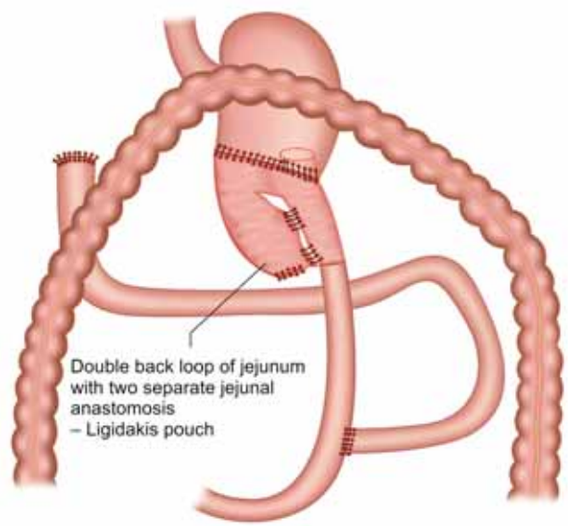


Fig. 20-80: Ligidakis pouch. Ligidakis modification of Hunt Lawrence pouch is said to provide normal pouch motility, required delayed gastric emptying, without any pouch dilatation and stasis.

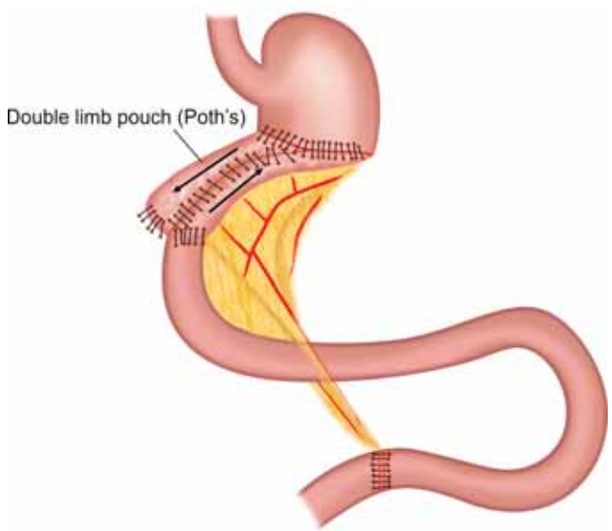


Fig. 20-81: Double limb jejunal pouch – Poth's.

Billroth I anastomosis and pyloroplasty. It is commonly phytobezoars (vegetable matter). Bezoar causes bleeding, perforation and malnutrition. It is treated by digestive agents like enterases, papase and other enzymes. Endoscopy removal may be required. Low fibre diet is required to prevent recurrence. Motility disorders can be treated by prokinetics, urecholine, coherin peptide, etc.

Gastric remnant carcinoma: It is more common after Billroth I operation, can occur in other gastric surgeries also. Reflux with deconjugation of bile acids with hypoacidity; bacterial reduction of nitrates into nitrosamines, and vagotomy—are the causes. Incidence is 5%. It occurs 10 years after the gastrectomy. It carries poor prognosis.

Gastrojejunocolic fistula occurs in retrocolic gastrojejunostomy. It can occur after Billroth II anastomosis or simple gastrojejunostomy (retrocolic) also. Incidence is 5%. Initially marginal ulcer occurs on the anterior wall/rim of the stoma which gradually deepens/penetrates to erode into the anteriorly located colon to create gastrojejunocolic fistula. As marginal ulcer occurs on the anterior aspect of the stoma

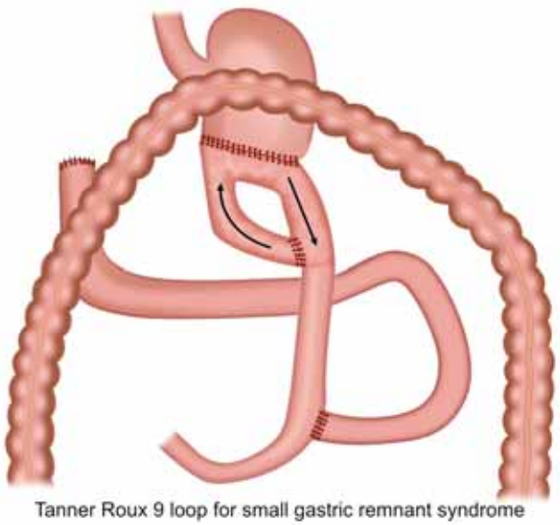


Fig. 20-82: Tanner roux 9 technique for small gastric remnant.

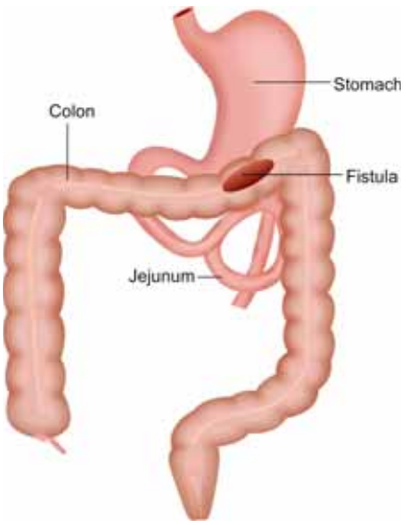


Fig. 20-85: Gastrojejunocolic fistula.

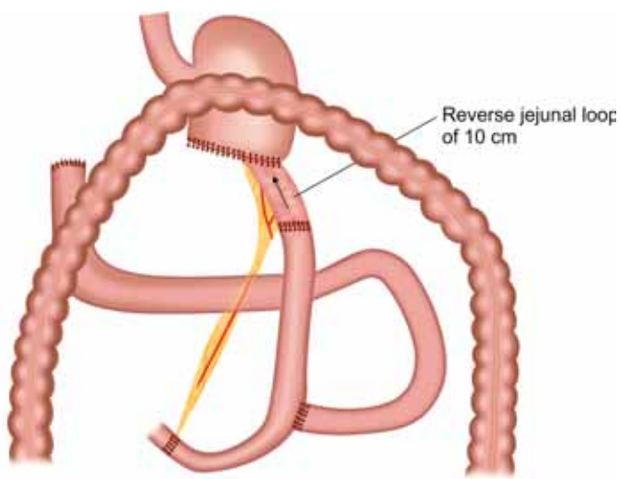


Fig. 20-83: Terrence Kennedy reverse jejunum technique. Reverse jejunal loop is interposed in the Roux limb at gastrojejunostomy level.

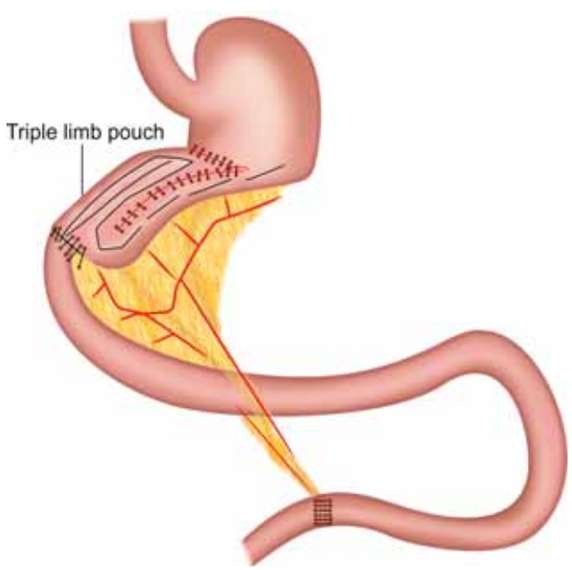


Fig. 20-84: Triple limb pouch across the Roux limb.

in antecolic gastrojejunostomy this ulcer erodes anteriorly into the abdominal wall and not into the colon. Faecal belching, vomiting, emaciation, anorexia, diarrhoea, gross weight loss—are the features **(Fig. 20-85)**.

Treatment is triple resection and maintaining the continuity with gastrojejunostomy, jejunojejunostomy, colocolic anastomosis. It is better to complete vagotomy and Roux-en-Y gastrojejunostomy if patient's general condition permits. In severely ill patient, initial ascending colostomy (*Phiffer*) proximal to colonic component of fistula is done to divert faecal matter so as to reduce the bacterial contamination in the fistula, then at a later stage, definitive triple resection is done. Alternatively often ileo sigmoidostomy (*Lahey*) is done between terminal ileum and sigmoid colon to divert the faecal content **(Fig. 20-86)**.

Roux stasis syndrome: It occurs after Roux-en-Y gastrojejunostomy. Its incidence is 10-30%. When Roux limb is longer, its incidence increases. Intolerance for solids is typical. Distressing bilious vomiting, loss of weight and recurrent pain are common. Gastroscopy shows patent stoma. Contrast study shows normal flow of dye. Radionuclide study reveals severe impairment of the gastric emptying. Roux limb in these patients acts as a barrier for gastric emptying. It shows severe gastric atony. It is common in females. Ectopic pacemaker in the Roux limb gets activated and delays the gastric emptying. There is uncoordinated peristalsis of Roux limb preventing progressive peristalsis. Uncoupled

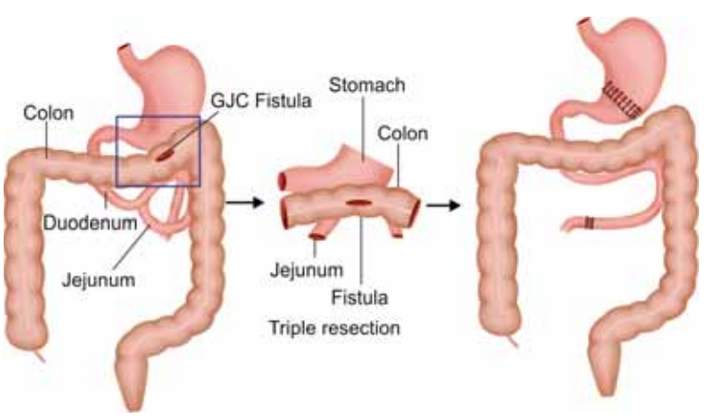


Fig. 20-86: Triple resection for gastrojejunocolic fistula. Condition has got high mortality.

myoelectric complex, increased nonperistaltic and retrograde waves cause dysmotility of Roux limb. Prokinetic drugs will not benefit. Erythromycin may be beneficial. Treatment is conversion into Billroth I or II loop gastrojejunostomy.

Long-term Complications

Chronic afferent loop obstruction: It is due to long afferent loop design in Billroth II reconstruction. It causes recurrent twist or kink at gastrojejunostomy site. Internal herniation of afferent under efferent, stenosis of afferent at junction with stomach, volvulus of the redundant afferent loop, adhesions of afferent loop are common causes. It is recurrent repetitive obstruction. There is projectile vomiting; and vomitus contains bile. Upper abdominal pain develops after meals. Pain is relieved by vomiting. (In reflux gastritis, pain is constant; pain is not relieved by vomiting. Anaemia and bleeding are not uncommon in reflux gastritis). Treatments of chronic afferent loop obstruction are jejunojejunostomy, suspension of afferent loop, resection and shortening of the afferent loop, conversion into Roux-en-Y (ideal) or Billroth I anastomosis.

Chronic efferent loop obstruction is usually due to adhesions and kinking. It is usually intermittent; but often, it may be severe causing efferent loop gangrene. Treatment is surgical. Release of adhesions, conversion into Roux-en-Y anastomosis; require resection if there is gangrene.

Internal hernias after gastric surgery: It can occur as afferent or efferent loop hernias. It is seen in Billroth II anastomosis or simple gastrojejunostomy. It is common in antecolic anastomosis. Here afferent loop is taken larger and there is large space behind the stomach. Retrogastric hernia is more common in such situation. Ideally in antecolic anastomosis, jejunal loops should be fixed to abdominal wall parietes (*Gry and Morton method*) to prevent herniation. But it is not commonly practiced. When afferent loop is sutured to lesser curvature then hernia chances are higher. When anastomosis is done with afferent from greater curvature to lesser curvature side (left to right), herniation of afferent loop is less likely. It is treated by surgical correction.

Jejunogastric intussusception: It is the retrograde intussusception of efferent jejunal loop into the stomach or gastric remnant. It occurs only in loop gastrojejunostomy. It is rare but severe. In 80% cases, efferent limb is involved. Rarely afferent limb or both can be involved. Palpable tender mass on left of the umbilicus, haematemesis, pain on left side of umbilicus radiating towards back are typical. Contrast study shows coiled spring appearance. Laparotomy should be done. Intussusception is reduced; if it is viable, it is fixed to abdominal parietes. If it is gangrenous, resection is done; with Roux-en-Y anastomosis **(Fig. 20-87)**.

RAMSTEDT'S PYLOROMYOTOMY FOR CONGENITAL HYPERTROPHIED PYLORIC STENOSIS

It is the manifestation of progressive hypertrophy of muscular wall of the pyloric sphincter muscle. Clinically non-bilious vomiting, palpable olive shaped pyloric mass in upper abdomen in a male infant of 3-4 weeks age; visible gastric peristalsis, with hypokalaemia and metabolic alkalosis sonologically pyloric channel > 3mm thickness and pyloric length > 2 cm is 100% diagnostic. *In 1912, Ramstedt* did pyloromyotomy but could not suture transversely as infant has become severely ill; but surprisingly infant recovered well, without a need for any further surgery.

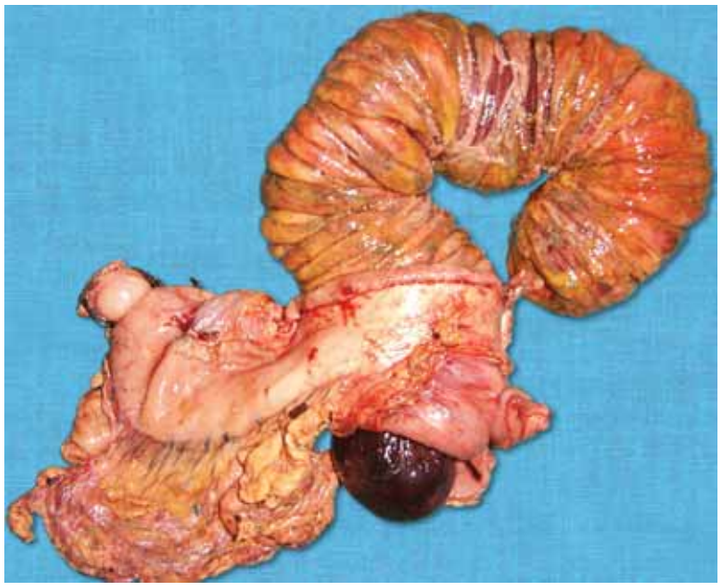


Fig. 20-87: Retrograde jejunogastric intussusception (*Courtesy:* Dr Arun kumar Mch GI surgeon).

Preparation

Initial electrolyte and fluid management is needed.

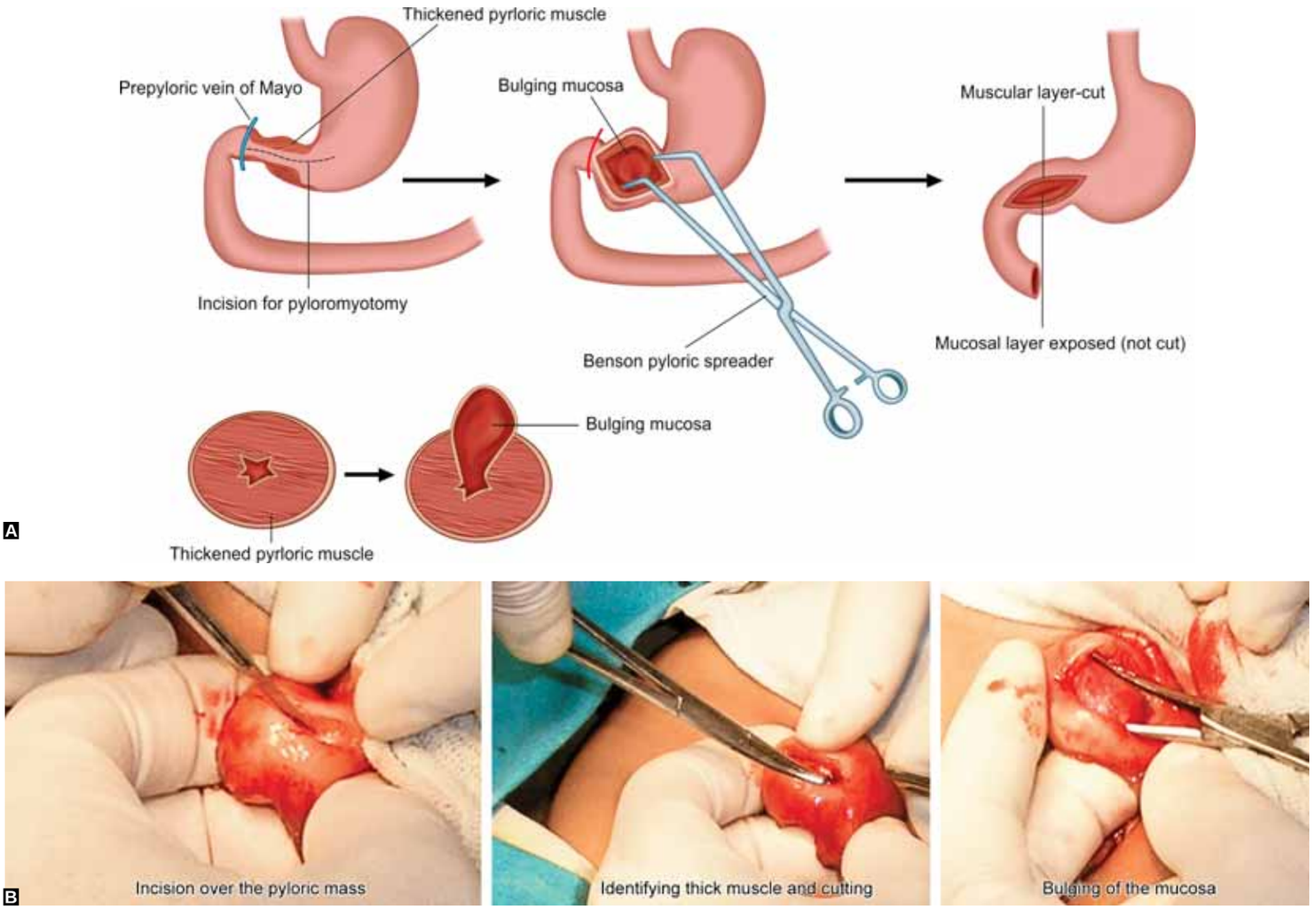
Technique

General anaesthesia is used. Infant is in supine position. Nasogastric tube (narrow/fine tube) is passed. Right upper quadrant transverse incision is used. External and internal oblique muscles are cut; transverse abdominis muscle is split. All layers muscle splitting incision also can be used. Peritoneum is opened. Body of the stomach is identified and held out of the wound. Pyloric hypertrophied mass should not be held as it will cause serosal tear and bleeding. If stomach is not clearly identifiable, then 30 mL of air is insufflated into the stomach to make it distend and visible. Greater curvature of the stomach is held and drawn towards left with traction. Mass extends distally up to the pyloric vein of Mayo. Middle of pylorus and mass on the anterior aspect is relatively avascular and is incised longitudinally for its entire length and thickness. Often muscle may invaginate into the duodenal bulb distally. Care should be taken not to injure the mucosa. If mucosal perforation occurs, mucosa is closed using 3 or 4 zero vicryl and omental patch is placed over it. Small venous ooze can occur due to venous congestion. Monopolar cautery should not be used; if needed, only bipolar cautery should be used. Benson pyloric spreader instrument is very useful to do proper pyloromyotomy. When superior and inferior margins of the cut pylorus move independently then pyloromyotomy is said to be complete.

If mucosal injury prevents further continuation of myotomy procedure, Graham patch of omentum is placed over it and sutured. Myotomy is done by rotating the pylorus to 180° **(Figs 20-88A and B)**.

Problems

Mucosal perforation, incomplete myotomy, postoperative vomiting and electrolyte imbalance, infection, pneumonia—are ontable and postoperative problems.



Figs 20-88A and B: Ramstedt's pyloromyotomy technique.

Postoperative Care

Feeding is started in 12 hours with graded protocol. Pyloric muscle regresses to its normal thickness in 12 weeks. Final result and cure rate is excellent.

Laparoscopic pyloromyotomy is equally good and technique is similar but through laparoscopic instruments. Umbilical port is placed for camera. Two 5 mm working ports are placed. Arthroscopy knife is used to make incision over the pylorus. Laparoscopic spreader similar to Benson spreader is available to spread the incised pyloric muscle completely to allow protrusion of the mucosa outwards. One should avoid perforation. Two edges are held apart to confirm the completion of myotomy. Stomach is insufflated with air using orogastric or nasogastric tube to confirm the leak through laparoscopic vision **(Fig. 20-89)**.

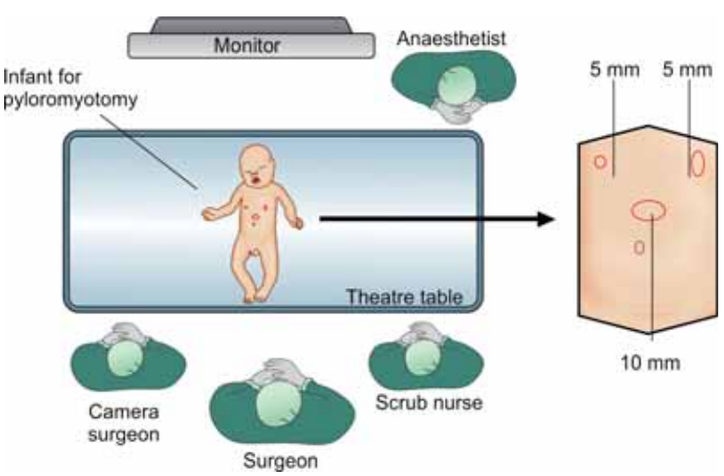


Fig. 20-89: Laparoscopic cardiomyotomy.

DUODENUM

Duodenum is derived from *dudekadaktulos* Latin–Greek word that means 12 fingers. It lies at the level of 1st, 2nd and 3rd lumbar vertebrae and at and above the level of the umbilicus in front. It is C-shaped with head of pancreas attached to its inner part. It is widest (2.5 cm), shortest, most fixed part of small intestine. The *duodenum* is 20-30 cm in length. It extends from pyloric sphincter to *ligament of Treitz*. It is divided into four parts. 90% of duodenal ulcer occurs in the 1st part of duodenum (duodenal bulb/cap). CBD and pancreatic duct merges to form *ampulla of Vater* and enter the 2nd part of duodenum. The 3rd part of duodenum is wedged between aorta and superior mesenteric artery.

Proximal part (2.5 cm) of the 1st part of the duodenum is intraabdominal and is mobile; its distal part (2.5 cm) is retroperitoneal.

First part behind is related to the common bile duct, portal vein, gastroduodenal artery and inferior vena cava. In front, it is related to caudate lobe of liver and gallbladder; above the epiploic foramen and below head and neck of the pancreas. At gastroduodenal junction, submucosal glands of Brunner appear which are not present in gastric mucosa. First part is 5 cm long. At superior duodenal flexure, it continues as 2nd part.

Second part is 7.5 cm long that begins at superior duodenal flexure runs downward; at the level of 3rd lumbar vertebra and at inferior duodenal flexure, it turns towards left to continue as 3rd part. Anteriorly is covered with peritoneum except in the middle where it is directly related to transverse colon. Other anterior relations are right lobe of the liver; transverse colon, root of transverse mesocolon, and small bowel. Posteriorly it is elated to right kidney, right renal vessels, inferior vena cava, right gonadal vein (joins the inferior vena cava behind 2nd part of the duodenum) and right psoas major. Medially it is related to head of pancreas and bile duct. Major duodenal papilla is located 10 cm distal to pylorus as an elevation. Accessory pancreatic duct opens at minor duodenal papilla, 6 cm from distal to pylorus.

Third part is 10 cm long that begins at inferior duodenal flexure at the level of the right margin of the lower border of the 3rd lumbar vertebra. It runs horizontally and upwards to continue as 4th part. In front it is related to superior mesenteric vessels and root of mesentery (vein is medial to artery); behind right ureter, right psoas major, right testicular or ovarian vessels; inferior vena cava; abdominal aorta with inferior mesenteric artery; above head of pancreas and uncinate process; below coils of jejunum.

Fourth part is 2.5 cm long; travels upwards left of the aorta up to superior margin of 2nd lumbar vertebra. Here it curves to form jejunum. Its terminal part is mobile. In front it is related to transverse colon, transverse mesocolon, lesser sac and stomach; behind left sympathetic chain, left psoas major, left renal vessels, left testicular vessels and inferior mesenteric vein; to the right upper part of the mesentery; to the left kidney (left) and ureter; above is body of the pancreas.

Suspensory ligament of Treitz is a fibromuscular band which arises from right crus of the diaphragm, passes downward behind the pancreas and splenic vein in front of the left renal vein. It is attached to the upper posterior surface of the duodenojejunal flexure and 3rd and 4th part of the duodenum. It may insert only duodenojejunal flexure or 3rd or 4th parts only or may have multiple attachments. Its proximal part is skeletal muscle; distal part is smooth muscle and in between elastic fibres **(Fig. 20-90)**.

Arterial supply of duodenum: Foregut part of the duodenum is supplied by superior pancreaticoduodenal artery (anterior and posterior), a branch of gastroduodenal artery; hindgut part is by inferior pancreaticoduodenal artery (anterior and posterior), a branch superior mesenteric artery. Other branches are supraduodenal artery of Wilkie, a branch of proper hepatic artery; retroduodenal artery of Edwards Michel, a branch of common hepatic artery. Inferior pancreaticoduodenal artery may arise from 1st jejunal branch of superior mesenteric artery or as a common trunk with 1st jejunal branch **(Fig. 20-91)**.

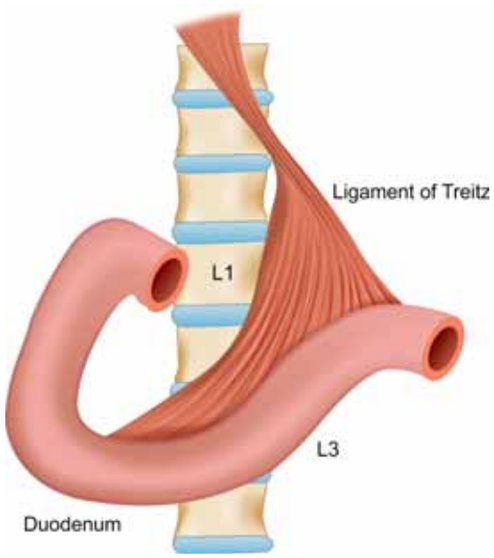


Fig. 20-90: Suspensory ligament of Treitz.

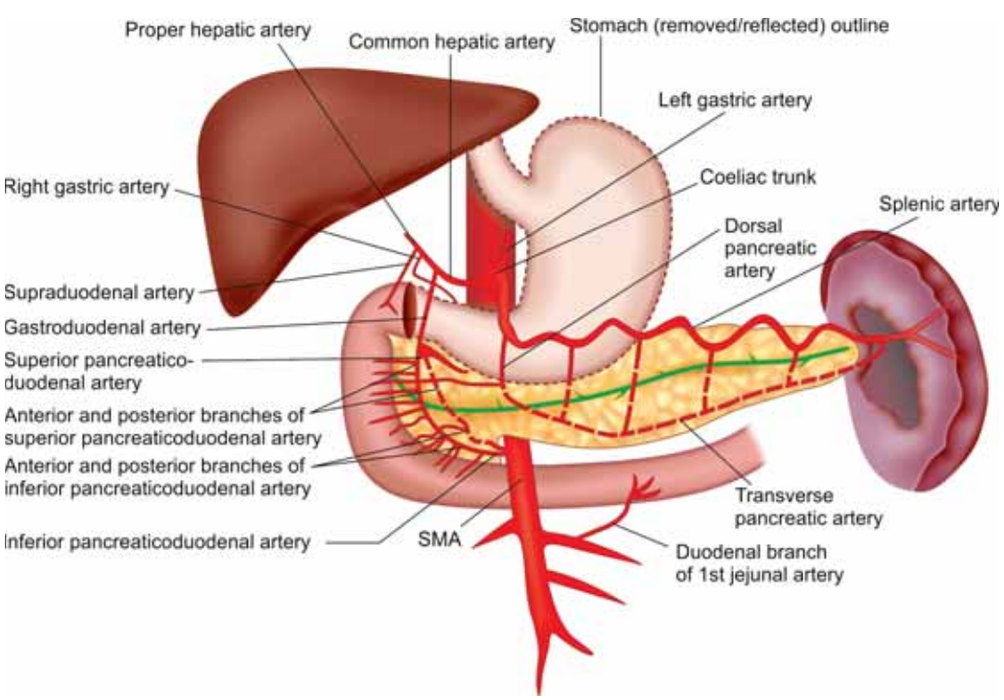


Fig. 20-91: Arterial supply of duodenum.

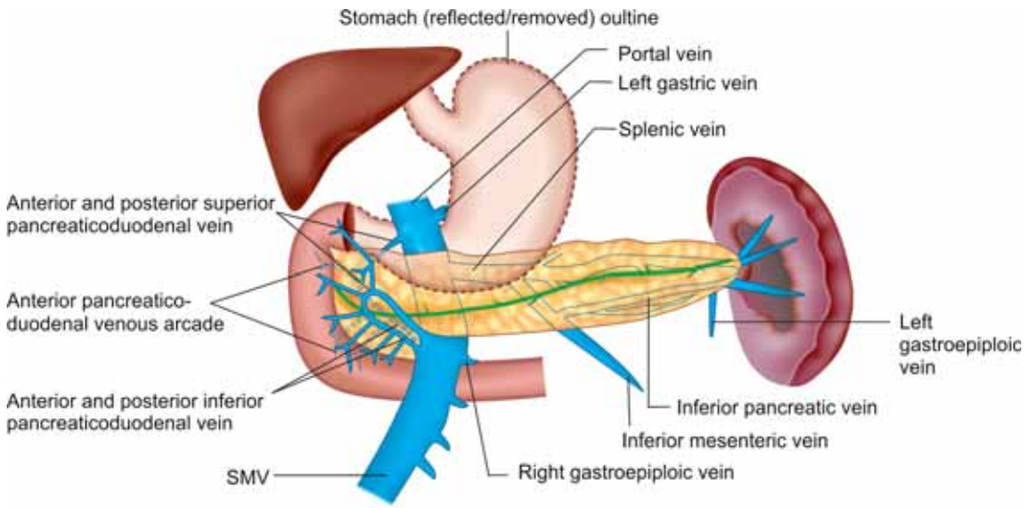


Fig. 20-92: Venous drainage of the duodenum.

Venous drainage is mainly portal, superior mesenteric and splenic veins. Venous arcade is superficial to arterial arcade **(Fig. 20-92)**.

Lymphatic drainage is to pancreaticoduodenal nodes; to hepatic nodes; coeliac nodes; often to pyloric and aortic nodes.

Surgical Significance

Kocherisation is needed in many oesophageal, gastroduodenal and pancreatic surgeries to mobilise the duodenum. It is done by incising the right peritoneal reflection of the 2nd part of the duodenum and mobilising it towards left in front of inferior vena cava and right renal vein and aorta. It is mobilised along the head of the pancreas. Even though plane is avascular, care should be taken not to injure the vena cava and right gonadal vein.

Mobilisation of the hepatic flexure and transverse colon from the 2nd and 3rd parts of the duodenum to expose duodenum proximal to superior mesenteric vein is necessary in colectomy and pancreatic surgeries – *Cattell maneuver*.

Only 2 cm of 1st part of the duodenum can be skeletonised so that to retain the blood supply of the stomach.

Suspensory ligament of Treitz can be divided without any problem.

Duct of Santorini is close to gastroduodenal artery and may get injured in gastrectomy while mobilising the duodenum. Accessory pancreatic duct passes under the gastroduodenal artery (*water under the bridge*); while ligating the gastroduodenal artery (bleeding ulcer), one should avoid anterior medial duodenal wall to avoid injury to gastroduodenal artery. Duodenum should not be mobilised beyond the gastroduodenal artery.

One of the pancreaticoduodenal arteries should be retained ideally to keep head of pancreas viable, otherwise head may go for necrosis.

SURGICAL TREATMENT OF SUPERIOR MESENTERIC ARTERY SYNDROME (WILKIE'S/VASCULAR COMPRESSION OF THE DUODENUM)

It is the compression of the 3rd part of the duodenum between aorta and emerging of superior mesenteric artery which is in front of the duodenum. It is due to acute angulation between SMA and Aorta leading into compression. Bilious vomiting, distension, electrolyte imbalance are the features. Contrast imaging is diagnostic.

Treatment is release of suspensory ligament of Treitz and duodenojejunostomy between proximal dilated 2nd part of the duodenum and jejunum 10-15 cm from the duodenojejunal flexure. Side to side anastomosis is done. Gastrojejunostomy should not be done **(Fig. 20-93)**.

DUODENAL ATRESIA

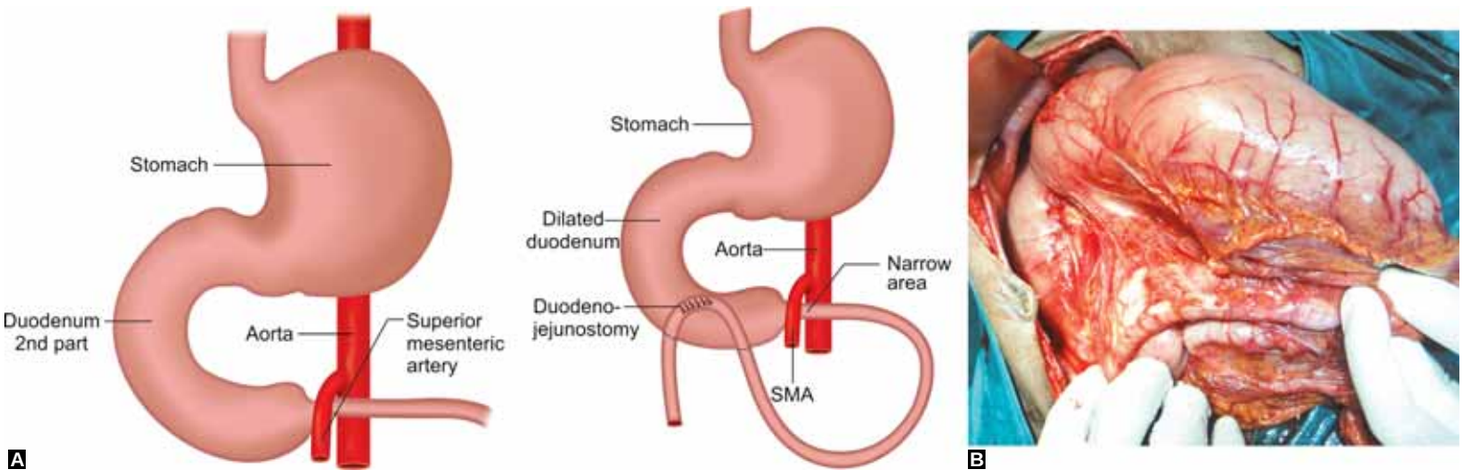
It is the commonest site of intestinal atresia. It is usually a complete stenosis of the second part of duodenum at the level of ampulla of Vater. It is defective fusion of foregut and midgut with failure of recanalisation. Incidence is one in 10,000 live births.

Types (Fig. 20-94)

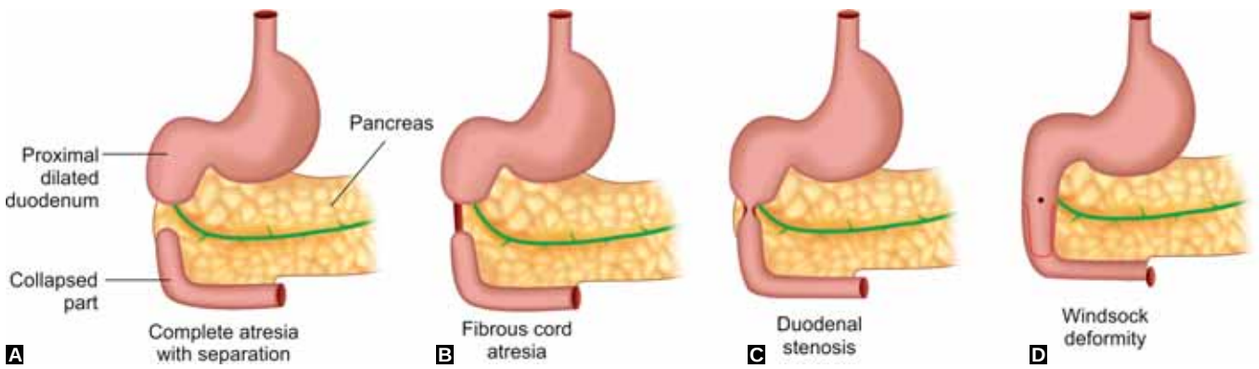
Type 1: Complete duodenal atresia: It is the commonest type (50%). It is usually complete separation with intact wall. In 25% cases, complete separation with wall also occurs. Type 2: Fibrous cord. Type 3: Incomplete or partial obstruction. It can be stenosis or web with an aperture. Duodenal diaphragm/web can present as complete; incomplete with a fenestra; incomplete diaphragm with central aperture which causes '*windsock' deformity* due to proximal dilatation. Here actual diaphragm will be proximal to the site of obstruction. Duodenal atresia may be *preampullary* (nonbilious vomiting) or *postampullary* (bilious vomiting). Postampullary is common (80-90%).

Associations

Duodenal stenosis is often associated with annular pancreas. It can be isolated with duodenal atresia or in association with Down's syndrome (30%)/incomplete rotation of gut (20%)/ congenital heart diseases (30%)/trisomy (30%)/anorectal malformations (10%), etc. It is commonly associated with maternal polyhydramnios (50%). Antenatal ultrasonography can confirm it. Fifty percent infants are premature.



Figs 20-93A and B: Vascular compression of the duodenum—Wilkie's syndrome.



Figs 20-94A to D: Types of duodenal atresia—(A) Complete; (B) Fibrous cord; (C) Duodenal stenosis and, (D) Windsock deformity.

Features

Jaundice, bilious/nonbilious vomiting immediately after birth, features of gastric outlet obstruction, dehydration, electrolyte changes are common, growth retardation of newborn due to deprived nutrition (by swallowed amniotic fluid in foetus).

Investigations

Plain X-ray shows classic *double-bubble sign with absence of air in the distal part.* In partial obstruction, air may be present in distal loop and so contrast study has to be done. Risk of aspiration in newborn infant should be remembered. Ultrasonography will show distended stomach and proximal duodenum, *rail road track* duodenum and features of associated anomalies. Maternal and foetal ultrasound in pregnancy may identify the pathology and also maternal polyhydramnios.

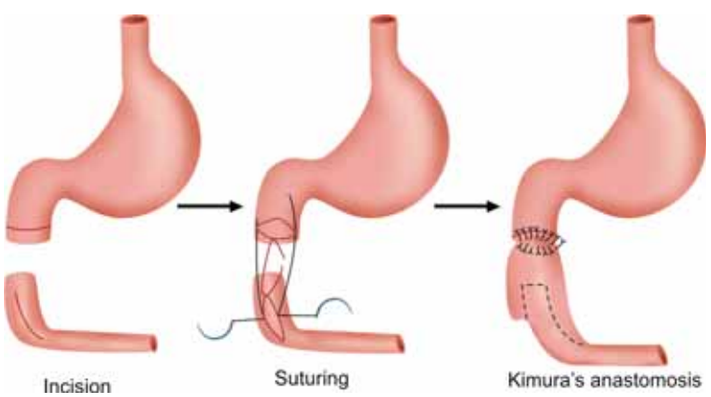


Fig. 20-95: Duodenal atresia is treated by duodenoduodenostomy ideally. Kimura's duodenoduodenostomy gives good results.

Treatment

Proper preoperative preparations like correction of fluid and electrolytes; gastric decompression; TPN; injection vitamin K; evaluation for associated anomalies.

Duodenoduodenostomy is done. Associated malrotation should be corrected in these patients (Ladd's operation).

Side-to-side duodenoduodenostomy may cause dilated duodenum (megaduodenum-30%); anastomotic dysfunction; and delayed transit of the content. *Kimura's diamond-shaped anastomosis* between transversely opened proximal pouch and longitudinally opened distal pouch reduces the problems of anastomosis. Presence of bile in the duodenum and proximal and distal patency should be confirmed by saline irrigation. Horizontal incision on the proximal dilated part; vertical incision in the lower collapsed part to create diamond-shaped gap which is sutured above with middle of the lower diamond-shaped edge will appose to corner of the proximal upper wound to create duodenoduodenostomy. Interrupted 4 zero or 5 zero vicryl or PDS is used for suturing. Transanastomotic nasojejunal or gastrostomy tube for feeding purpose is needed as prolonged postoperative ileus is the usual problem. *Tapering duodenoplasty* may be required if there is persistent duodenal dysmotility with a megaduodenum **(Fig. 20-95)**.

Duodenojejunostomy may cause blind loop problems. When gap and defect are long, retrocolic loop jejunojejunostomy is done. Gastrojejunostomy should not be done due to high incidence of marginal ulceration and bleeding.

Chapter

21

Surgeries of Small Bowel and Appendix

A. SMALL BOWEL

SURGICAL ANATOMY

The small intestine is 6 m in length. This includes upper fixed part (duodenum, 25 cm) and lower mobile part (proximal 2/5th is jejunum and distal 3/5th is ileum). At death intestine elongates as muscle tone is lost much faster in longitudinal muscle than circular muscle. Length of the small bowel mesentery is 15-25 cm. Mesentery attaches the small intestine to the posterior abdominal wall, contains blood vessels, lymphatics and fat. Line of attachment of the mesentery is an oblique line starting from a point 2.5 cm left of the midline and 1.0 cm below the transpyloric line extending downwards to the right iliac fossa. It extends from ligament of Treitz at the level of L2/L3 vertebra to right sacroiliac joint. Small bowel is 6 meters in length but mesentery is only 15-25 cm in length at its *root* **(Fig. 21-1)**.

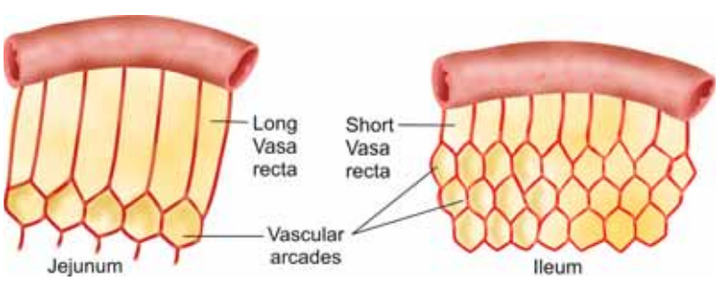


Fig. 21-1: Surgical anatomy of small bowel.

Differences Between the Features of Jejunum and Ileum

Jejunum	*Ileum*
1. Long and few vasa rectae	Short and numerous vasa rectae
2. Long plicae	Small plicae
3. Thick wall	Thin wall
4. Mesentery transparent	Mesentery contains fat
5. Peyer's patches are scanty	Peyer's patches are abundant, located in the antimesenteric border
6. Villi, leaf like and more abundant	Villi, finger like and less abundant
7. Proximal 40% of small bowel	Distal 60%

Small bowel wall contains serosa, longitudinal and circular muscles, submucosa, mucosa with muscularis mucosa. Submucosa should be included to achieve optimum integrity in anastomosis **(Fig. 21-2)**.

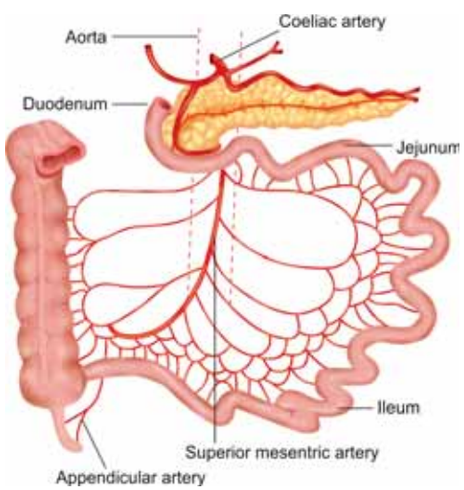


Fig. 21-2: Arterial supply of the small bowel.

Nerve Supply

Sympathetic supply is from T9-T11 and parasympathetic supply is from vagus. Both pass through coeliac and superior mesenteric plexus. Bowel wall contains the myenteric plexus of Auerbach which lies between the circular and longitudinal muscle coats; and submucous plexus of Meissner. Sympathetic nerves are motor to sphincter, inhibitory to peristalsis; parasympathetic nerves are inhibitory to sphincter and stimulates peristalsis.

Normal GIT secretions

Saliva: 1000 mL
Gastric: 1500 mL
Intestinal: 4000 mL
Bile: 1000 mL
Pancreas: 1500 mL

Cell type function

Goblet cells: Mucous
Paneth cells: Lysozyme, tumour necrosis factor, cryptidins
Enterocytes: Absorption
Enteroendocrine cells: Different hormones

SURGICAL TREATMENT OF MECKEL'S DIVERTICULUM

It is a congenital diverticulum arising from the terminal ileum and is part of the unobliterated proximal portion of the vitellointestinal duct **(Fig. 21-3)**.

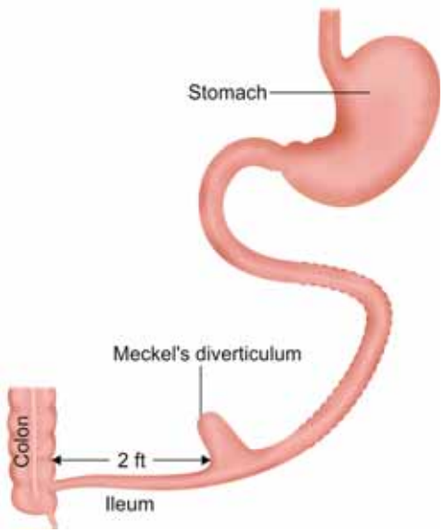


Fig. 21-3: Anatomy of Meckel's diverticulum.

It is 2% common; 2 feet from the ileocaecal valve; 2 inch in length; 2% of Meckel's diverticulum only will be symptomatic; 50% of symptomatic are below 2 years of age; 2:1 female preponderance is seen. It is congenital, results from incomplete closure of vitellointestinal duct. It is the most common congenital anomaly of small intestine. It arises from the antimesenteric border of the ileum, containing all three layers of the bowel with independent blood supply. In 20% of cases mucosa contains heterotopic epithelium like gastric (commonest—50%), colonic and pancreatic tissues (5%). It may be connected to or communicates with the umbilicus through a band or fistula. It may be associated with oesophageal atresia, exomphalos, and anorectal malformations **(Fig. 21-4)**.

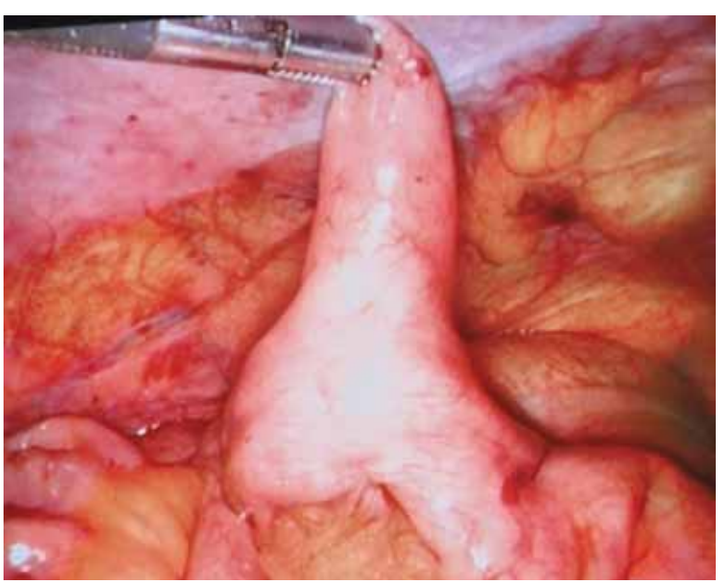


Fig. 21-4: Meckel's diverticulum—laparoscopic view.

Presentations in Meckel's Diverticulum

It is asymptomatic in majority of the cases. Severe haemorrhage most common, seen in children aged 2 years or younger (*Maroon coloured blood)*. It can cause intestinal obstruction due to bands/adhesions/intussusception, perforation, volvulus of small bowel, peptic ulceration, diverticulitis (20%)—features mimic acute appendicitis. *Littre's hernia*—it is the presence of Meckel's diverticulum in hernial sac as content. It is observed in inguinal/femoral hernia. Silent Meckel's diverticulum may be found during laparotomy or laparoscopy or by radioisotope study. Carcinoid or GIST can occur in Meckel's diverticulum.

It is diagnosed by Technetium (Tc99) radioisotope scan which is very useful (90-95% accuracy). Ninety per cent of heterotrophic gastric mucosa can be identified in Meckel's diverticulum by radioisotope study. It can detect Meckel's diverticulum with minimal bleeding also (0.1 mL/minute). So it is very useful investigation in children presenting with bleeding. X-ray abdomen is taken to see complications like obstruction, perforation. *Laparoscopy is very useful way to confirm the diagnosis.* Enteroclysis/small bowel enema under fluoroscopy may show the Meckel's diverticulum. It is probably the most accurate investigation **(Fig. 21-5)**.

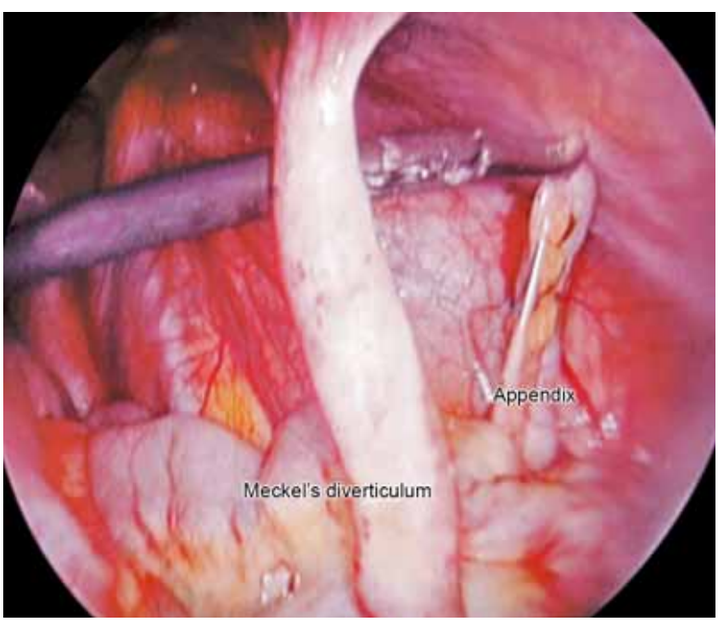


Fig. 21-5: Laparoscopic view of Meckel's diverticulum. Patient presented with features of acute appendicitis. On laparoscopy, Meckel's diverticulum which was adherent to umbilicus by a cord was found. Appendix was identified separately. Appendicectomy and Mecklian diverticulectomy was done.

Treatment

Asymptomatic Meckel's diverticulum can be left alone when identified during laparotomy.

Surgical treatment

Surgery is done whenever the base is narrow, in lengthy diverticulum, in presence of adhesions or band which may precipitate obstruction, intussusception or volvulus in symptomatic patients or presence of complications, when found in children below 2 years.

Resection of a short segment of ileum containing Meckel's diverticulum and end-to-end anastomosis is done.

Meckelian diverticulectomy with closure of enterotomy also can be done, but chances of retaining heterotopic tissues and stenosis are higher **(Figs 21-6 and 21-7)**.

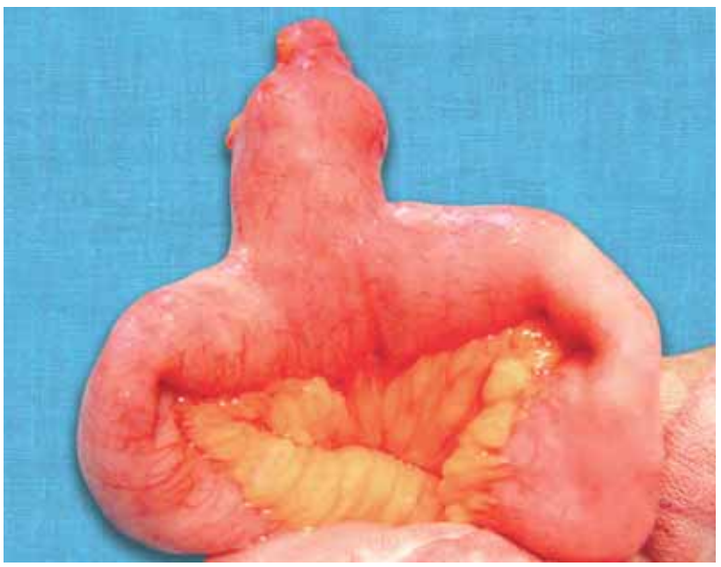


Fig. 21-6: Meckel's diverticulum on table look. Patient underwent resection and anastomosis.

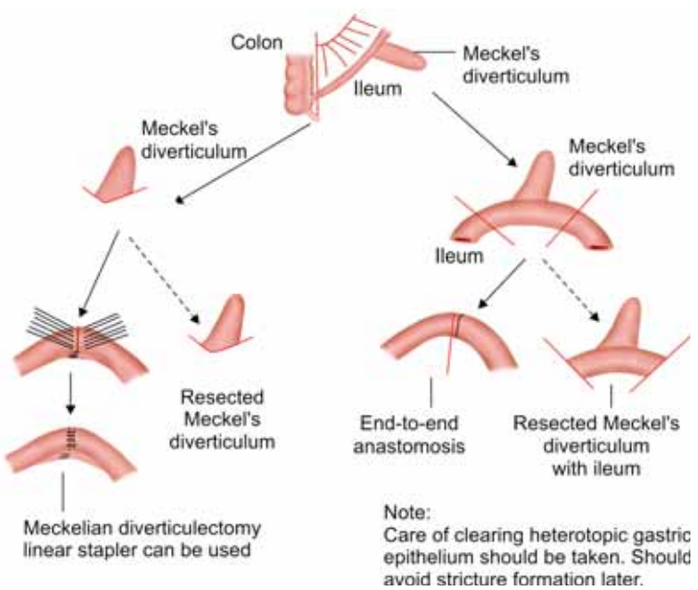


Fig. 21-7: Meckel's diverticulum—surgical treatment. Meckelian diverticulectomy is done by obliquely clamping beyond the base of the Meckel's diverticulum. Care should be taken not to retain heterotopic gastric (or other) epithelium which can be felt like indurated area. Enough precaution should be taken so that stricture will not form later. When heterotopic tissues extend beyond the Meckel's diverticulum into the ileum, then resection of ileum with Meckel's and anastomosis is done. Clamping distal to the base of the Meckel's diverticulum like appendicectomy should not be done. It will cause stricture, leak or retaining heterotopic tissues in the part.

SMALL BOWEL RESECTION

It is one of the common surgeries done in the abdomen. It may be in emergency situation or elective one.

Indications: small bowel tumour, multiple perforation, trauma, bowel ischaemia, strangulation, Crohn's disease, intussusception **(Figs 21-8 and 21-9)**.

Fig. 21-8: Intussusception.

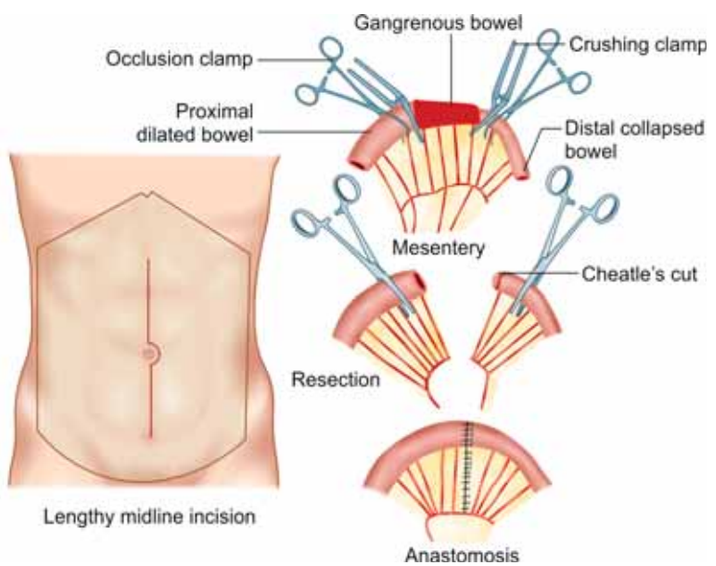


Fig. 21-9: Bowel resection and anastomosis for gangrene in case of intestinal obstruction. Cheatle's cut on the antimesenteric margin of the collapsed distal segment is often needed to avoid discrepancy in luminal width. Single layer interrupted (silk/vicryl) or two layered continuous sutures can be used. Single layer is better in acute conditions.

Principles in Bowel Surgery

Antimesenteric border is having least blood supply and is so critical point in bowel anastomosis. So antimesenteric border should be

cut obliquely while doing bowel anastomosis. Mesenteric arterial pulsation should be checked. Cut edge bleeding is very important. If surgeon is not satisfied about cut edge bleeding then one should trim the edge adequately. Blood supply is absolute deciding factor in bowel anastomosis.

Colour, peristalsis, pulsation in the arcade, bleeding suggests adequate blood supply. This is often confirmed by asking anaesthetist to give 100% oxygen for few minutes or by placing warm mop over the bowel or by on table Doppler study.

Serosal area should be *cleared off from fat* for 1 cm margin before doing bowel anastomosis. Fat will interfere with proper apposition of the cut edges. It also reduces the blood supply.

Luminal size of the anastomotic segments should be near equal to have proper serosal apposition. If it is not then narrower segment should be widened by incising antimesenteric border obliquely to widen the lumen *(Cheatle's cut*). Usually distal collapsed part will be narrower compared to proximal dilated segment; so commonly distal part needs Cheatle's cut.

Anastomotic edges should have free mobility; once anastomosis is done, stoma should not be under any tension. Release of adhesions, adequate mobilization by incising the peritoneal layer of the mesentery may be occasionally needed.

Knot should be tied with only optimum force. Excessive force will strangulate the cut edges. Loose knot will leave a gap causing inadequate apposition.

While suturing anterior layer one should be careful in avoiding inadvertent bites of the posterior layer which will block the lumen partially causing stricture and obstruction. Bites should be taken at 5 mm gap with 5 mm thickness of tissue from the cut edge.

Handling: Bowel should be handled carefully using nontoothed dissecting forceps or finger; one should not use toothed dissecting forceps or Allis forceps.

Clamps over the bowel should be placed at 30 degrees at antimesenteric border. Clamps should not extend far into the mesentery. Occlusion clamps are applied at viable part to prevent spillage of contents into peritoneal cavity, to prevent oozing from cut edges of the bowel and to stabilize the gut. Crushing clamps are placed after ligation of mesentery just prior to cutting the bowel; it is applied on the specimen side. One should take care about avoiding twisting of mesentery prior to anastomosis after resection.

Corners of the cut edge of the bowel should be held with seromuscular sutures or Babcock's forceps to allow posterior layer to drop behind and to facilitate proper bite taking of the cut edges.

Anastomosis can be done as continuous layer or interrupted sutures. In acute conditions as there is oedema interrupted one is better. Single layer interrupted sutures are safer and equally good. If two layer anastomosis is done outer interrupted silk sutures are used; inner continuous absorbable sutures like vicryl or PDS are used.

Posterior layer knots are placed inside the lumen; anterior layer knots are placed outside. Posterior layer knots can be placed outside also but it is technically tedious and it does not make any difference in outcome. In interrupted sutures bites should be taken as all layer through and through and kept long untied; once all bites are taken along one (posterior) layer, they are tied together. In the same way anterior layer is sutured. But it needs more suture material and becomes costly. It is possible to place suture and knot immediately and consecutively to complete the anastomosis of one layer in elective cases. Probably in acute conditions where there is oedema and inflammation in the cut edge of the bowel all layer tying together should be done.

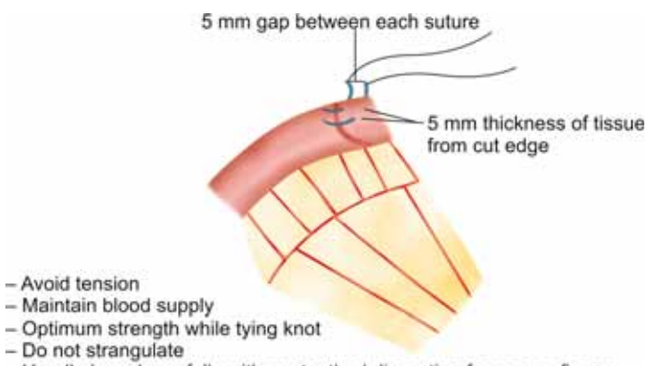
In two layer anastomosis first posterior seromuscular interrupted sutures are taken which should include submucosa (which is strongest); then posterior 2nd layer of all layer through and through continuous sutures are taken at 5 mm gap with 5 mm tissue thickness bites. It is locked in between to prevent purse string effect on the stoma (*posterior continuous locking sutures*). Usually this suture begins at mesenteric end, runs towards antimesenteric end where it can be adjusted for size discrepancy; same suture material is continued as anterior layer towards again mesenteric end from antimesenteric end; anterior layer is sutured as outside in and inside out each from opposite side as inverting suture (anterior inverting sutures) or as outside in and inside out each from side looping over the cut edge towards opposite (*Connell suture*). Anterior layer is sutured afterwards as interrupted seromuscular silk sutures **(Figs 21-10 and 21-11)**.

Suture materials usually used are silk or polyglactic acid (vicryl) or polydioxazone suture (PDS). Usually 3 zero suture materials are used. In difficult situations 2 zero may be needed. In children 4 zero is used. Curved round body needle is used.

After completion of the anastomosis, additional sutures at corners may be added to prevent possible leak.

Mesenteric defect should be closed using interrupted or continuous sutures.

In emergency conditions tube drain may be required.



- Avoid tension
- Maintain blood supply
- Optimum strength while tying knot
- Do not strangulate
- Handle bowel carefully with nontoothed dissecting forceps or finger
- Do not use Allis forceps or toothed dissecting forceps
- Hold the corners with stay sutures on each side or Babcock's forceps
- Both two layers or single layer anastomosis are acceptable
- Continuous or interrupted sutures; interrupted sutures are preferred
- In acute condition like in gangrene interrupted single layer is ideal as due to oedema seromuscular layer suturing is difficult
- Knots in posterior layer can be inside the lumen in bowel; knot in anterior layer is placed outside; however, posterior layer outside knot placing can be done but it is technically tedious and there is no difference between two in relation to outcome

Fig. 21-10: Principles in taking bites in cut edges.

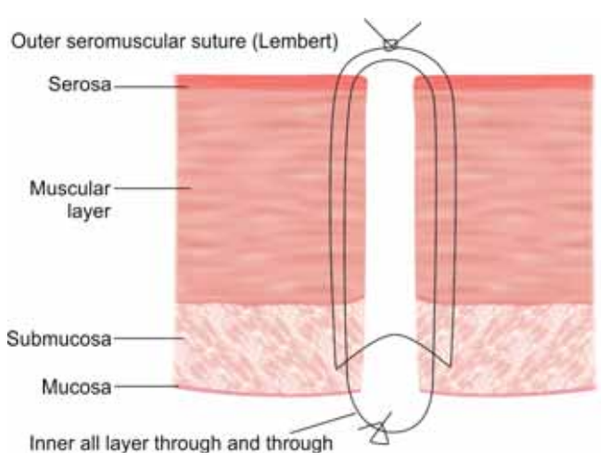


Fig. 21-11: Two layer suturing of the bowel wall.

To check for viability of bowel, look for:
Peristalsis
Pulsations
Bleeding in mesentery and bowel wall
Friability—friable, flabby muscle is seen in ischaemia
Colour (black/pink)
Dull, lusterless, without shining serosa is seen in ischaemia

Different suturing used in bowel are:

Single layer seromucosal suture of bowel: It is now well practiced method of suturing of the bowel. Interrupted seromucosal sutures using three zero/two zero vicryl or PDS takes up well. Nonabsorbable silk or linen can also be used. *These nonabsorbable sutures are good old suture materials which are even now accepted well*. Only drawback presumed is formation of suture granuloma at the anastomotic site **(Fig. 21-12)**.

Gambee single layer full thickness (all layers) sutures using vicryl are also used in bowel anastomosis. It can also be used as continuous sutures especially during gastrojejunostomy. *Continuous suturing* is quicker; alternate bites should be locked to prevent purse string effect; anterior layer is closed with inverting sutures. *Interrupted suture* is more stable and stronger with less chances of anastomotic disruption. It also maintains the blood supply better than continuous sutures. Width of suture bite taken should be less over mucosal part than seromuscular part. Bites are taken 3 mm from the cut edge of the serosa; each bite is taken in a 5 mm gap **(Fig. 21-13)**.

Lembert suture: It is the commonly used seromuscular suture. Silk 3 zero or vicryl 3 zero is used. Deep seromuscular suture including submucosal layer is taken at a point 5 mm from the cut edge of the serosa; this bite emerges at same line (2 mm) from the cut closer edge of serosa; bite is taken on the opposite part of the bowel at 2 mm from the serosal cut edge as seromuscular which emerges at 5 mm point away in the same longitudinal line and knot is placed. It can be used as continuous suture also **(Fig. 21-14)**.

Cushing suture: It is similar to Lembert suture wherein seromuscular bites are taken parallel to the cut edge of the serosa (at 2 mm from the cut edge). Thickness of tissue taken is 5 mm. Both interrupted and continuous sutures can be taken **(Fig. 21-15)**.

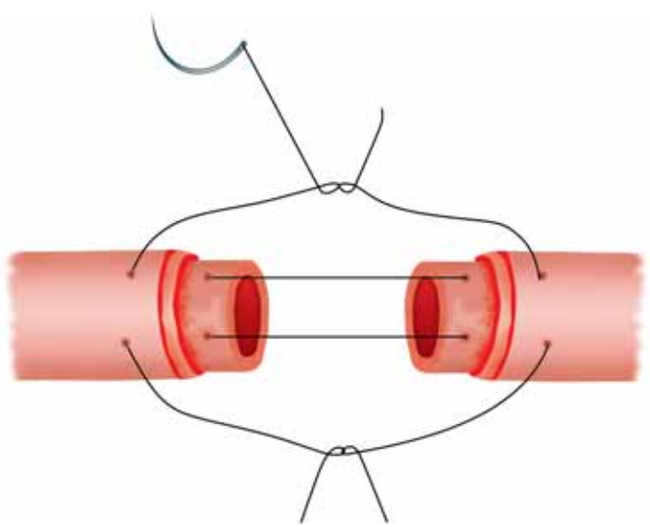


Fig. 21-12: Single layer seromucosal suturing of the bowel.

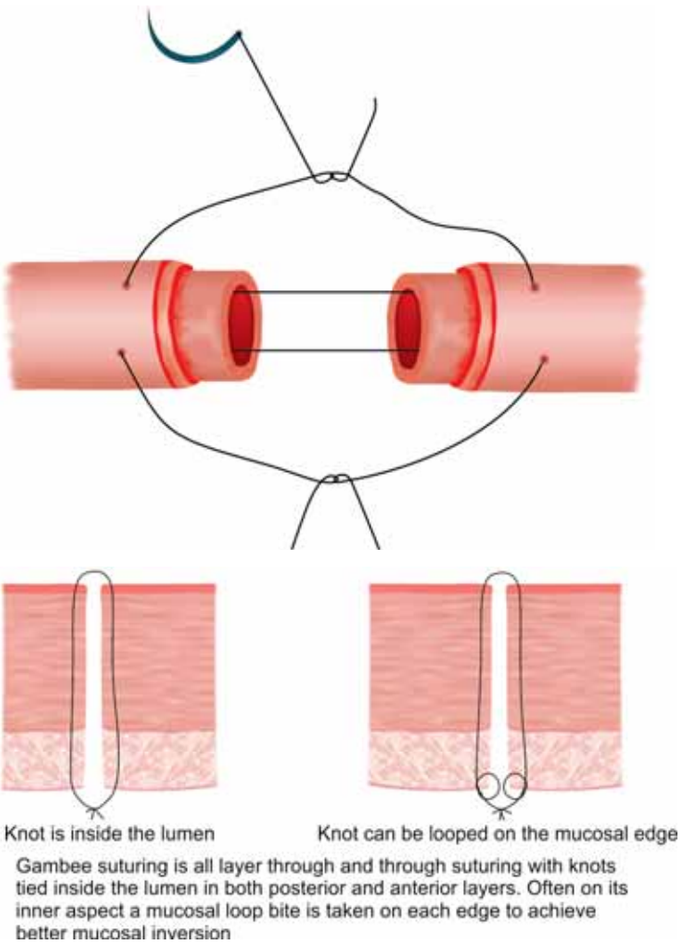

Knot is inside the lumen
Knot can be looped on the mucosal edge
Gambee suturing is all layer through and through suturing with knots tied inside the lumen in both posterior and anterior layers. Often on its inner aspect a mucosal loop bite is taken on each edge to achieve better mucosal inversion

Fig. 21-13: Gambee suture.

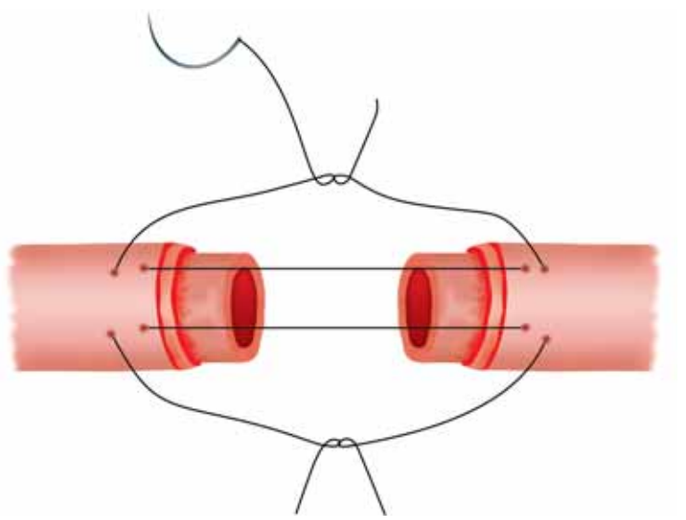


Fig. 21-14: Lembert suture.

Halsted suture: It is actually seromuscular horizontal mattress suture. Care must be taken to avoid excessive tension over the suture line as this may lead in to ischaemia of the anastomotic site **(Fig. 21-16)**.

Connell suture: Here suture material passes through all the layers of the intestine from serosa to mucosa; again brought out through all layers of the intestine on the same side from mucosa to serosa; passed over opposite segment of the bowel; passing from serosa

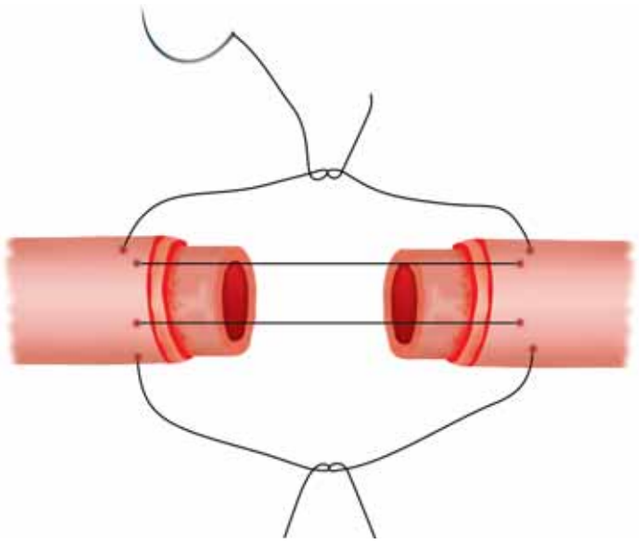


Fig. 21-15: Cushing suture.

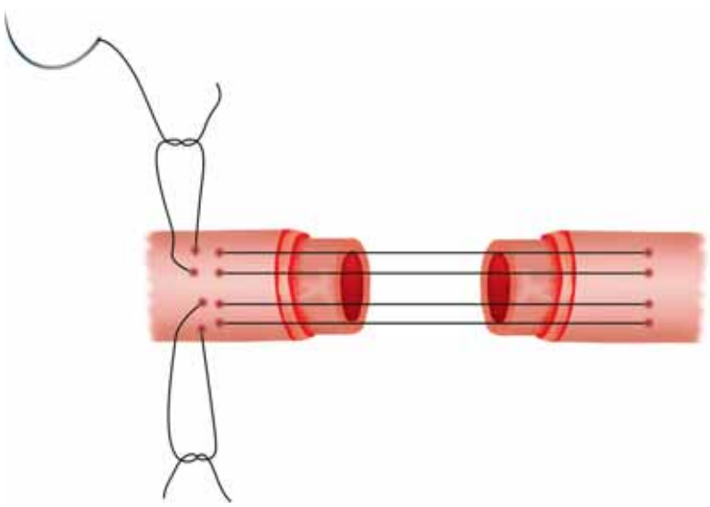


Fig. 21-16: Halsted suture.

to lumen/mucosa and from mucosa to outside towards serosa; again coming towards same side to repeat the technique. It is very good technique to invert the mucosal part of the anterior layer. It is commonly used in double layer anastomosis but can be used in single layer anastomosis. Connell suture apposes well; achieves good mucosal inversion. But it is *not adequately haemostatic* and so bleeders on the cut edge of the bowel should be ligated or cauterized individually **(Fig. 21-17)**.

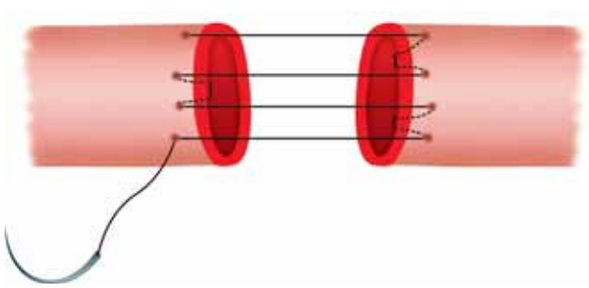


Fig. 21-17: Connell suture for bowel anastomosis.

Resection for gangrenous bowel should be done with division of mesentery very close to the bowel wall. In *small bowel tumour* mesentery is divided away at main branch vessel level with adjacent mesenteric lymph node clearance **(Figs 21-18 to 21-20)**.

Any serosal tear during small bowel surgery should be invaginated transversely using interrupted silk sutures. It prevents adhesion formation and possible chance of post-operative perforation from serosal tear site.

Technique

Nasogastric tube and urinary catheter is passed. Under general anaesthesia with patient in supine position, upper midline incision or middle midline incision running over left side of the umbilicus is made **(Fig. 21-21)**.

After laparotomy abdomen is explored routinely. In obstruction, junction of the proximal dilated segment and distal collapsed segment is identified. In tumour, site of tumour is recognized. Entire small and large bowel should be inspected and palpated for additional pathology. Mesenteric lymph nodes should be looked for. Bowel to be resected is clamped using occlusion clamps on either side at the line of resection. Clamps should not extend far into the mesentery. These clamps should be placed obliquely. Mesenteric vasculature is studied using transillumination. Once vascularity is identified, small windows are made in avascular area using artery forceps and is clamped with artery forceps, divided and ligated. If mesentery is bulky it is better to place two clamps proximally and two ligatures; often it is also necessary to transfix proximal sides of the windows with transfixation sutures to avoid slippage of ligature and bleeding. In resection of tumour, main branch vessel close to that particular loop is clamped, ligated and divided to achieve nodal clearance. Alternatively after creating two consecutive windows silk ligatures are passed and tied, two proximally and one distally and divided between proximal two ligatures and distal one; these tied ligatures should be cut only after dividing the pedicle/vessel. Instead of distal ligatures, artery forceps can be kept and left like that as it will come out with the specimen at the end which will avoid additional ligature passage but it is cumbersome because of so many instruments in the surgical field. In gangrene arcades are ligated close to bowel wall. All vessels entering the bowel are ligated and divided between two clamps. *Payr's* crushing clamp is applied on the specimen side; bowel is cut between occlusion clamp and crushing clamp. Division of bowel is done using no 15 blade or cautery from mesenteric side to antimesenteric side; it is advisable to keep mop or flat instrument underneath to prevent injuring the deeper structures. Clamps should be at 30° angle to the antimesenteric part of the bowel and specimen is removed with the crushing clamp. In tumour, mesentery is ligated proximal to the arcade level away from mesenteric margin of the bowel at main vessels (jejunal or ileal branches) to include adjacent lymph nodes in the specimen; bowel should be divided 5 cm away from the outer margin of the tumour on both sides. Superior mesenteric vessels will be much closer to dissecting area in such situation and so should be careful while applying clamps in such situation. Bulk clamping should be avoided. Large area of mesenteric clamping also can lead to mesenteric tear and causes difficulty in placing ligatures. Small mesenteric segments are clamped, ligated and divided consecutively till one reaches across towards clamp on other (opposite) side of the resecting segment **(Fig. 21-22)**.

Anastomosis is done by different methods—end to end anastomosis; side to side anastomosis; end to side anastomosis **(Fig. 21-23)**.

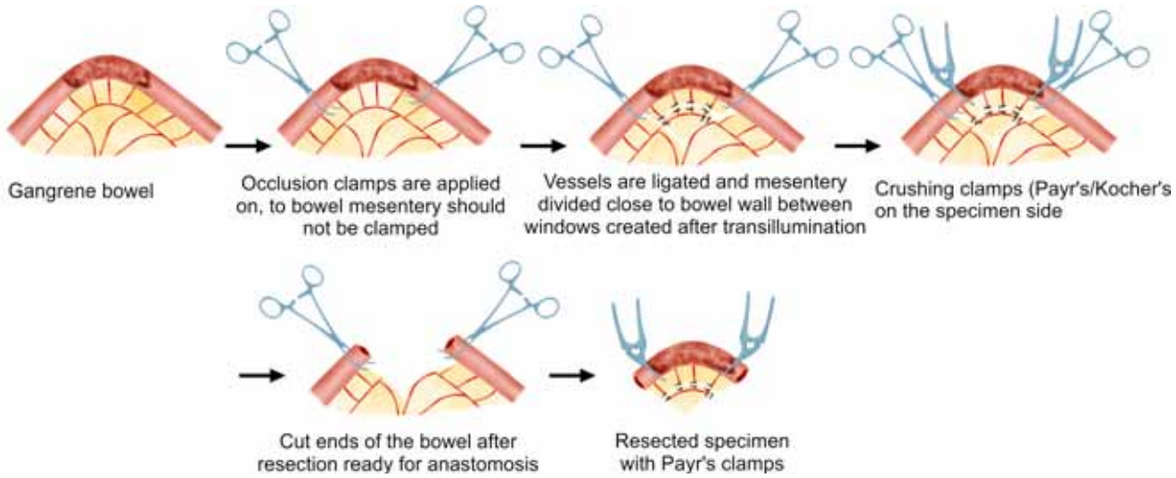

Gangrene bowel
Occlusion clamps are applied on, to bowel mesentery should not be clamped
Vessels are ligated and mesentery divided close to bowel wall between windows created after transillumination
Crushing clamps (Payr's/Kocher's on the specimen side
Cut ends of the bowel after resection ready for anastomosis
Resected specimen with Payr's clamps

Fig. 21-18: Resection of bowel in gangrene.

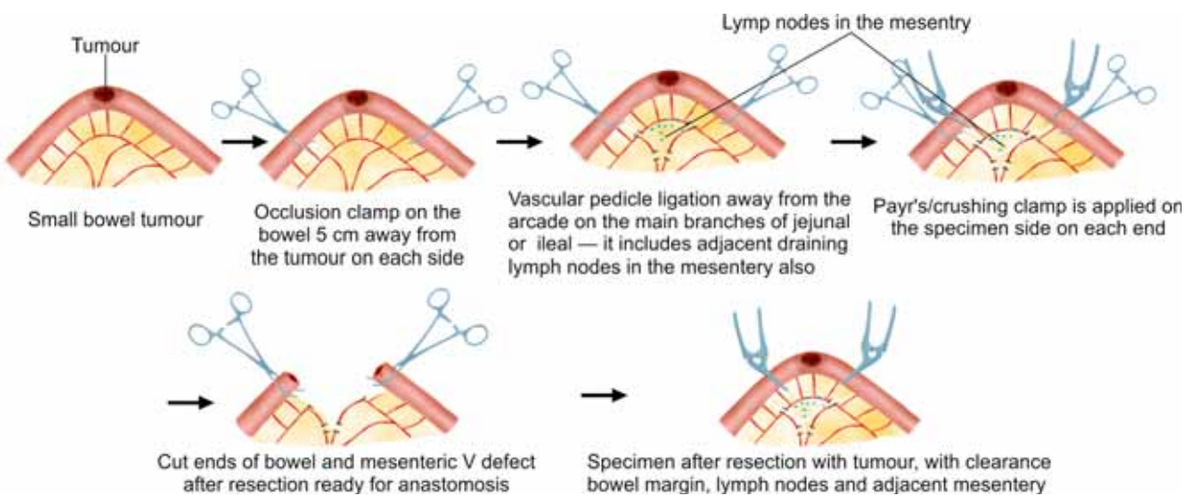

Tumour
Lymp nodes in the mesentry
Small bowel tumour
Occlusion clamp on the bowel 5 cm away from the tumour on each side
Vascular pedicle ligation away from the arcade on the main branches of jejunal or ileal — it includes adjacent draining lymph nodes in the mesentery also
Payr's/crushing clamp is applied on the specimen side on each end
Cut ends of bowel and mesenteric V defect after resection ready for anastomosis
Specimen after resection with tumour, with clearance bowel margin, lymph nodes and adjacent mesentery

Fig. 21-19: Resection of bowel in small bowel tumour.

Fig. 21-20: Serosal tear suturing should be done as interrupted seromuscular suture using silk—3 zero.

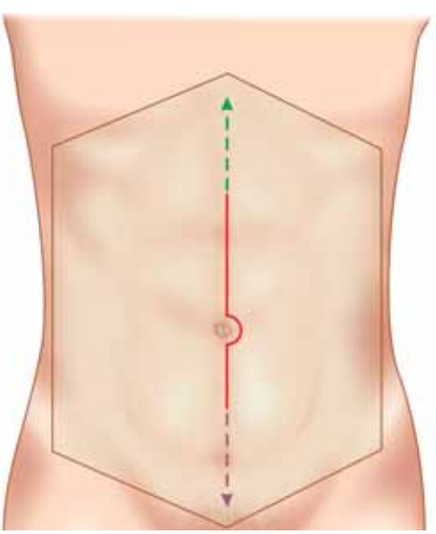


Fig. 21-21: Incision for bowel resection.

Commonly *end to end anastomosis* is used. First step is to place a seromuscular Lembert suture at mesenteric side 1 cm from the mucosal cut edge; often this stitch is taken as a through and through all layer single suture which acts as stay suture also which is held with a small haemostat. If there is discrepancy in size between two ends then *Cheatle's cut* is given to distal collapsed smaller sized bowel. Either single layer interrupted full thickness all layer sutures with 3 zero silk are placed or outer interrupted silk sutures with inner continuous vicryl sutures as two layers is used. After completion of the anastomosis stoma should be checked for patency and adequacy by placing fingers (two fingers); it is important to look whether sutured part is pink and healthy or dusky and unhealthy. If it is dusky then anastomosis is

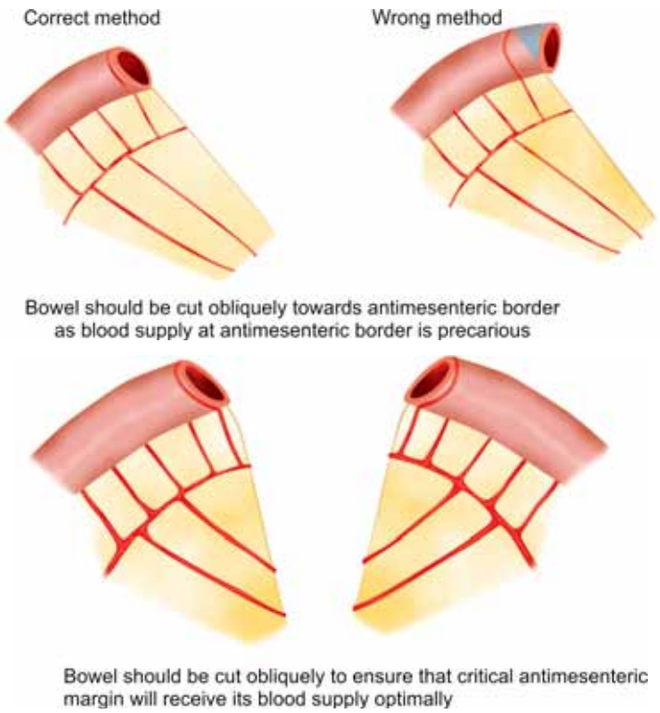

Correct method
Wrong method
Bowel should be cut obliquely towards antimesenteric border as blood supply at antimesenteric border is precarious
Bowel should be cut obliquely to ensure that critical antimesenteric margin will receive its blood supply optimally

Fig. 21-22: Correct and wrong methods of dividing bowel margin.

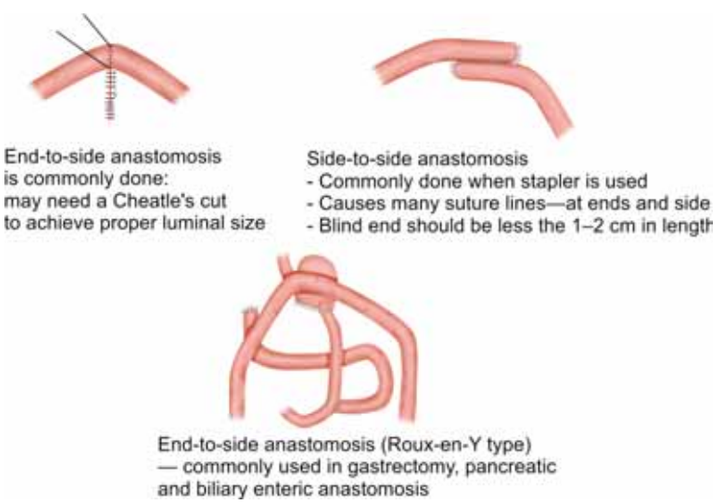

End-to-side anastomosis
is commonly done:
may need a Cheatle's cut
to achieve proper luminal size
Side-to-side anastomosis
- Commonly done when stapler is used
- Causes many suture lines—at ends and side
- Blind end should be less the 1–2 cm in length
End-to-side anastomosis (Roux-en-Y type)
— commonly used in gastrectomy, pancreatic
and biliary enteric anastomosis

Fig. 21-23: Different types of bowel anastomosis.

disconnected and edges are trimmed until it bleeds and anastomosis is redone. Supportive *crown stitch* is placed on the mesenteric side of the anastomotic site to avoid any possible leak. Tube drain is placed in difficult cases **(Figs 21-24 to 21-30)**.

In single layer interrupted anastomosis *Gambee stitch* with all layer through and through sutures from mucosa to serosa serosa and bowel wall and mucosa of opposite edge and knot is tied in the lumen. Often while taking bite from mucosa, loop can be done in the mucosa in Gambee stitch to achieve proper mucosal inversion. In single layer anastomosis often four quadrant (two on each side) seromuscular sutures are placed to relieve tension on inner layer.

Parker Kerr basting stitch previously was in use; after applying Parker Kerr clamps, basting Cushing's continuous suture bites are taken on the seromuscular layer over the clamp on each side circumferentially and then clamps are released.

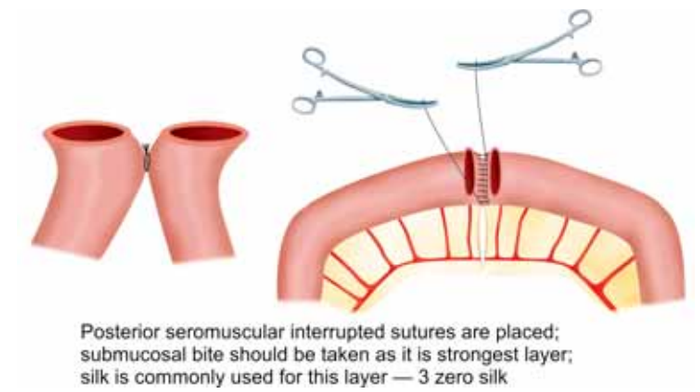

Posterior seromuscular interrupted sutures are placed;
submucosal bite should be taken as it is strongest layer;
silk is commonly used for this layer — 3 zero silk

Fig. 21-24: Interrupted posterior outer seromuscular layer suture.

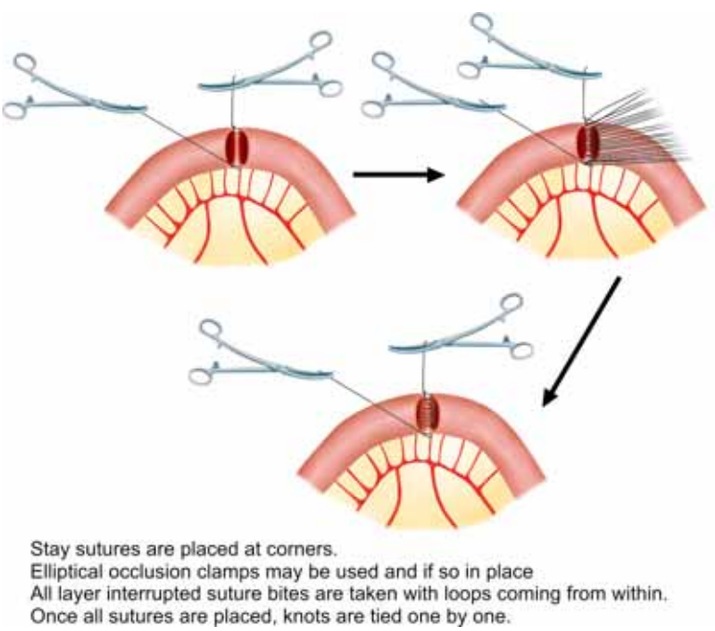

Stay sutures are placed at corners.
Elliptical occlusion clamps may be used and if so in place
All layer interrupted suture bites are taken with loops coming from within.
Once all sutures are placed, knots are tied one by one.

Fig. 21-25: Posterior all layer suturing is done as either interrupted full thicknes sutures (silk—3 zero); or continuous locking sutures using vicryl.

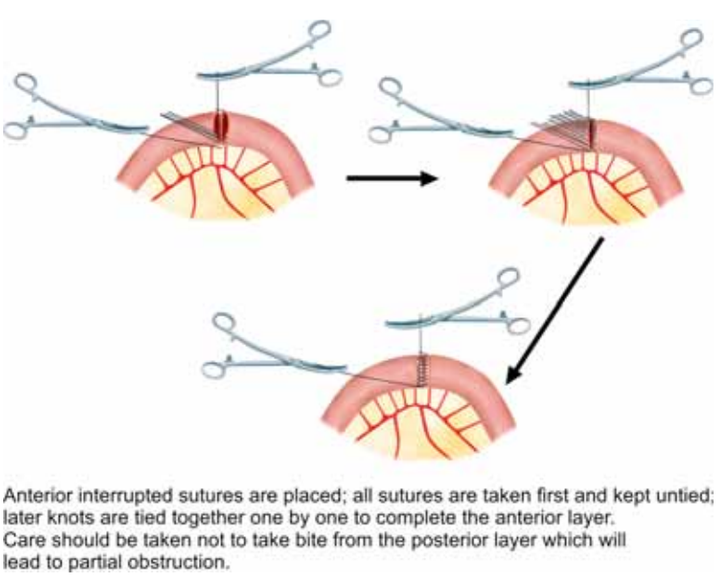

Anterior interrupted sutures are placed; all sutures are taken first and kept untied;
later knots are tied together one by one to complete the anterior layer.
Care should be taken not to take bite from the posterior layer which will
lead to partial obstruction.

Fig. 21-26: Anterior layer interrupted suture in bowel anastomosis.

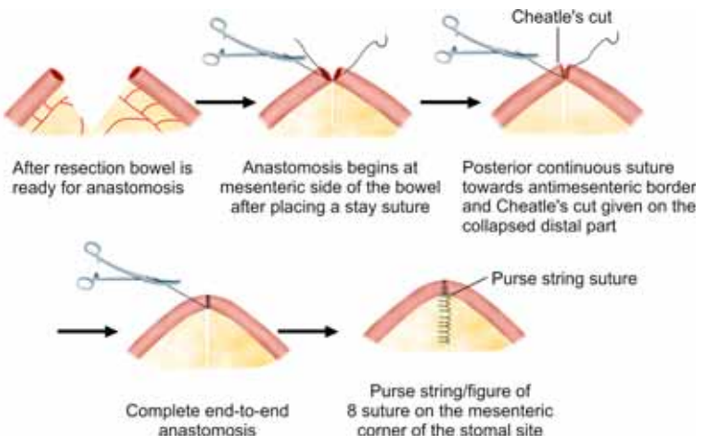

Cheatle's cut
After resection bowel is ready for anastomosis
Anastomosis begins at mesenteric side of the bowel after placing a stay suture
Posterior continuous suture towards antimesenteric border and Cheatle's cut given on the collapsed distal part
Purse string suture
Complete end-to-end anastomosis
Purse string/figure of 8 suture on the mesenteric corner of the stomal site

Fig. 21-27: Technique of end-to-end anastomosis.

V shaped mesenteric defect is closed with interrupted silk sutures (ideal); often corresponding parts of the edges are held together with haemostats and ligature is tied around each pair to close the mesenteric defect (as here needle bite is not taken needle bite bleeding and haematoma of the mesentery will not occur). Continuous suturing even though mesenteric practiced causes troublesome tear at mesenteric edge and bleeding **(Figs 21-31 and 21-32)**.

Problems and Complications

Friable bowel wall with poor blood supply can lead into leak and enterocutaneous fistula. Ileostomy may be better in such situation rather than doing anastomosis.

Sepsis, subphrenic abscess and pelvic abscess can occur.

ENTEROLYSIS/ADHESIOLYSIS

Adhesions and bands are the most common causes of intestinal obstruction in Western countries. In India, hernia and then adhesions are the two common causes of intestinal obstruction **(Fig. 21-33)**.

Causes

Infection due to peritonitis; appendicitis; postlaparotomy; materials used during surgery can cause dense inflammatory reactions—suture materials like silk, thread, and foreign body, mop, and gauze, talc

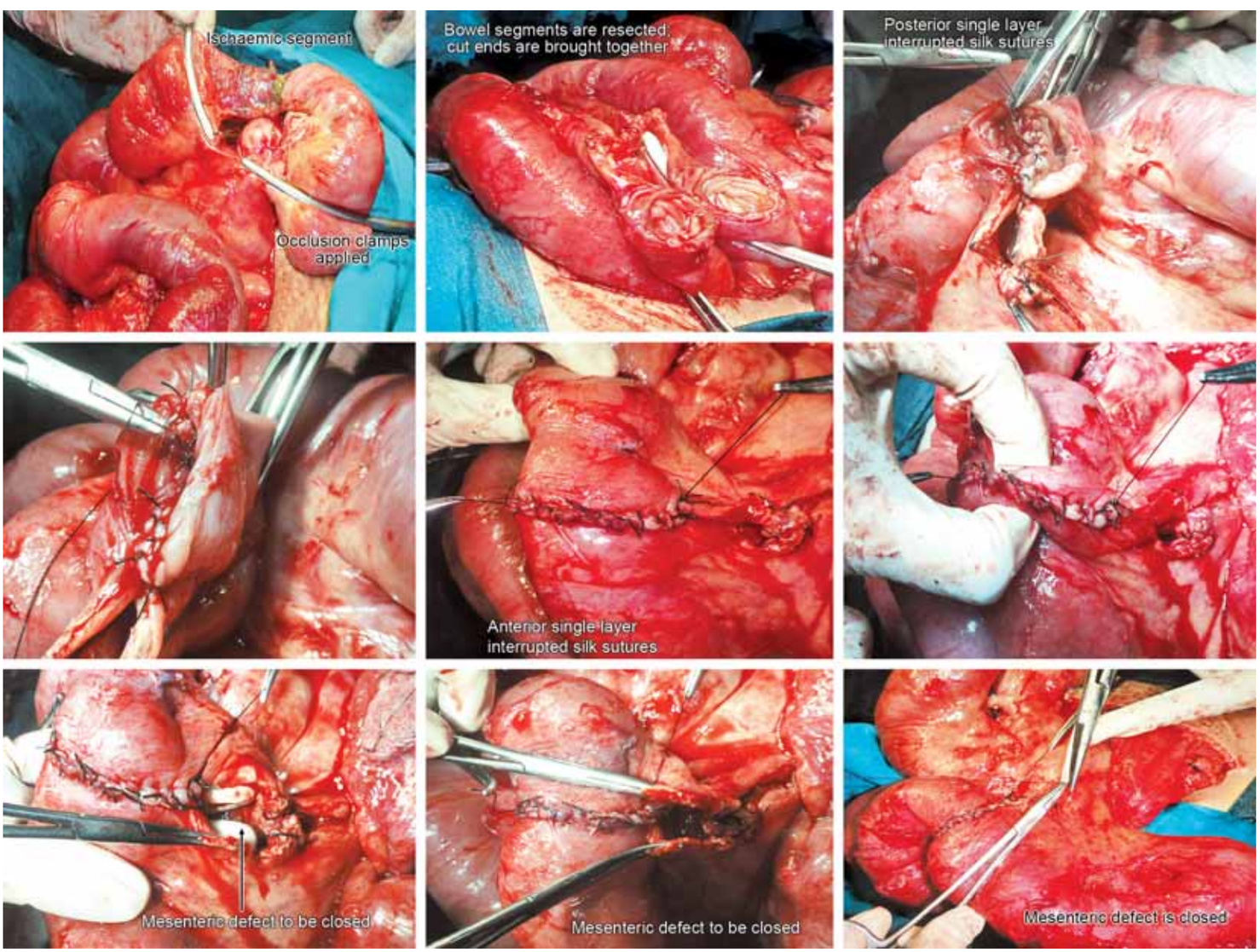
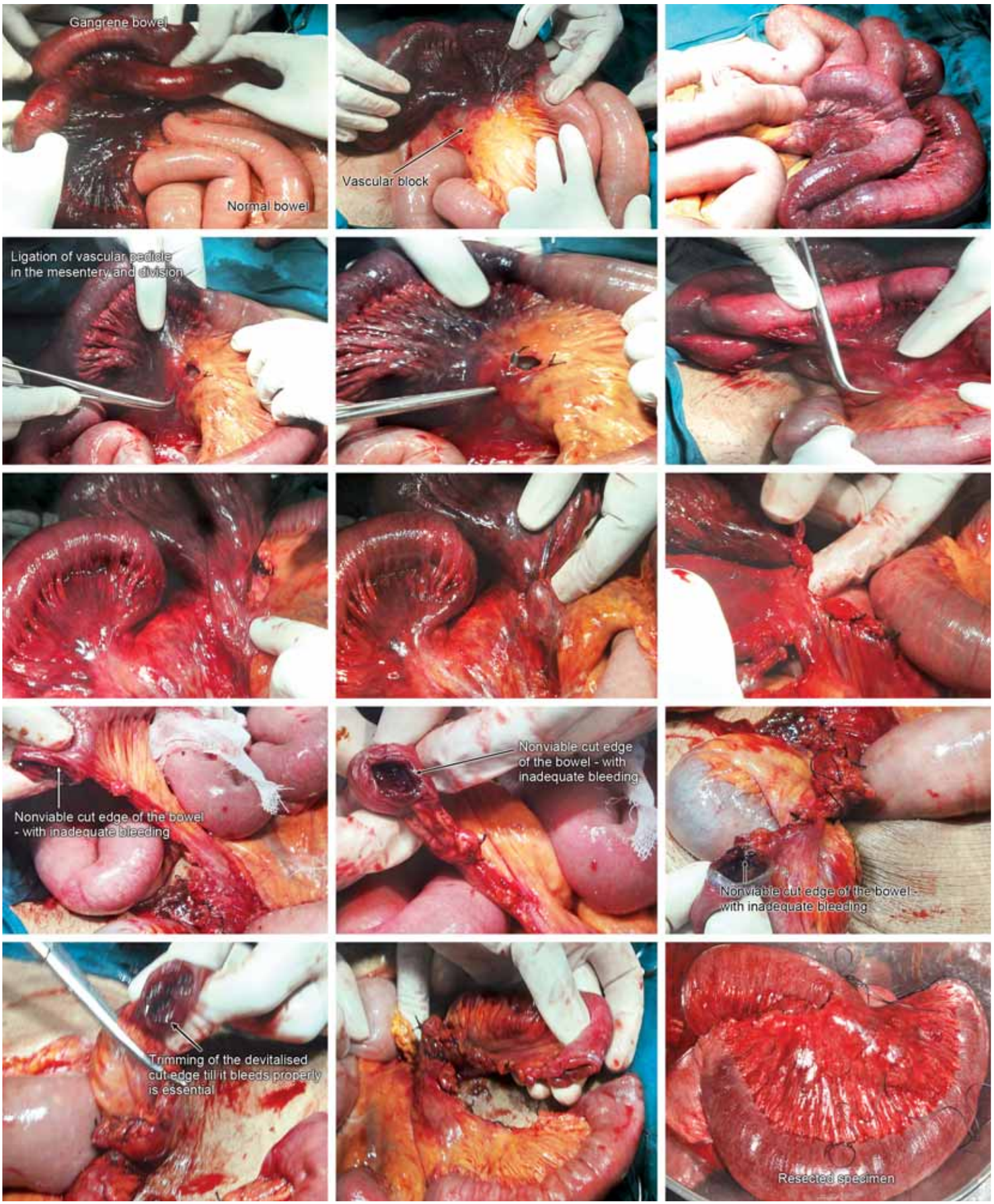
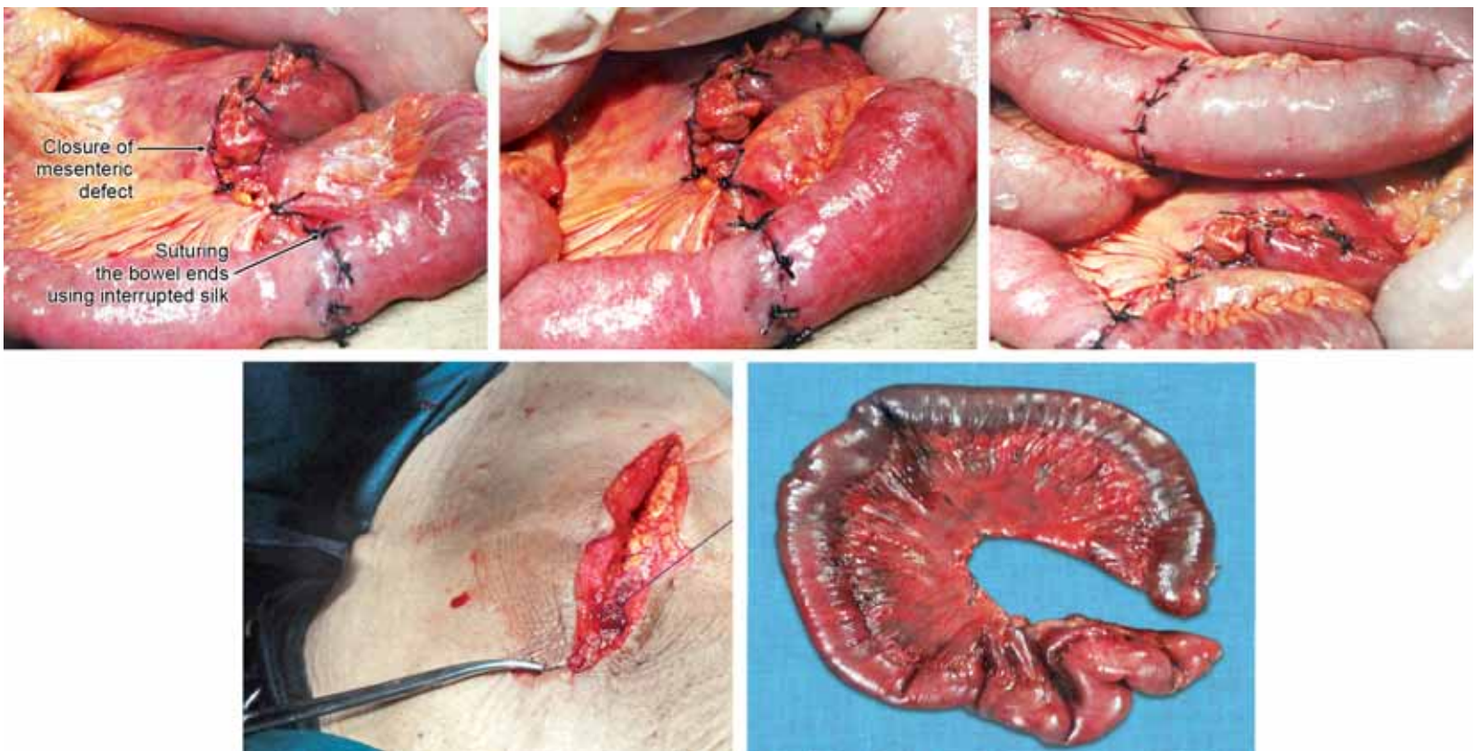

Ischaemic segment
Occlusion clamps applied
Bowel segments are resected; cut ends are brought together
Posterior single layer interrupted silk sutures
Anterior single layer interrupted silk sutures
Mesenteric defect to be closed
Mesenteric defect to be closed
Mesenteric defect is closed

Fig. 21-28: Technique of resection and anastomosis.


Gangrene bowel
Normal bowel
Vascular block
Ligation of vascular pedicle in the mesentery and division
Nonviable cut edge of the bowel - with inadequate bleeding
Nonviable cut edge of the bowel - with inadequate bleeding
Nonviable cut edge of the bowel - with inadequate bleeding
Trimming of the devitalised cut edge till it bleeds properly is essential
Resected specimen

Figs 21-29(1)



Figs 21-29(2)

Figs 21-29(1 and 2): Resection of bowel in (massive resection) extensive gangrene due to mesenteric artery thrombosis.

powder; drugs like sulphonamides and penicillins; ischaemia of bowel due to poor blood supply; gynaecological conditions; bowel injury; radiation-induced enteritis, Crohn's disease and other inflammatory bowel diseases; specific conditions like tuberculosis, malignancy **(Figs 21-34 and 21-35)**.

Note:

- It is often called as *adhesive small bowel obstruction* (ASBO). 80% cases showed earlier laparotomies; 35% multiple laparotomy. In such patients 75% of surgeries are emergency ones.
- *Causes may be classified as—Congenital* adhesions; *Ischaemic*—Reduced blood supply of the bowel, *Traumatic*—Patients have undergone laparotomies for intraabdominal injuries; *Irritants*—Talc powder used for gloves, starch, antibiotics, nonabsorbable suture materials, gauze and cotton filaments, barium; *Inflammatory*—Appendicitis, cholecystitis, pelvic infection, Crohn's disease, tuberculosis; *Others*—Serosal denudation during surgery precipitates adhesions.
- Initial cause ischaemia/injury → inflammatory exudates → fibrinous adhesions → fibrous adhesion → fibrinolysis. Fibrinous adhesion is avascular. Often thick vascular adhesions develop. Adhesions can be localized or extensive.

Types

Type I—Fibrinous adhesions occur during 5th to 10th post-surgical period. It usually gets resolved completely. It is avascular and flimsy. *Type II—Fibrous* adhesions. Due to lack/poor blood supply, bowel gets attached to part of peritoneum or omentum or other parts of the bowel with dense vascular adhesions to maintain blood supply. It will persist and precipitate intestinal obstruction, often subacute and recurrent type.

Adhesions due to tuberculosis are severe, dense and difficult to separate.

Obstruction due to Bands

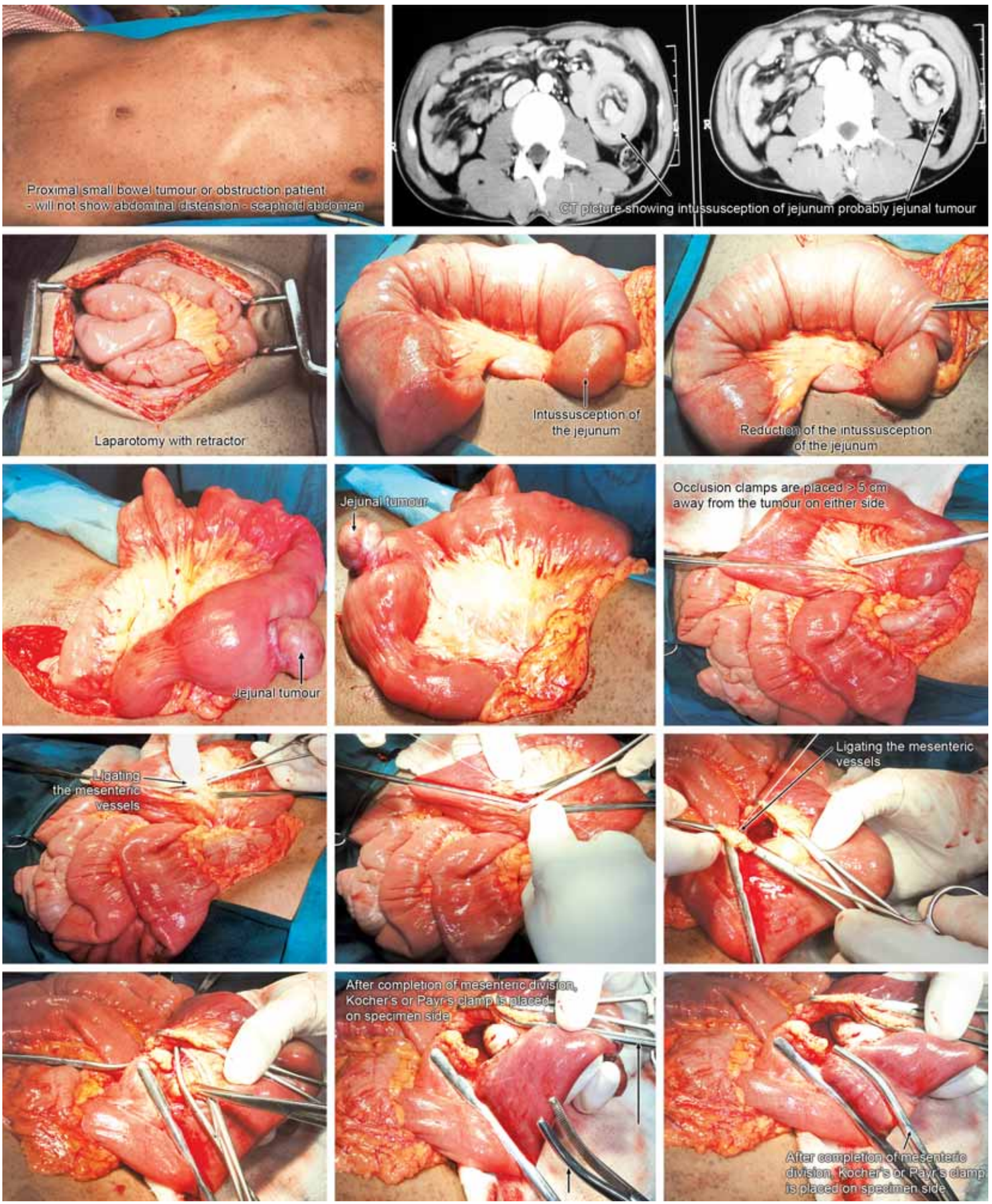
These are *dense fibrous strings* attached from one portion of the abdomen to another area or bowel causing entrapment of intestines leading into obstruction and often dangerous *strangulation.* Common causes are vitellointestinal duct, Ladd's band, omental band, postsurgical fibrous band, tuberculous band.

Clinical features are like that of intestinal obstruction. Management is release of the band either through laparoscopy or through laparotomy.

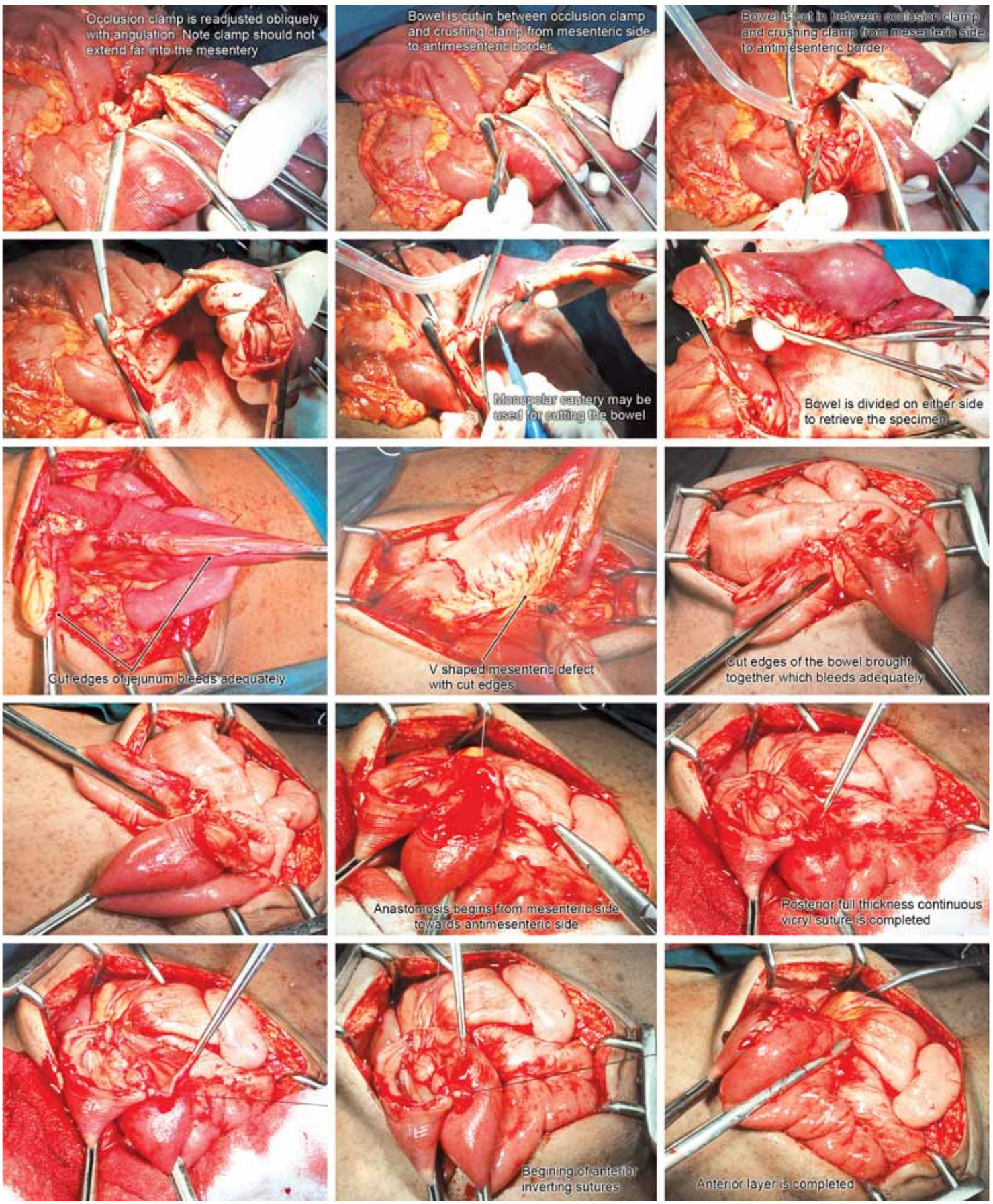
Features

Pain abdomen—colicky type and recurrent and episodic; distension, vomiting, constipation; reduced bowel sounds on auscultation; previous surgical scars commonly observed; dehydration, tachycardia, hypotension.

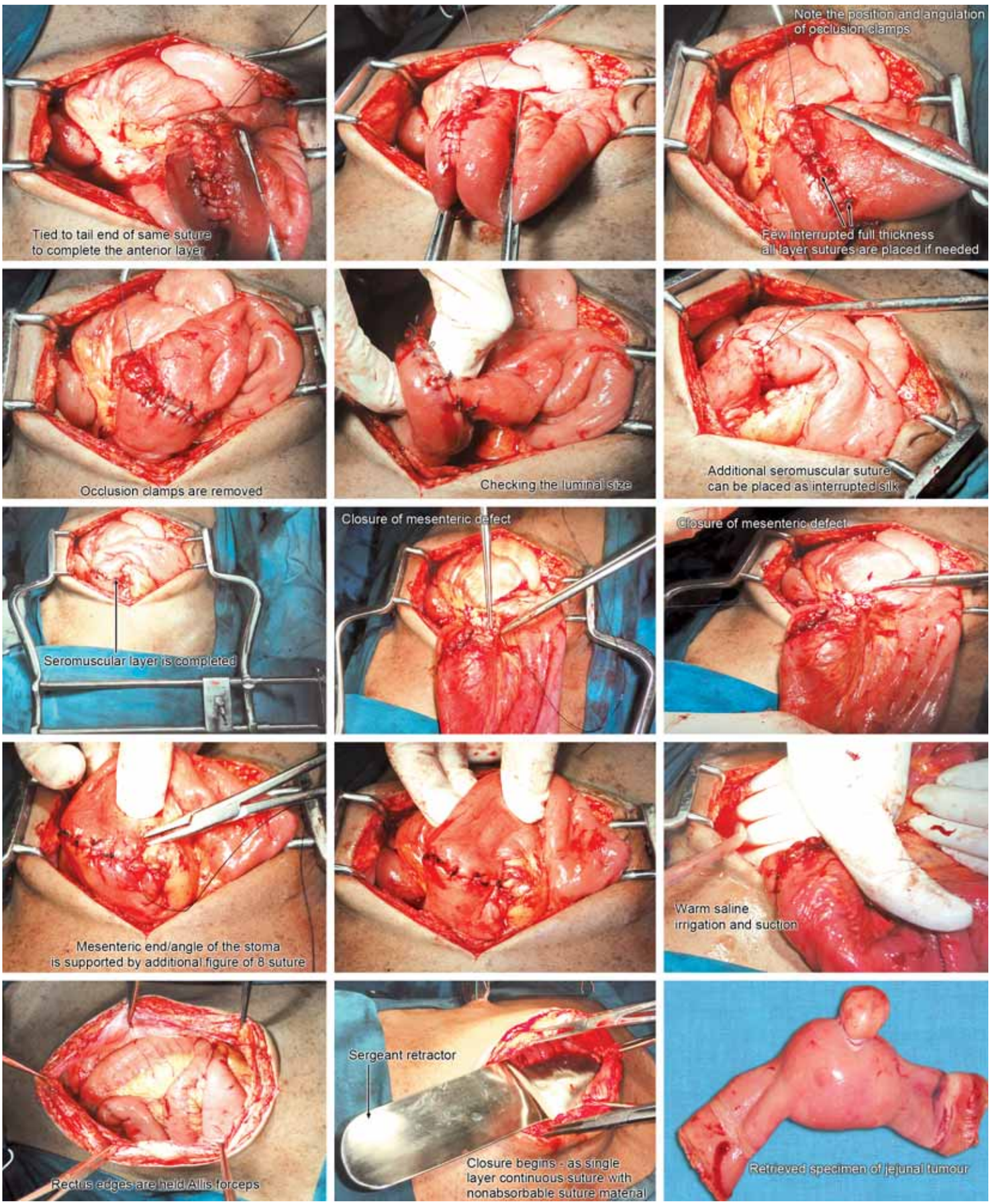
Commonest symptom in adhesions is ***pain*** which is sharp, sudden, recurrent, episodic and colicky. Colicky pain is more common in midlevel obstruction. *Gilroy Bevan triad* of adhesive pain is—(1) Pain may get aggravated or relieved on change of posture. (2) Pain in the region of old abdominal scar. (3) Tenderness is elicited by pressure over the scar.


Proximal small bowel tumour or obstruction patient
- will not show abdominal distension - scaphoid abdomen
CT picture showing intussusception of jejunum probably jejunal tumour
Laparotomy with retractor
Intussusception of the jejunum
Reduction of the intussusception of the jejunum
Jejunal tumour
Jejunal tumour
Occlusion clamps are placed > 5 cm away from the tumour on either side
Ligating the mesenteric vessels
Ligating the mesenteric vessels
After completion of mesenteric division, Kocher's or Payr's clamp is placed on specimen side
After completion of mesenteric division, Kocher's or Payr's clamp is placed on specimen side

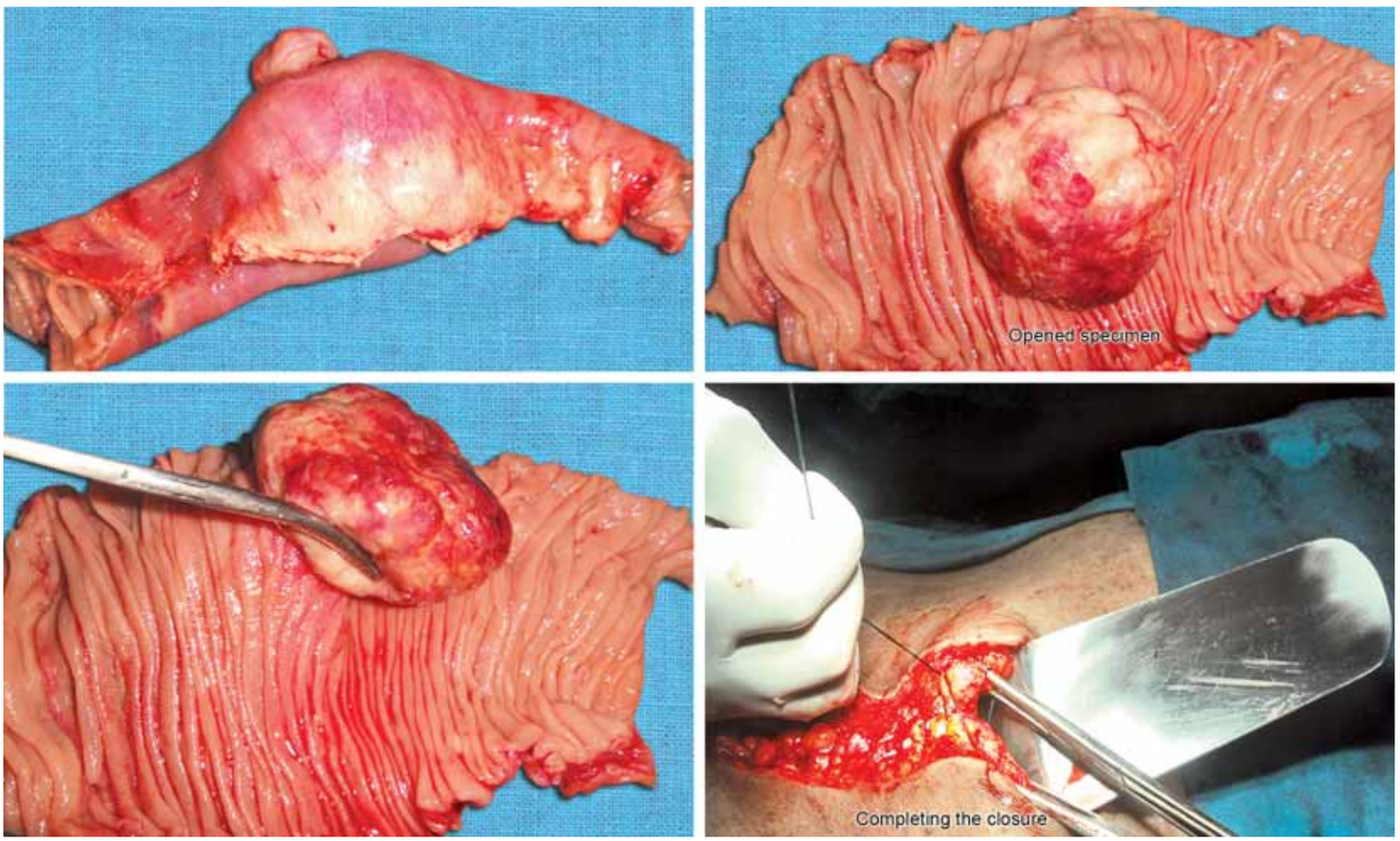
Figs 21-30(1)


Occlusion clamp is readjusted obliquely with angulation. Note clamp should not extend far into the mesentery
Bowel is cut in between occlusion clamp and crushing clamp from mesenteric side to antimesenteric border
Bowel is cut in between occlusion clamp and crushing clamp from mesenteric side to antimesenteric border
Monopolar cautery may be used for cutting the bowel
Bowel is divided on either side to retrieve the specimen
Cut edges of jejunum bleeds adequately
V shaped mesenteric defect with cut edges
Cut edges of the bowel brought together which bleeds adequately
Anastomosis begins from mesenteric side towards antimesenteric side
Posterior full thickness continuous vicryl suture is completed
Begining of anterior inverting sutures
Anterior layer is completed

Figs 21-30(2)


Tied to tail end of same suture to complete the anterior layer
Note the position and angulation of occlusion clamps
Few interrupted full thickness all layer sutures are placed if needed
Occlusion clamps are removed
Checking the luminal size
Additional seromuscular suture can be placed as interrupted silk
Seromuscular layer is completed
Closure of mesenteric defect
Closure of mesenteric defect
Mesenteric end/angle of the stoma is supported by additional figure of 8 suture
Warm saline irrigation and suction
Rectus edges are held Allis forceps
Sergeant retractor
Closure begins - as single layer continuous suture with nonabsorbable suture material
Retrieved specimen of jejunal tumour

Figs 21-30(3)



Figs 21-30(2)

Figs 21-30(1 and 2): Resection of jejunal tumour and end-to-end anastomosis.

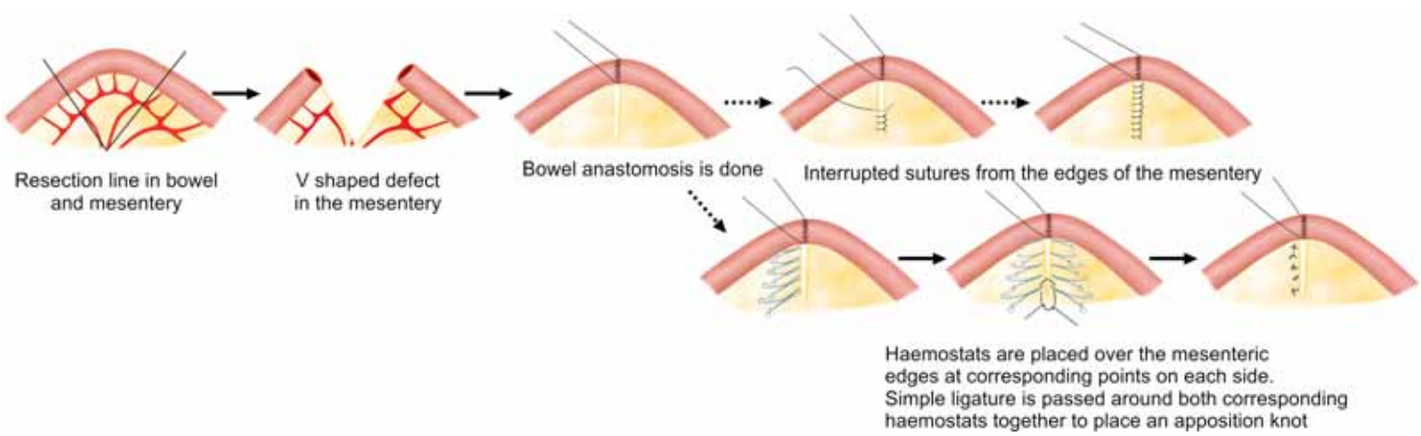

Resection line in bowel and mesentery
V shaped defect in the mesentery
Bowel anastomosis is done
Interrupted sutures from the edges of the mesentery
Haemostats are placed over the mesenteric edges at corresponding points on each side. Simple ligature is passed around both corresponding haemostats together to place an apposition knot

Fig. 21-31: Closure of mesenteric defect using interrupted sutures.

Lower adhesions will have more distension compared to proximal adhesion.

Often it presents with features of obstruction initially, later features of strangulation (toxicity, fever, tachycardia, guarding, rigidity, rebound tenderness). Adhesions may be asymptomatic for many years but later become symptomatic.

Plain X-ray abdomen shows dilated bowel loops; oral contrast with CT scan is very useful; only in partial obstruction enteroclysis with water-soluble iodine dyes can be done.

Level of obstruction should be assessed probably by X-ray and CT scan; CT may show radiological features of strangulation—intramesenteric fluid; mesenteric oedema, congestion, bowel wall thickening more than 2 mm, reduced mural enhancement in strangulated bowel compared to adjacent bowel. Small bowel loop may go for volvulus showing *Whirl sign* in CT scan which is due to whirlpool mesentery of that part of the bowel. Electrolyte estimation, total count, serum creatinine, blood grouping—are needed **(Figs 21-36 and 21-37)**.

Fig. 21-32: Laparotomy wound closed after resection and anastomosis.

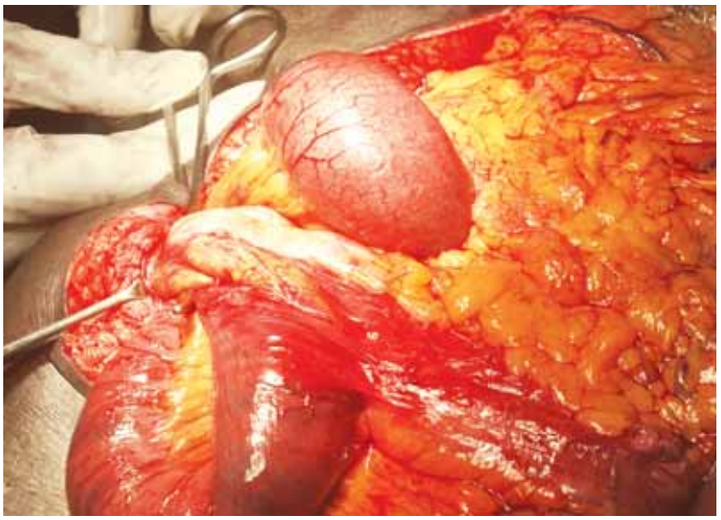


Fig. 21-34: Band with adhesions causing intestinal obstruction.

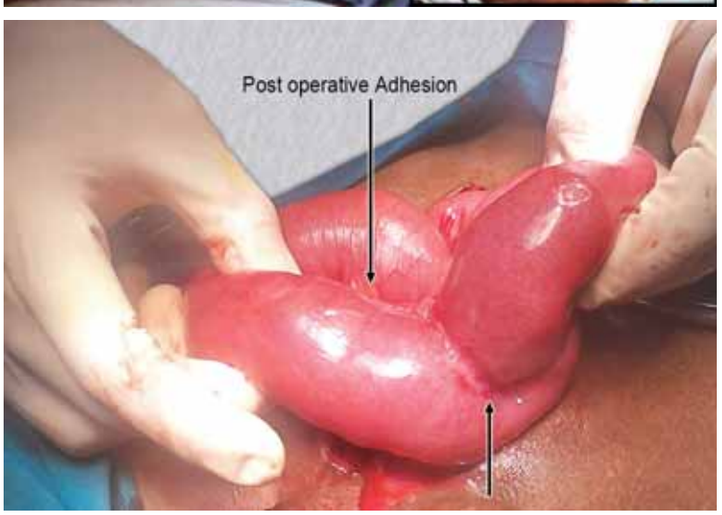


Fig. 21-33: Step ladder peristalsis in intestinal obstruction. Post-operative adhesions have become commonest cause of intestinal obstruction. Note the abdominal distension in a previous laparotomy patient and on table adhesions.

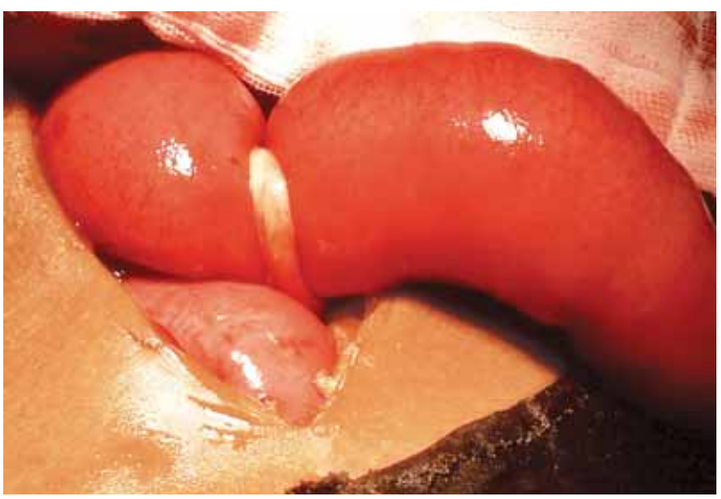


Fig. 21-35: A band causing stricture of small bowel.

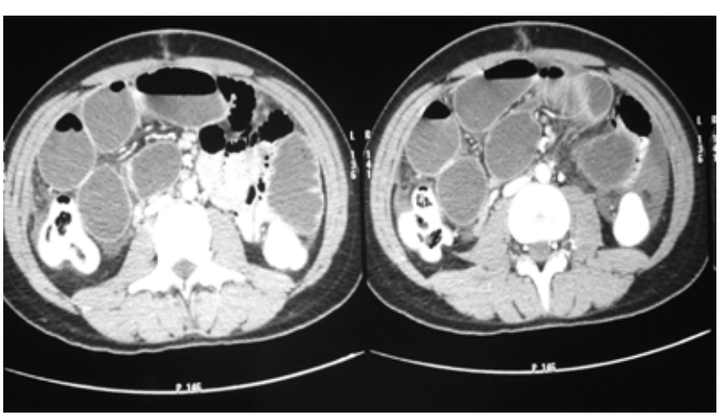


Fig. 21-36: CT is ideal and diagnostic for intestinal obstruction.

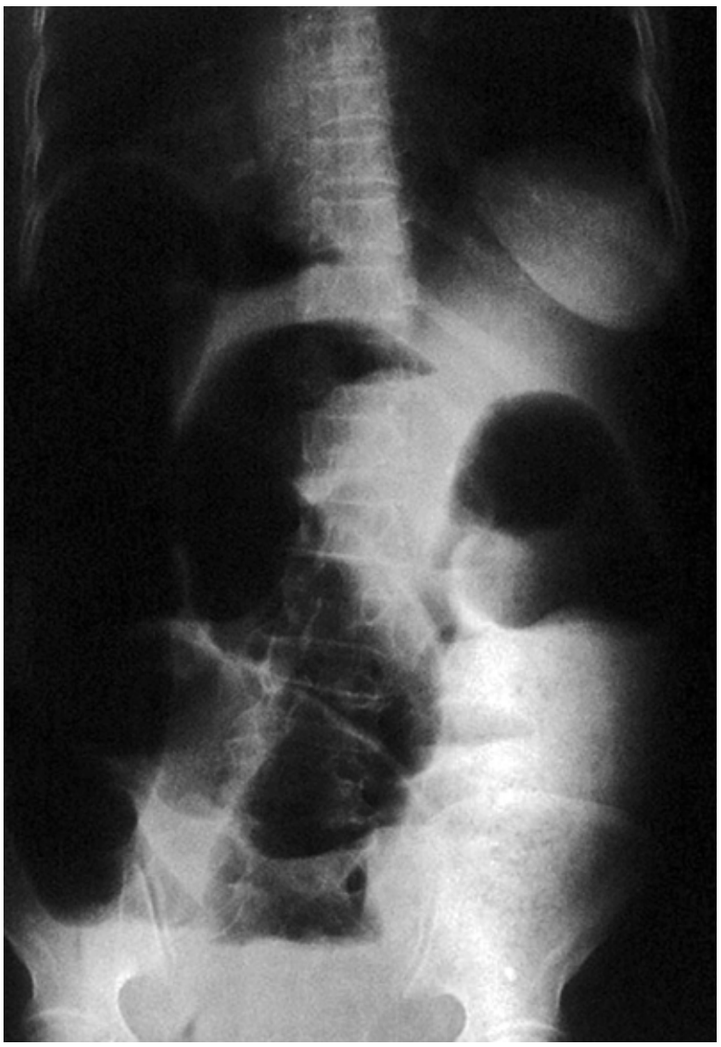


Fig. 21-37: X-ray showing small bowel obstruction with multiple air fluid levels.

Fig. 21-38: Laparoscopic view of dense adhesions—postoperative cause.

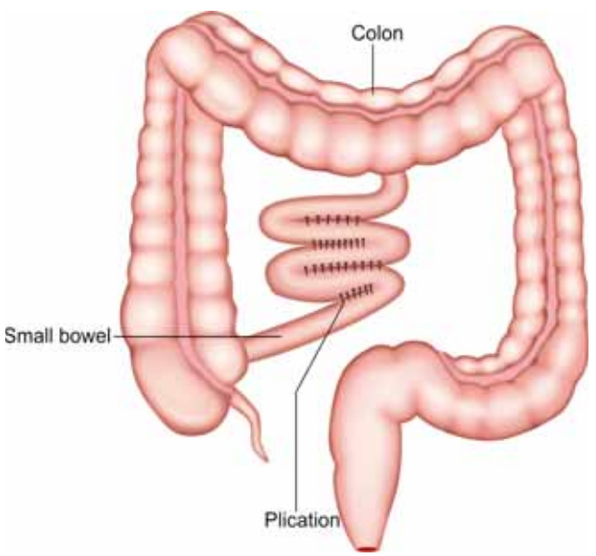


Fig. 21-39: Methods used to prevent recurrent adhesions and so to reduce the chances of intestinal obstruction. Noble's plication is plication of intestines.

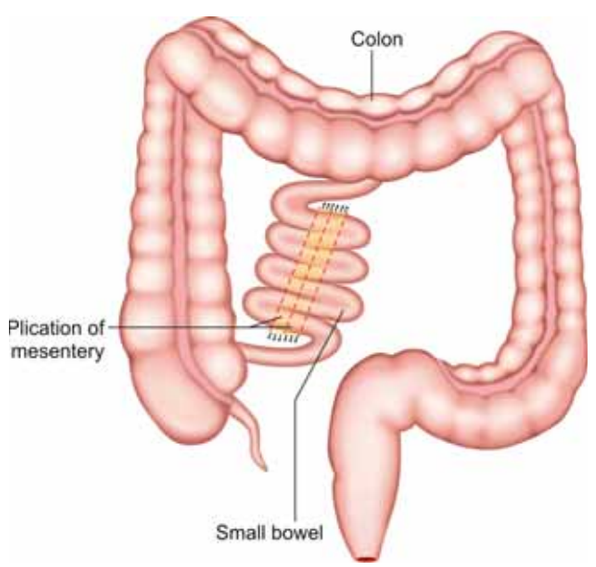


Fig. 21-40: Childs-Phillips operation done to prevent adhesive obstruction by plicating mesentery.

Treatment

Initial Treatment

IV fluids, nasogastric aspiration, antibiotics, often per anal flatus tube insertion, commonly patient responds in 4-5 days of therapy.

Later Treatment

Open surgical adhesiolysis using fingers gently.

Laparoscopic adhesiolysis is becoming popular, safer, and ideal with less recurrent adhesion rate and good results **(Fig. 21-38)**.

Noble's plication of intestines—wherein adjacent coils of small bowel are sutured to prevent going in for further recurrent adhesions.

Childs-Phillips mesenteric plication is a similar way of plication of intestinal mesentery, which will prevent crumpling of bowel and adhesion formation.

Passing long stiff tube from exterior through an opening in the proximal bowel up to the entry into the large bowel, which acts as intraluminal splinting **(Figs 21-39 and 21-40)**.

Intestinal intubation is technically difficult with chances of perforation and fistula formation. *Baker's tube* insertion through

jejunostomy site; *Stewardson insertion of Baker tube* through nasogastric route; In *Nelson and Nyhus* method, 2nd balloon to Baker tube 25 cm proximal to the first to facilitate easier insertion of the tube—are different tubes and techniques used **(Figs 21-41 and 21-42).**

Expandable PTFE membrane barriers or hyaluronic acid and carboxymethyl cellulose membrane barriers are also used.

Surgical Treatment for Adhesions—Enterolysis

Adhesions are common causes of intestinal obstruction. Usual treatment is adhesion release either through open or laparoscopic approach. Laparoscopic approach has become standard now. However principles of adhesiolysis are similar in both approaches.

Open Method

Usually it is diagnosed by recurrent pain, distension, vomiting. CT scan confirms the diagnosis. Approach is through same previous scar with extension on either ends. But peritoneum should be opened through normal part of the incision not through the old scar area. Once peritoneum is opened remaining part of the wound is opened under vision with release of any adherent omentum or bowel.

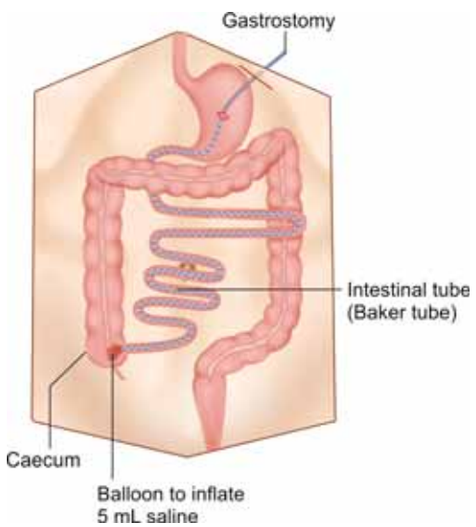


Fig. 21-41: Intestinal intubation via a gastrostomy tube used for adhesions.

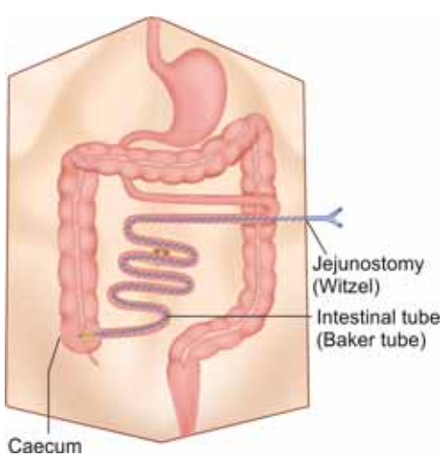


Fig. 21-42: Intestinal intubation via a jejunostomy tube used for adhesions.

Sharp dissection is better if adhesions are fibrous and thick. In bowel adhesions to abdominal wall, dissection should be carried out very close to the abdominal wall; it is better to incise the abdominal wall peritoneum rather than creating a nonexisting plane between adherent bowel and abdominal wall; if it is tried it will surely create a rent in the bowel. While cutting adhesion finger is used underneath for guidance.

Flimsy thin fibrinous adhesions are dissected using index finger. *Gentle finger dissection* is carried out with care to avoid serosal or deeper tears in the bowel wall. *Oozing* while releasing adhesions usually subside after keeping a mop on the site.

Vascular adhesions need *bipolar cautery* to prevent bleeding. *Harmonic scalpel* can be used to release vascular adhesions. Monopolar cautery *should be avoided* as much as possible as bowel injury is likely to occur.

Release of omentum often needs ligature and division or harmonic scalpel. Adherent omentum pulls transverse colon along with it; colon will be often very close to crumpled adherent omentum; during dissection care should be taken not to injure colon inadvertently.

Adhesions very close to mesenteric vessels often will be thick and release should be careful to avoid injury to vessels.

Adhesions especially after hysterectomy and pelvic surgery will be mainly in the pelvis; such adhesions commonly involve terminal ileum and omentum. These adhesions are often stiff and difficult to release as they are deep in pelvis. Finger dissection may be helpful but has to be done with care. Undue traction to the bowel causes tear in the bowel.

Always adhesion release should begin from *easier area to difficult area*. Once all easier area is released, difficult area becomes easier to release.

Mesenteric peritoneal tear often occurs while releasing the bowel; placing a mop on the mesentery usually controls any ooze if occurs; definitive bleeding needs bipolar cautery fulguration or transfixation stitch using 3 zero silk or vicryl.

Entire small bowel from suspensory ligament of Treitz (duodenojejunal junction) to ileocaecal junction should be released.

Any small *serosal tear* is sutured using vicryl or silk seromuscular Lembert suture to invaginate the raw area. Lengthier tear should be sutured transversely using Lembert suture. Perforated bowel segment should be closed using interrupted 2 zero silk sutures. If certain part of the released bowel wall looks nonviable and dusky it should be resected and anastomosed without any doubt or debate. If bowel wall is oedematous and friable and difficult to undertake the resection and anastomosis then loop or end ileostomy is done; closure of ileostomy is done at a later stage after 3-6 months.

On table *Doppler evaluation* should be done if there is doubt about the viability of the bowel.

Some adhesive parts if it looks like to form adhesions again, such part can be *diverted* by doing enteroenterostomy or ileotransverse anastomosis. But it creates a blind pouch and may cause blind loop syndrome.

On table intestinal decompression is often needed if bowel is distended enormously. *Baker intestinal tube* (270 cm long with a 5 mL balloon) is passed by nasogastric route by anaesthetist or by operating surgeon through a gastrotomy incision creating a Stamm gastrostomy. Tube is gently negotiated across the pylorus into the duodenum gently and balloon is inflated partially to negotiate it into the entire length of small intestine by slow milking into the caecum across the ileocaecal valve. Balloon is fully inflated with 5 mL of saline. Suctioning of the tube should be done while negotiating it through the small bowel to decompress it. It can be kept for 3 weeks to create a *stitchless plication*

of the small bowel. Tube is adjusted to make bowel as multiple 'S'. Tube is removed after 3 weeks. While removing it should be deflated completely otherwise it will create reverse intussusception of the small bowel **(Fig. 21-43)**.

Laparoscopic Method

Laparoscopy is better than open method. However, if bowel resection is needed open method is preferred or conversion has to be done. Camera port is placed away from previous scar. Usually it is placed in *left Palmar point* (left subcostal point) or right upper abdomen. Open method is ideal for placing first port. Visiport can be used safely. Stomach should be decompressed. Nasogastric tube and urinary catheter should be passed. Once main port is passed remaining ports (5 mm) are placed depending on the location of adhesions. One on each side and additional 5 mm on left side may be needed. First abdominal wall adhesions are released using scissor and bipolar cautery keeping scissor very close to abdominal wall. 30 degree telescope is ideal for this purpose. After releasing all abdominal wall adhesions bowel loop adhesions which are bands are released. Initially easier part is released with sharp scissor dissection. Later dense and difficult adhesions are released slowly, carefully and gently with patience. Entire small bowel is dissected off to complete the adhesiolysis. Serosal tear is sutured with intracorporeal Lembert suture using 3 zero vicryl. If perforation occurs it is better to convert into open method; however, if the surgeon is experienced and confident the perforation can be sutured laparoscopically using silk or vicryl by intracorporeal suture. But proper closure should be ensured otherwise peritonitis due to leak will occur **(Fig. 21-44)**.

Fig. 21-43: Releasing adhesions through open method.

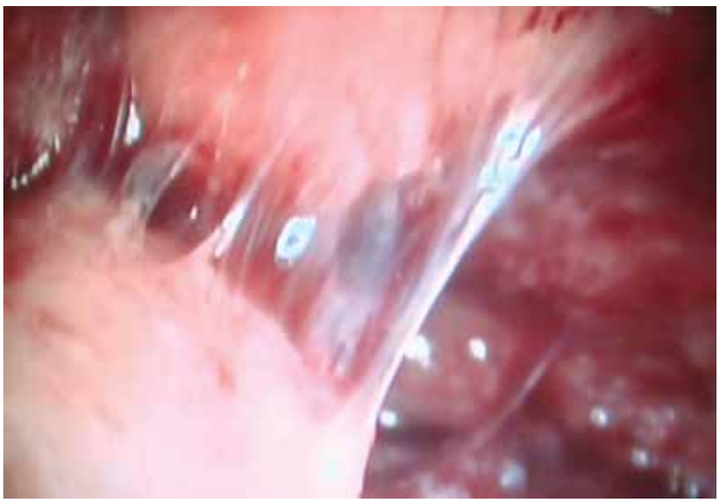


Fig. 21-44: Adhesion seen through laparoscopy.

Problems and Complications

Serosal tear may be missed or overlooked and may leak at a later period causing peritonitis. Recurrent obstruction after adhesiolysis is 15%. Many patients undergo repeated laparoscopic or open surgeries to relieve the obstruction. Slow recovery, prolonged ileus requiring many days nasogastric tube placement, long time intravenous fluids and lengthy hospitalisation are the problems.

Prevention of Adhesions

Prevention is done by instilling drugs like hyaluronidase, steroids, dextrans, dextrins, polyvinyls, silicone, fibrinolysins, chondroitins, streptomycins; gentle handling of the bowel; prevention of spillage of contents like bile, faeces; ideal peritoneal wash using 8-10 liters of saline before closing the abdomen; careful placing of the drains; *Laparoscopic procedures has got lesser chance of adhesions than open method.*

STRICTUROPLASTY

It is commonly done for ileal stricture. Common cause is Crohn's disease. Strictures may be multiple in Crohn's disease. Even after resection disease or stricture may recur. Hence often, instead of resection stricturoplasty is done in these patients. It is useful in recurrence of stricture after previous resection of more than 100 cm; short fibrotic stricture.

Perforation, fistula due to Crohn's disease, haemorrhage are contraindications for stricturoplasty.

Types

Heineke Mikulicz stricturoplasty is similar to Heineke Mikulicz pyloroplasty, used in strictures less than 8 cm (short segment). It is longitudinal incision of stricture segment for its full thickness and transverse closure as a single layer with interrupted silk suture. Stricture is incised longitudinally 2 cm beyond the stricture on to the normal bowel on either side.

Finney's stricturoplasty is done for longer segment stricture. It is similar to Finney's pyloroplasty. Adjacent strictured bowel loops are brought together; U incision is made on the antimesenteric border

of the bowel segments; anastomosis is done as in pyloroplasty with posterior seromuscular interrupted silk sutures, posterior all layer continuous or interrupted vicryl sutures, anterior all layer continuous or interrupted sutures and anterior seromuscular interrupted silk sutures **(Figs 21-45 and 21-46)**.

Problems and Complications

Recurrence, failure, re-obstruction at same segment, leak and peritonitis due to anastomotic dehiscence as anastomosis is on a scarred segment.

JEJUNOSTOMY

Jejunostomy for enteral nutrition is becoming more popular because of its comfort, easy to do, can be kept for long time, lesser complication than gastrostomy. *Indications* are same as gastrostomy.

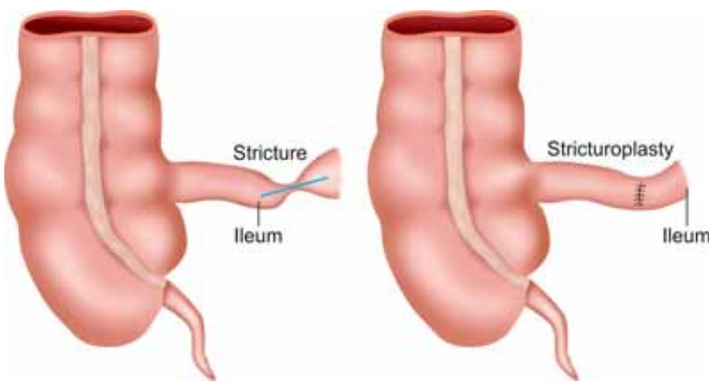


Fig. 21-45: Heineke Mikulicz stricturoplasty.

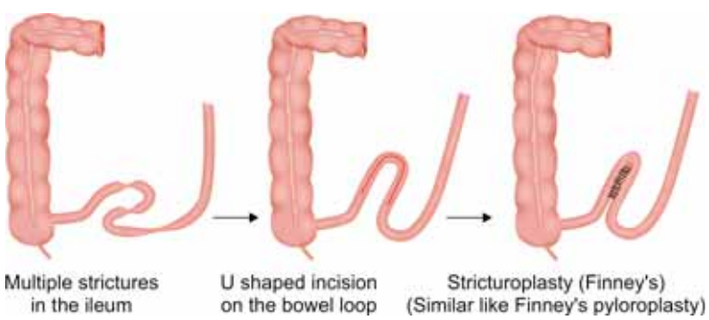

Multiple strictures in the ileum
U shaped incision on the bowel loop
Stricturoplasty (Finney's) (Similar like Finney's pyloroplasty)

Fig. 21-46: Finney's stricturoplasty.

Types

Witzel jejunostomy: Site of placing jejunostomy is 20 cm from duodenojejunal junction. It is usually done after major abdominal surgeries. After finishing procedures like pancreatic surgery, a stab incision is made on the left side of the abdomen at the level or above the umbilicus. Catheter tip is passed from outside across the abdominal stab wound using a long artery forceps. Loop of jejunum 20-30 cm from the duodenojejunal junction is selected and held with Babcock's forceps. A small incision is made on the antimesenteric border of the selected jejunum of 5 mm in size; entire thickness of the bowel is opened using cautery; jejunostomy catheter (Foley's catheter 16 F or 18 F or feeding tube or nasogastric tube) is passed into the jejunum for adequate length beyond next loop. A purse string seromuscular suture using vicryl is placed around it and tightened securely around the catheter. A seromuscular tunnel of 5 cm length is created around the tube using 3 zero silk interrupted sutures. Serosa at proximal part of the tunnel may be fixed to parietal peritoneum at the abdominal wall. Tube outside is fixed to the skin **(Fig. 21-47)**.

Problems are: tube dislodgement, jejunal obstruction, intestinal juice leak, torsion of the bowel loop, catheter block, leak into the peritoneal cavity, diarrhoea, abdominal discomfort, abscess formation, metabolic problems. Problems may be mechanical, metabolic, gastrointestinal and infectious.

Jejunostomy can be done using gastroduodenoscopy (gastroscopy) similar like PEG. Gastroscopy is passed across the duodenum to jejunum; under visualization and guidance percutaneous needle is punctured into the jejunum and fine catheter through the needle is passed which is held using endoscopic snare and pulled out; jejunostomy catheter is tied.

Laparoscopic jejunostomy is done similar to needle jejunostomy under laparoscopic vision.

Needle catheter jejunostomy using catheter of small gauge can be done. Here percutaneous needle is passed across the abdominal wall into the abdominal cavity which is then inserted into the jejunum 20 cm from duodenojejunal junction. Fine catheter is passed through it; needle is removed. Purse string suture is placed. Jejunum is fixed to abdominal wall to prevent torsion. Tube is fixed to skin **(Fig. 21-48)**.

SMALL BOWEL PERFORATION

Perforation of small bowel can occur by various causes like trauma, typhoid ulcer, enteritis, roundworm infestation, bands causing initial

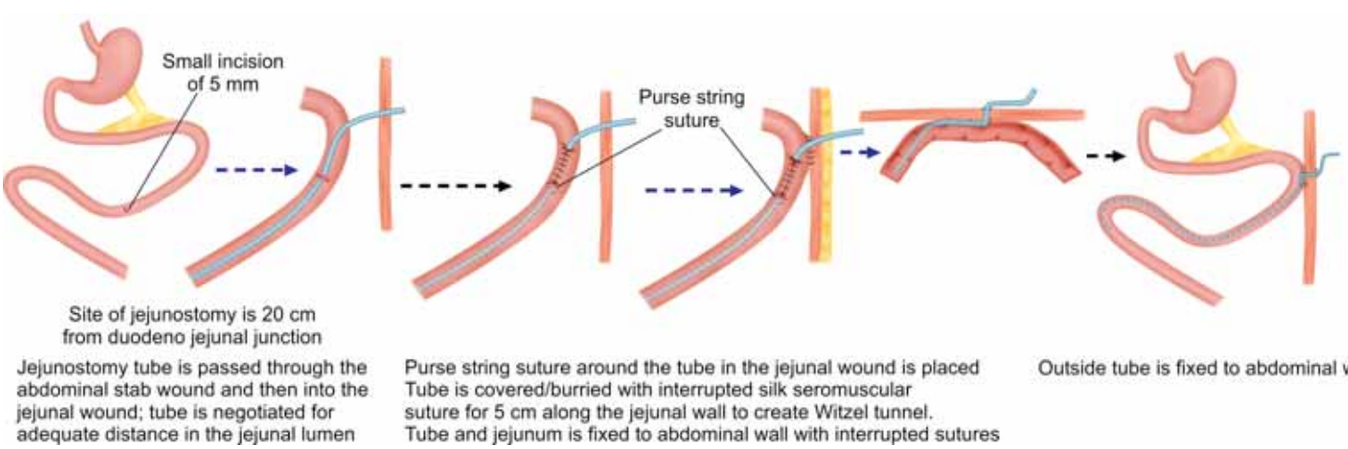

Small incision of 5 mm
Purse string suture
Site of jejunostomy is 20 cm from duodeno jejunal junction
Jejunostomy tube is passed through the abdominal stab wound and then into the jejunal wound; tube is negotiated for adequate distance in the jejunal lumen
Purse string suture around the tube in the jejunal wound is placed
Tube is covered/burried with interrupted silk seromuscular suture for 5 cm along the jejunal wall to create Witzel tunnel.
Tube and jejunum is fixed to abdominal wall with interrupted sutures
Outside tube is fixed to abdominal wall

Fig. 21-47: Witzel jejunostomy.

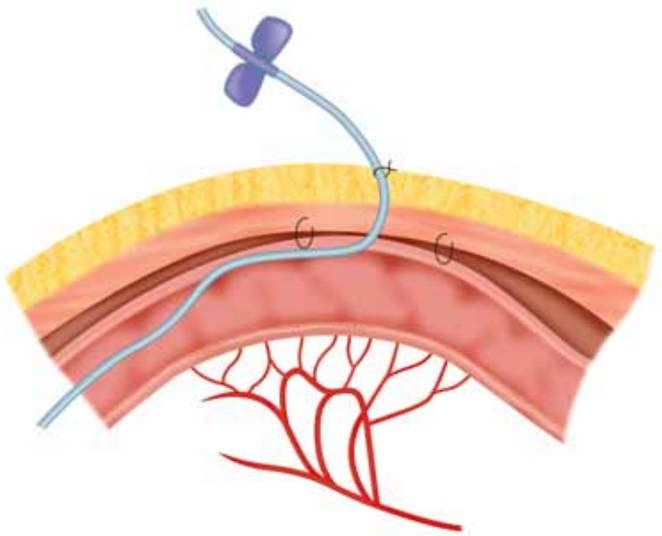


Fig. 21-48: Needle catheter jejunostomy.

obstruction and later perforation. Patients present with features of peritonitis. Typhoid perforation which occurs on day 3rd after the infection, are usually multiple, along the antimesenteric border on the Peyer's patch. Guarding, rigidity which are definitive features of perforation may not be present in typhoid perforation. Traumatic perforation may be due to stab injury or blunt injury. Blunt injury causes traction at duodenojejunal junction leading to disruption of the bowel on the first loop of the jejunum; often it may be in ileocaecal region also for the same reason. Occasionally specific diseases like Crohn's or tuberculosis or malignancy or lymphoma of bowel can cause perforation **(Fig. 21-49)**.

Perforations should be treated surgically. After laparotomy entire small bowel should be inspected. Peritoneal cavity contains pus and intestinal juice. Pus should be collected for culture and sensitivity. Site should be held with Babcock's forceps. Peritoneal infected fluid is sucked out. Perforation edge is trimmed off. Perforation is closed transversely using interrupted 2 or 3 zero silk sutures. Often biopsy from the edge of the perforation should be taken especially when perforation at ileal site. Seromuscular Lembert interrupted suture may be placed; but it is often difficult in a friable oedematous bowel. Any mesenteric tear if present should be sutured. In multiple perforations resection of the ileum is necessary. If patient's general condition is not good and bowel is friable then loop ileostomy is preferred. Often after resection distal end may be closed and fixed at definitive point in the abdominal wall; and proximal part is brought out as end ileostomy. Ileostomy closure is done in 3-6 months.

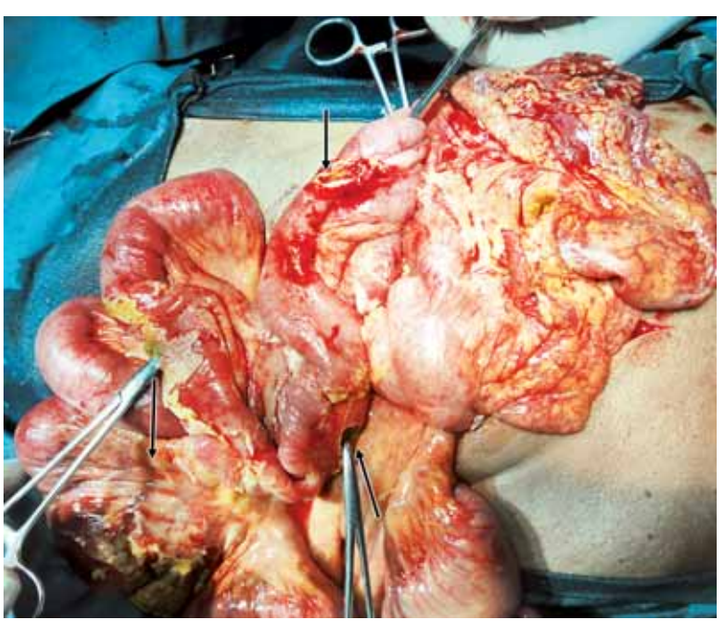


Fig. 21-49: Multiple perforations in the ileum; could be due to typhoid.

Adequate peritoneal wash using *warm normal saline* is needed. Tube drain is put. Abdomen is closed as single layer. Smead Jones suture may be needed to avoid burst abdomen **(Figs 21-50 and 21-53)**.

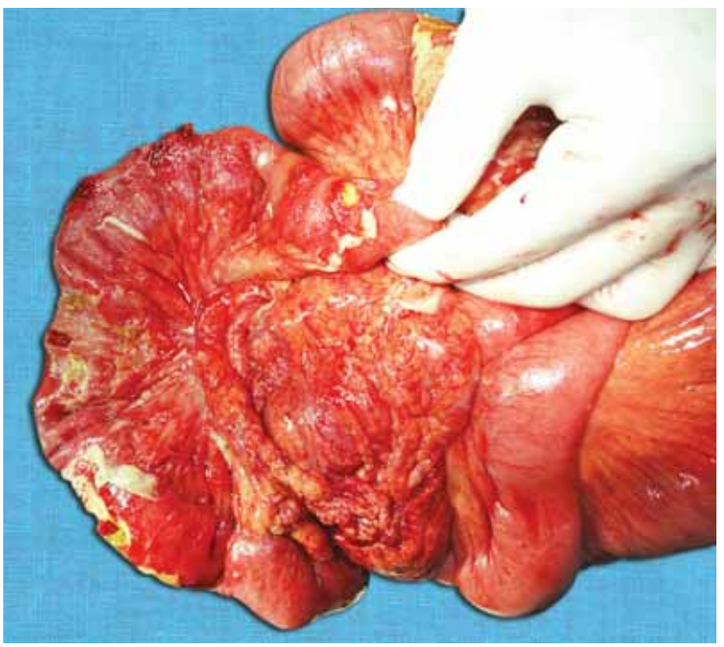


Fig. 21-50: When bowel is viable in multiple perforations, it is nor resected but individual perforations are closed.

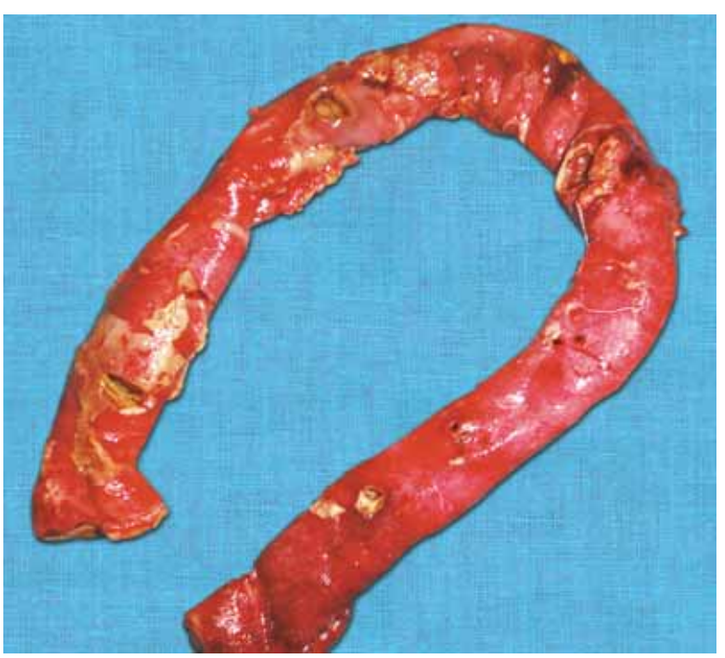


Fig. 21-51: When multiple perforations are present and bowel is ischaemic and nonviable, resection is done. Either primary anastomosis is done; or ileostomy is done (better when there is severe sepsis); or primary anastomosis with proximal diversion ileostomy may be done.

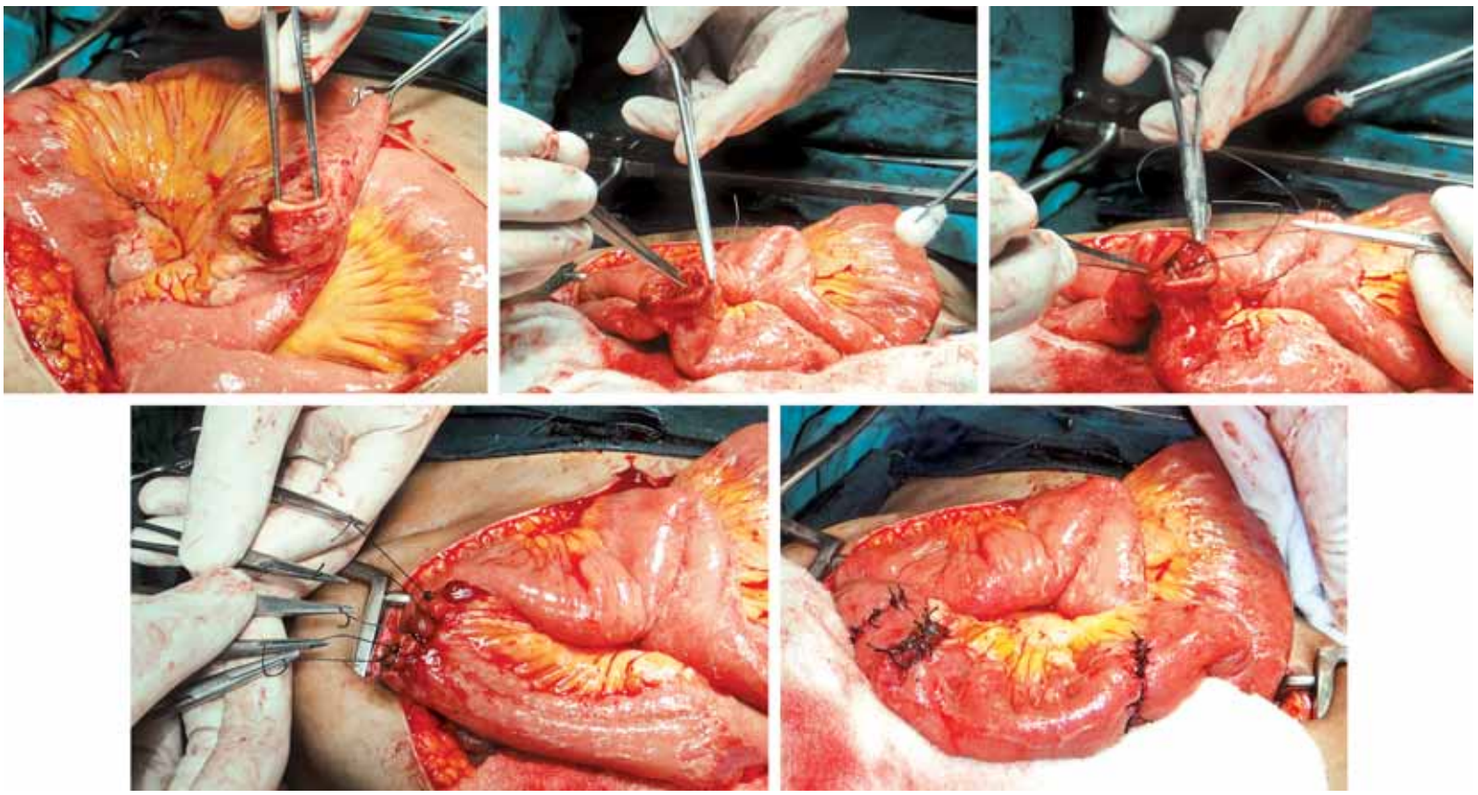
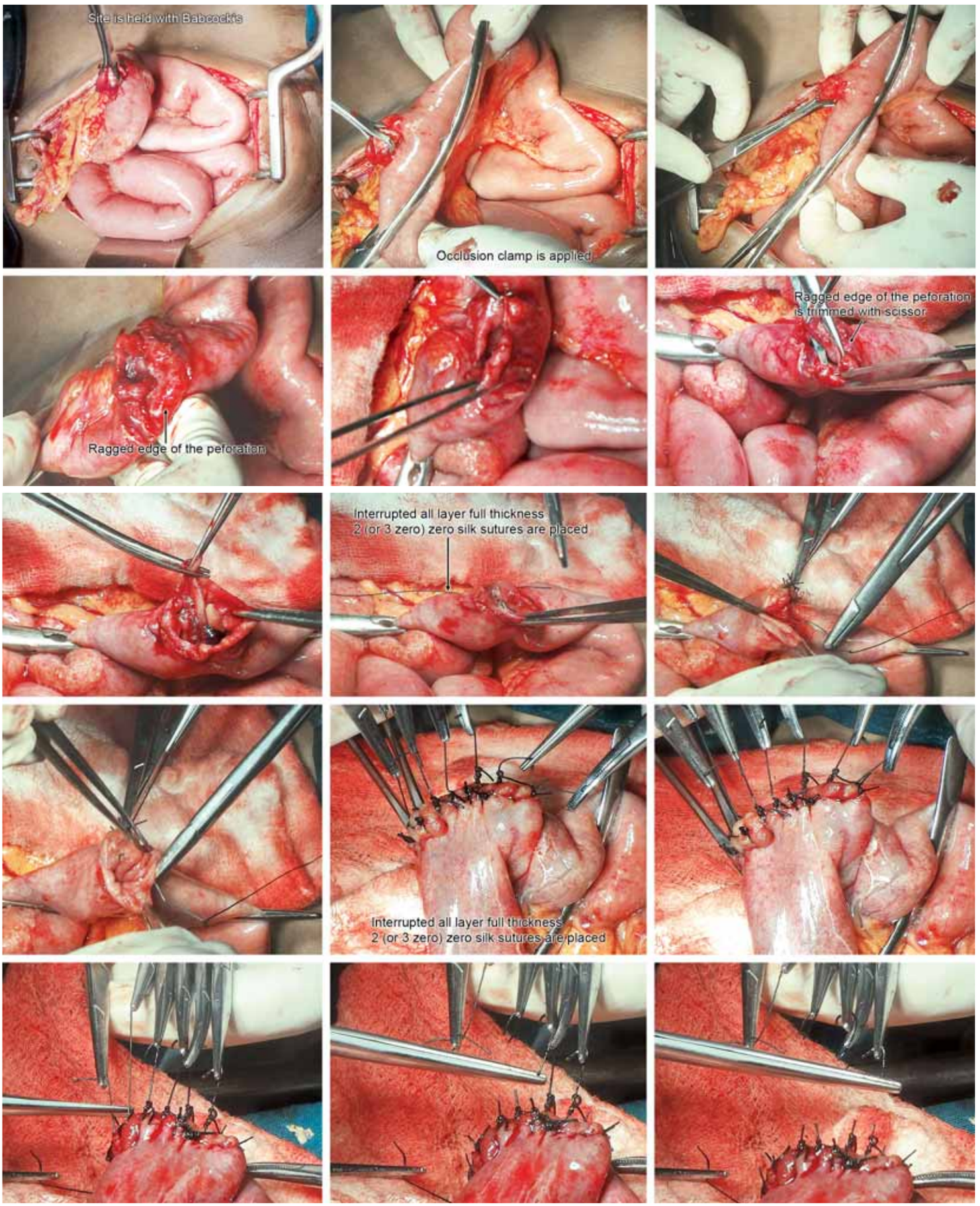
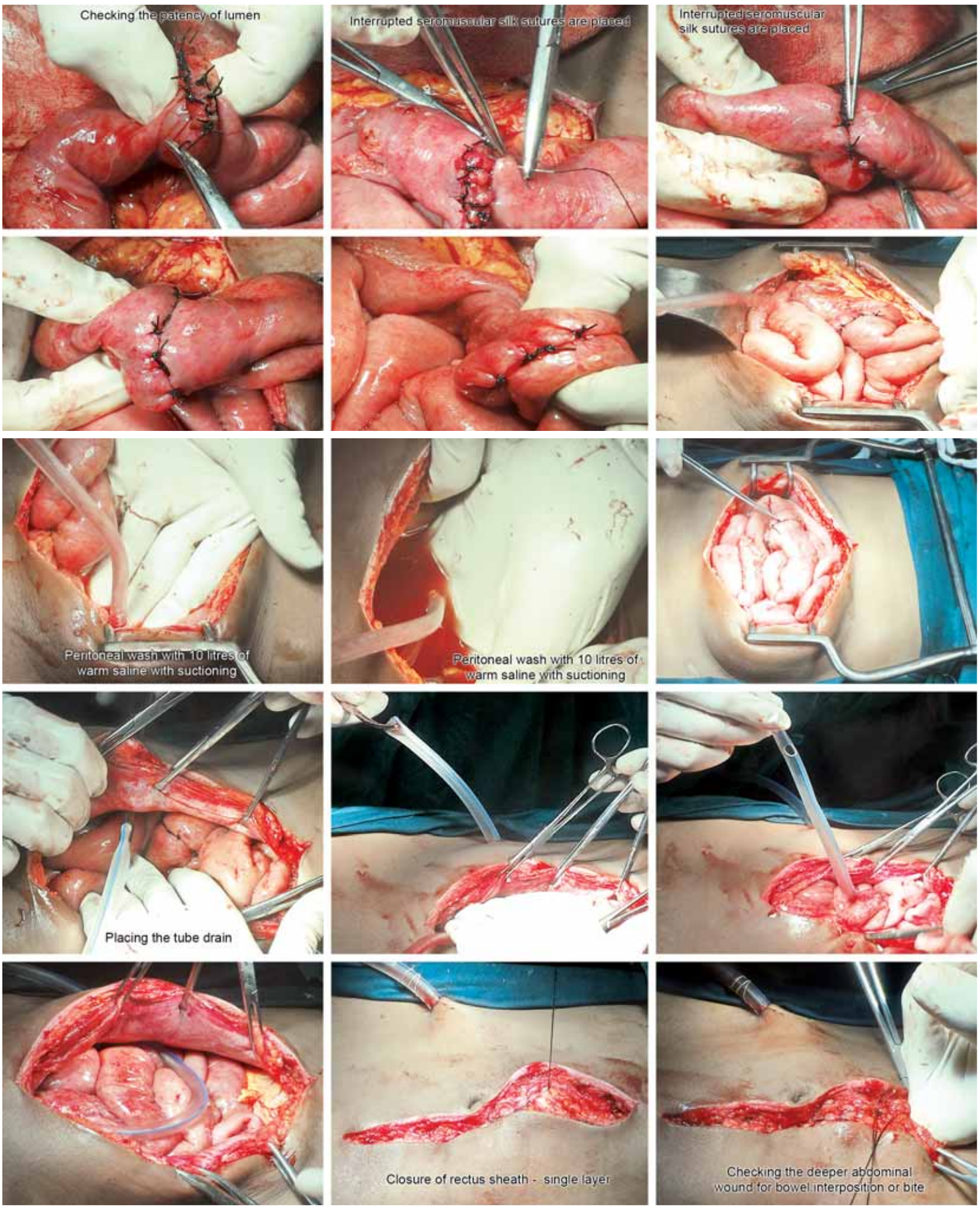


Fig. 21-52: Closure of ileal perforation.

Figs 21-53(1)


Site is held with Babcock's
Occlusion clamp is applied
Ragged edge of the peforation
Ragged edge of the peforation is trimmed with scissor
Interrupted all layer full thickness 2 (or 3 zero) zero silk sutures are placed
Interrupted all layer full thickness 2 (or 3 zero) zero silk sutures are placed

Figs 21-53(2)


Checking the patency of lumen
Interrupted seromuscular silk sutures are placed
Interrupted seromuscular silk sutures are placed
Peritoneal wash with 10 litres of warm saline with suctioning
Peritoneal wash with 10 litres of warm saline with suctioning
Placing the tube drain
Closure of rectus sheath - single layer
Checking the deeper abdominal wound for bowel interposition or bite

Figs 21-53(3)

Figs 21-53(4)

Figs 21-53(1 to 4): Traumatic perforation of the small bowel due to blunt injury abdomen; London's sign with echymotic patch in the abdomen; X-ray showing gas under diaphragm; closure of perforation as shown.

Post-operative Care

Antibiotics, intravenous fluids, TPN, central line – CVP, urinary output measurement, monitoring and ICU care is needed. Nasogastric tube is kept in place. Prevention of DVT using low molecular heparin is better. Drain is removed in 5 days as well as nasogastric tube once bowel sounds appear. Observation for complications is very important.

Problems and Complications

Septicaemia, ARDS, DVT, DIC, acute renal failure, subphrenic abscess, pelvic or interloop abscess formation. Reperforation and peritonitis is a real threat. Burst abdomen, enterocutaneous fistula, are again a problem. Wound infection can occur.

INTESTINAL BYPASS PROCEDURE

Diverting a loop which is nonfunctioning or creating problem may be required as a surgical technique so as to relieve the obstruction or complication like leak. It is done in severe localized adhesions, malignancy, trauma, tuberculosis or Crohn's disease. However, formation of blind loop and its consequences like malabsorption, recurrent infection in blind loop are the problems and setback to this procedure. Small bowel bypass, ileo transverse anastomosis, ileo-sigmoid anastomosis are few bypass procedures usually advocated in selected patients. All these procedures are done as side to side anastomosis. It can be done as two layer anastomosis hand sewn or through stapler. In two layer anastomosis both layers are done as interrupted sutures using silk or inner vicryl and outer silk. While doing ileo transverse anastomosis transverse colon is opened longitudinally along its taenia **(Figs 21-54 and 21-55)**.

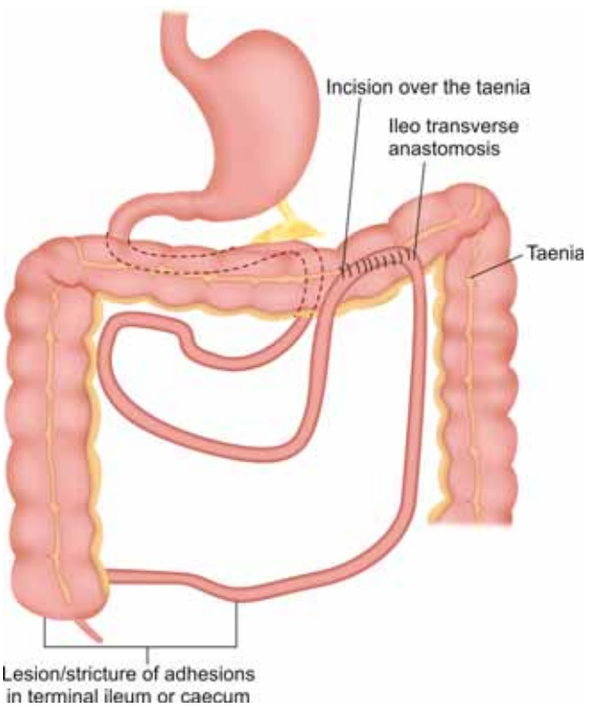

Incision over the taenia
Ileo transverse anastomosis
Taenia
Lesion/stricture of adhesions in terminal ileum or caecum

Fig. 21-54: Ileo transverse anastomosis.

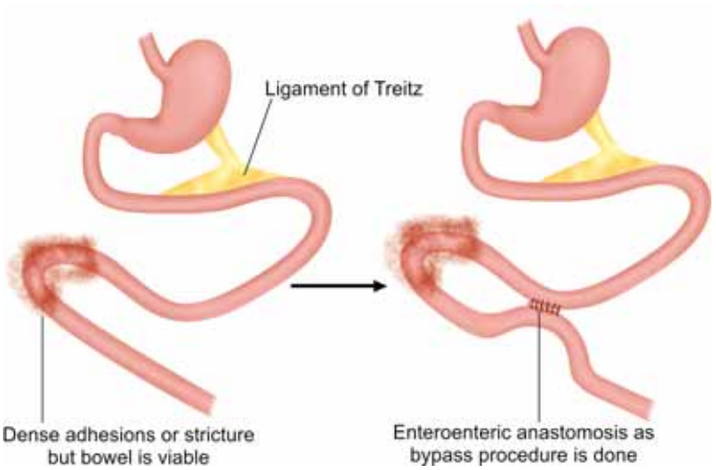

Ligament of Treitz
Dense adhesions or stricture but bowel is viable
Enteroenteric anastomosis as bypass procedure is done

Fig. 21-55: Small bowel bypass.

ILEOSTOMY

There two types of ileostomy—end and loop. Usually end ileostomy is done as a permanent one after total proctocolectomy if ileal pouch to anal canal is not contemplated. Occasionally temporary end ileostomy is done; in such situation distal segment is closed and kept in right iliac fossa with a fixation stitch to abdominal wall. Temporary end ileostomy may be indicated in Crohn's disease, complex fistulas, ileocaecal trauma. While creating urinary diversion as ileal conduit ileostomy is needed.

Loop ileostomy is always temporary for diversion of small bowel content in any terminal ileal disease or proximal colonic disease.

Principles in Ileostomy

Stoma site should be marked in individual patient prior to surgery. It should be clearly discussed with patient. Stoma therapist and rehabilitation and counselling should be done.

Stoma site is right iliac fossa with infraumbilical mould of fat as summit. Incision should be marked at the surface on the rectus abdominis muscle. Stoma site should be away from scars, umbilicus, bony points, burn injury etc.

Stoma is marked as round line using a faceplate placed in proposed site.

Muscle should only be split not cut.

Creation of *spout* is important.

Types (Fig. 21-56)

End
Loop
Loop end

End Ileostomy

It is usually done after total proctocolectomy in ulcerative colitis, familial adenomatous polyp (here ileal pouch is contraindicated), multiple synchronous carcinomas, occasionally as temporary end ileostomy in Crohn's disease, ileocaecal trauma, right colonic obstruction.

Terminal ileum is brought out as ileostomy. Terminal ileum is mobilised from its mesentery keeping its arcade and blood supply intact. Terminal ileum is very important for absorption and so one should avoid unnecessary excision of terminal ileum.

Stoma site is in the right iliac fossa over the outer half of the right rectus extending downwards for 2 cm. *Skin is excised* for about a 2 cm circle. Subcutaneous fat is not excised **(Fig. 21-57)**.

Vertical (3-3.5 cm) or cruciate incision is made in the rectus sheath. Only vertical incision on the rectus sheath is sufficient; it is not mandatory to place the cruciate incision. With haemostat and finger dissection peritoneum is reached which is opened to enter the peritoneal cavity. Muscle should be *only split,* never cut. Through laparotomy wound a mop is firmly kept and pressed over the rectus muscle to prevent muscle getting slipped while splitting the rectus muscle. Vertical incision is made in the posterior rectus sheath and peritoneum. Peritoneal opening should be of *two finger size (index and middle)* snugly fitting; it should not be more as it will cause parastomal hernia. As laparotomy wound already exists through which access can be made easily. Injury to inferior epigastric vessels should be avoided. Terminal ileum is transected 2 cm from the ileocaecal valve in case if ileal pouch is being planned later; maximum up to 10 cm of terminal ileum can be removed but not beyond that in any type of ileostomy. *Stapler division* of the ileum is done to prevent the contamination. Stoma is fashioned by retaining the arcade; proximal to arcade few vessels are ligated. Incised rectus sheath is retracted. Babcock's forceps is passed across the ileostomy wound into the peritoneal cavity and cut end of the ileum is held and gently pulled out through the wound *for 6 cm* **(Fig. 21-58)**.

Mesentery may be fixed to the lateral abdominal wall using interrupted 2 zero vicryl sutures. *Seromuscular interrupted stitches* are placed between the ileum and peritoneum as stabilization stitch. It is not done in case of Crohn's disease as fistula may form. This suture is placed through laparotomy wound from inside by everting the cut edge of laparotomy wound. Laparotomy wound is closed. Stapler line

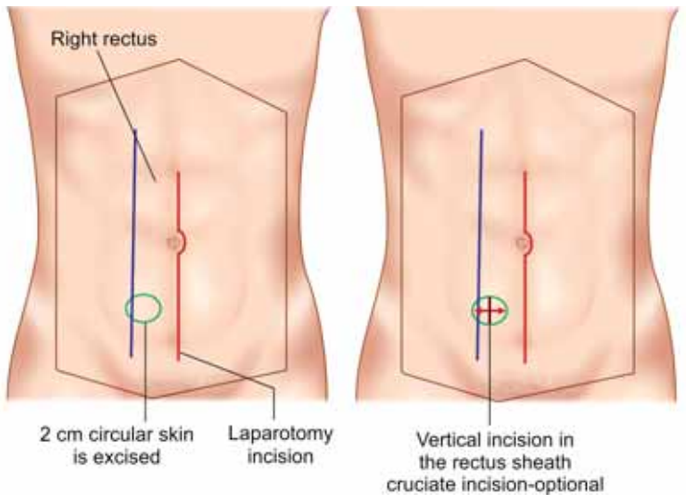

Right rectus
2 cm circular skin is excised
Laparotomy incision
Vertical incision in the rectus sheath cruciate incision-optional

Fig. 21-57: Incision site for ileostomy.

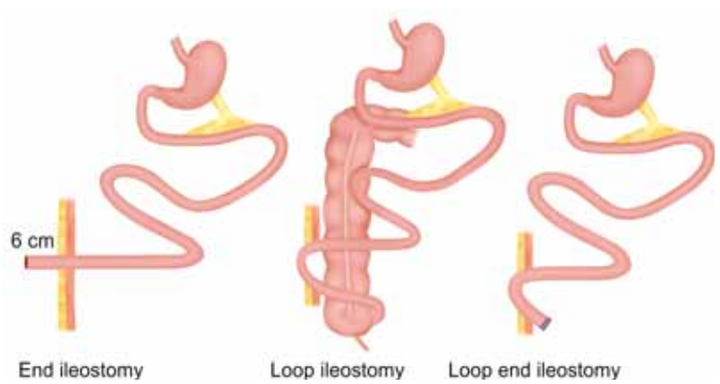


Fig. 21-56: Ileostomy types—end, loop, loop end.

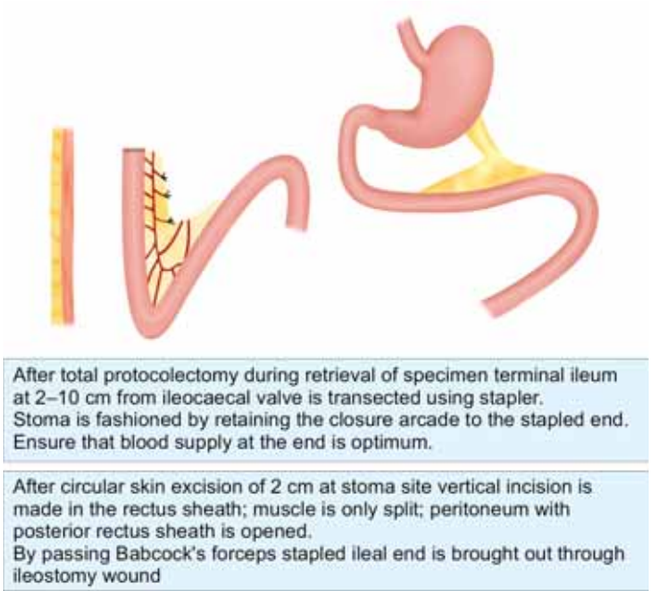

After total protocolectomy during retrieval of specimen terminal ileum at 2–10 cm from ileocaecal valve is transected using stapler.
Stoma is fashioned by retaining the closure arcade to the stapled end.
Ensure that blood supply at the end is optimum.
After circular skin excision of 2 cm at stoma site vertical incision is made in the rectus sheath; muscle is only split; peritoneum with posterior rectus sheath is opened.
By passing Babcock's forceps stapled ileal end is brought out through ileostomy wound

Fig. 21-58: Ileostomy stoma fashioning.

is excised from the terminal end. Often another seromuscular bite is taken from ileum 1 cm from the ileal cut end and superficial fat layer (Camper); it prevents formation of the *parastomal gully*. Cut edge of the ileum (full thickness all layer interrupted) is apposed to subcuticular part of the skin (not full thickness skin) with initial four points then additional four sutures in between (*maturation*) **(Fig. 21-59)**.

After placing all sutures, knots are tied one by one. In a different method, alternate sutures are placed with an additional seromuscular stitch prior to passing through the skin subcuticular part. Through and through skin is better avoided otherwise there are chances of mucosal island implantation and early separation of stoma appliances.

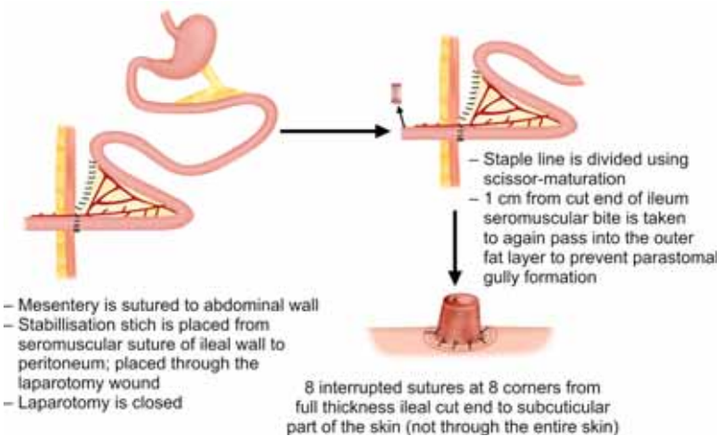
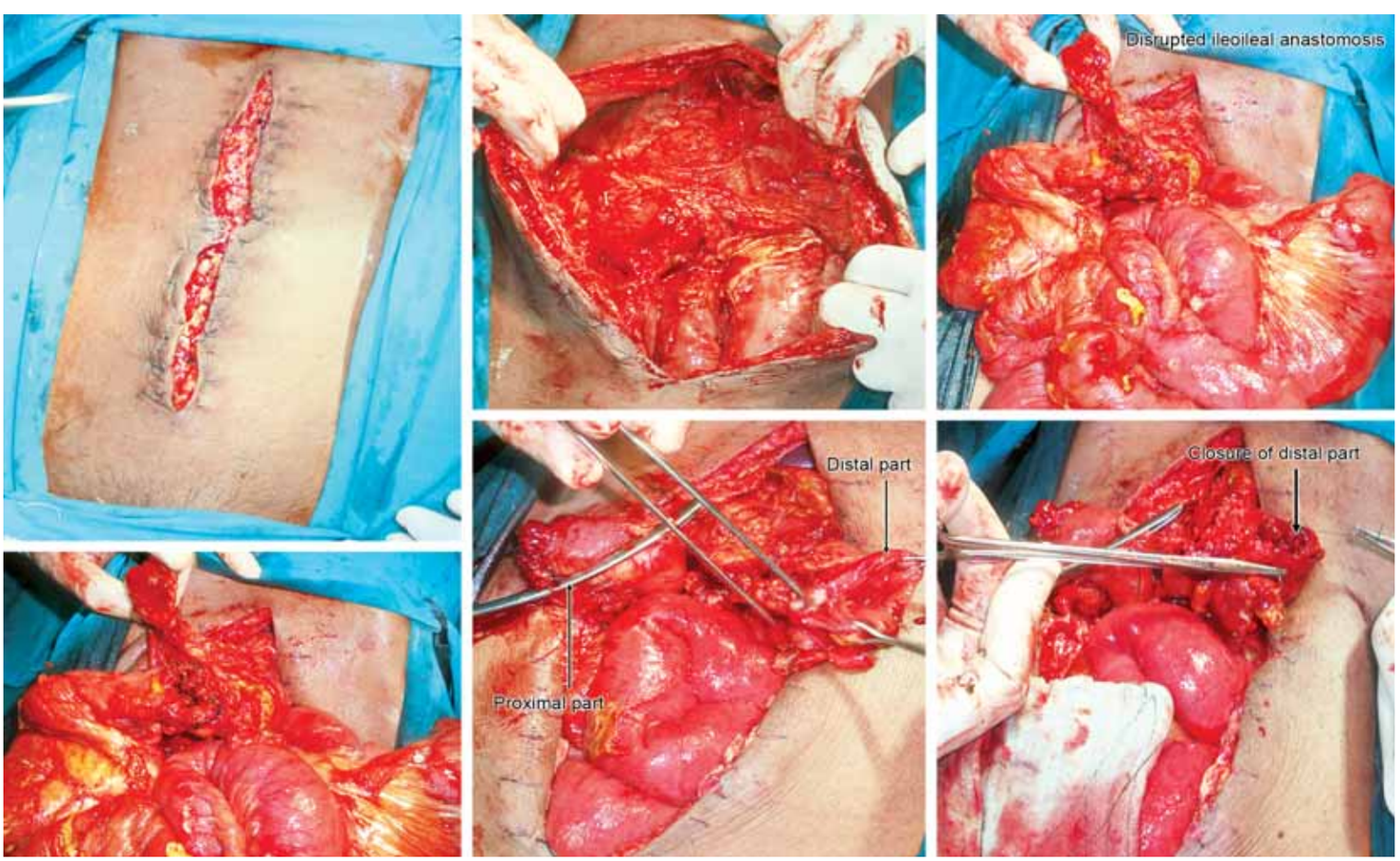

– Staple line is divided using scissor-maturation
– 1 cm from cut end of ileum seromuscular bite is taken to again pass into the outer fat layer to prevent parastomal gully formation
– Mesentery is sutured to abdominal wall
– Stabillisation stich is placed from seromuscular suture of ileal wall to peritoneum; placed through the laparotomy wound
– Laparotomy is closed
8 interrupted sutures at 8 corners from full thickness ileal cut end to subcuticular part of the skin (not through the entire skin)

Fig. 21-59: Maturation of ileostomy.

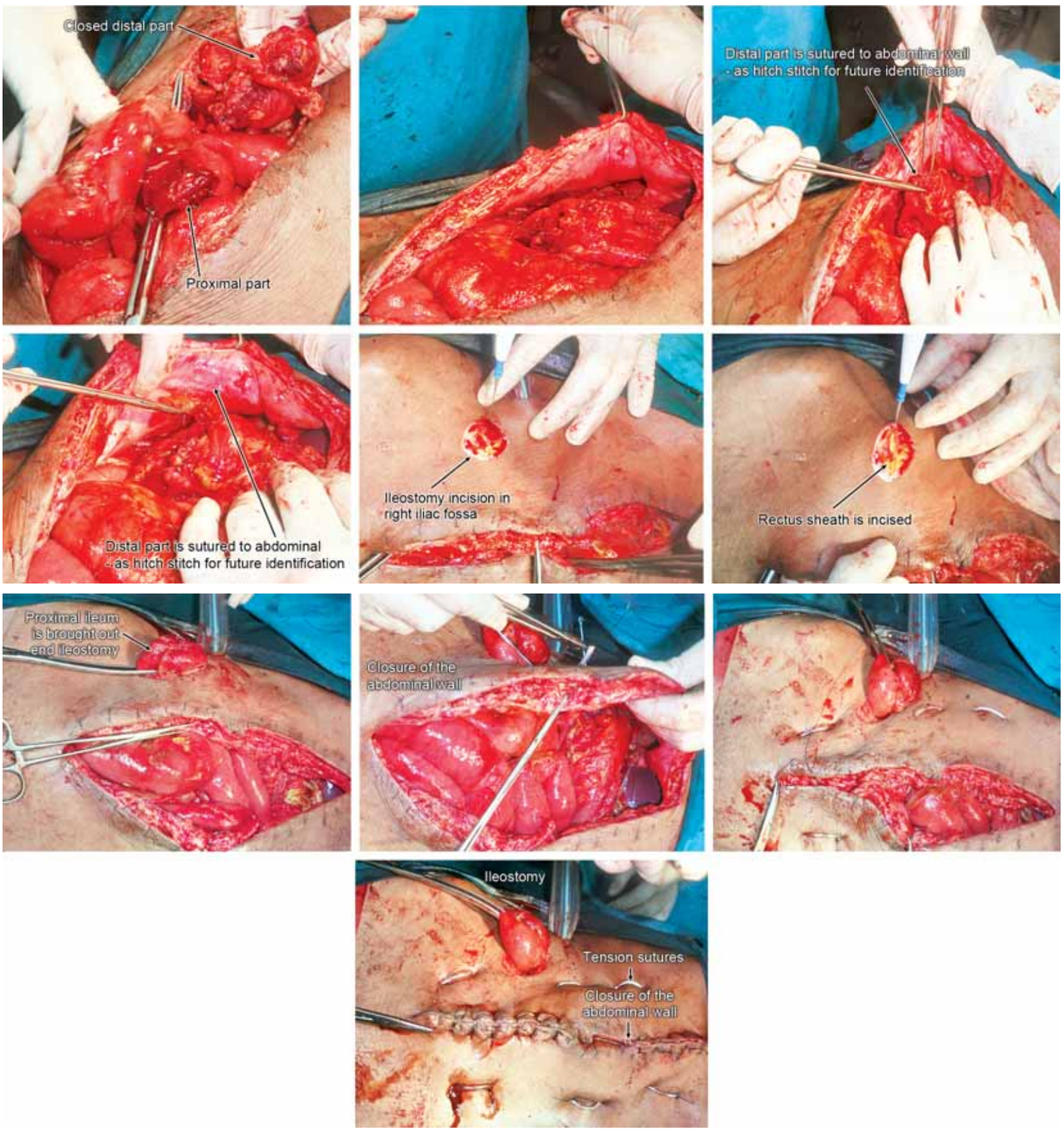
Placement of two myotomies of the stoma before suturing to skin will also prevent the recession of the ileostomy to create needed *spouting*. While taking seromuscular suture, care should be taken not to enter mucosa to avoid stoma fistulas at the edge.

Often *spout is created* in such a way that stoma is made *to face downwards* which is ideal. It is done while placing seromuscular—outer fat suturing where in the proximal part this is taken shorter while in the caudal part it is longer and it is in between at sides. It can also be achieved while taking final bite between subcuticular and cut edge of ileum, additional seromuscular bites are taken at different levels **(Fig. 21-60)**.

Midline laparotomy → definitive procedure (proctocolectomy) → *marking the stoma site* on the right lower rectus → 2.5 cm *circular skin is excised* → fat is *not* removed → *vertical* 3.5 cm or cruciate incision in the *rectus sheath* → rectus muscle is *split* → mop with finger support through the laparotomy wound to prevent slipping of the rectus → posterior rectus sheath and peritoneum is incised vertically for *two finger breadth only* → *stapler transection* of the terminal ileum at 2-10 cm from ileocaecal valve → *stoma fashioning* is done with retaining the arcade → *Babcock's forceps* is passed from outside into the peritoneal cavity across the ileostomy wound → stapled ileum is held → brought out gently for *6 cm exteriorization* → mesentery may be obliterated by suturing it to abdominal wall → through laparotomy wound *stabilization interrupted stitches* are placed between seromuscular ileum and peritoneum all round → laparotomy wound is closed → ileostomy maturation is done by cutting stapled area → seromuscular stitch 1 cm away from the cut end of ileum is sutured to outer fatty layer to avoid parastomal gully by creating concertina effect → full thickness cut edge of the ileum is sutured to subcuticular part of the skin as interrupted sutures (8 sutures).



Figs 21-60(1)


Closed distal part
Proximal part
Distal part is sutured to abdominal wall - as hitch stitch for future identification
Distal part is sutured to abdominal - as hitch stitch for future identification
Ileostomy incision in right iliac fossa
Rectus sheath is incised
Proximal ileum is brought out - end ileostomy
Closure of the abdominal wall
Ileostomy
Tension sutures
Closure of the abdominal wall

Figs 21-60(2)

Figs 21-60(1 and 2): End ileostomy done for critically disrupted earlier closed ileal perforation.

Loop Ileostomy

It is done to create diversion as temporary method. After ileal pouch with pouch anal canal anastomosis, covering diversion loop ileostomy is placed for 3-6 months. It is used in enterocutaneous fistula, ascending colon or caecal sepsis or gangrene, in radiation related severe pelvic problems, in multiple perforations of terminal ileum where severe sepsis prevents from doing primary anastomosis, diversion ileostomy is always better. Mesenteric vessels are not divided here. Loop ileostomy is done 15-20 cm proximally as ileum is not resected and later repositioned once its purpose is served **(Fig. 21-61)**.

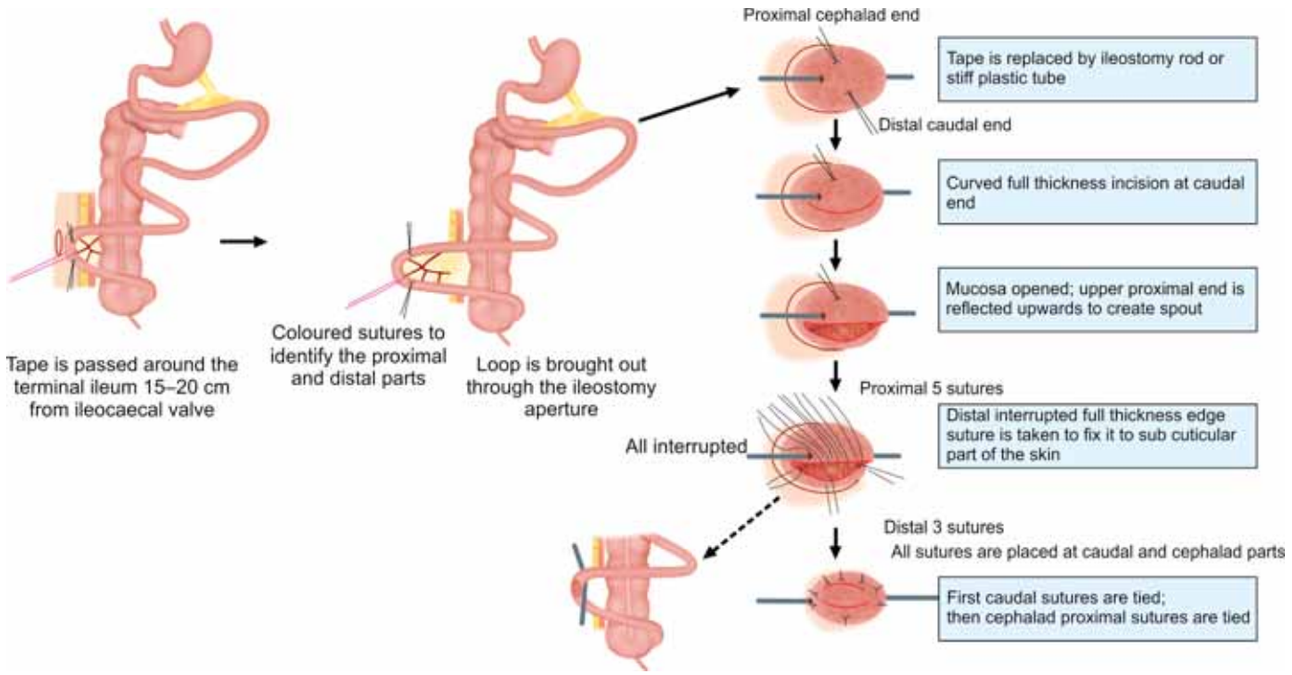

Tape is passed around the terminal ileum 15–20 cm from ileocaecal valve
Coloured sutures to identify the proximal and distal parts
Loop is brought out through the ileostomy aperture
Proximal cephalad end
Tape is replaced by ileostomy rod or stiff plastic tube
Distal caudal end
Curved full thickness incision at caudal end
Mucosa opened; upper proximal end is reflected upwards to create spout
Proximal 5 sutures
All interrupted
Distal interrupted full thickness edge suture is taken to fix it to sub cuticular part of the skin
Distal 3 sutures
All sutures are placed at caudal and cephalad parts
First caudal sutures are tied; then cephalad proximal sutures are tied

Fig. 21-61: Technique of doing loop ileostomy.

Midline laparotomy is done for definitive condition. Once loop ileostomy is planned; stoma site is marked alike in end ileostomy on the right iliac fossa at lower rectus muscle area. Site in the ileum is identified and antimesenteric part is held with a Babcock's forceps. A small window is made in the small bowel mesentery and a tape is passed around it. Proximal and distal parts are tagged with stay stitches of different colours for identification purpose when it is brought out of the ileostomy aperture. Loop is brought out of the ileostomy wound. Rotation or twist or tear in the mesentery should not occur while pulling out. Proximal end is identified and oriented at cephalad direction; distal end is at caudal end. Tape is replaced with ileostomy rod; or stiff plastic tube can be placed. Laparotomy wound is closed. After proper identification of loops coloured stiches can be removed. Incision is made on the distal caudal end transversely using no 15 blade or cautery 0.5 cm from the distal skin margin. Incision extends 5 mm in front of the mesenteric attachment. Scissor is often better to the needed enterotomy. 3 zero vicryl interrupted sutures are placed from full thickness cut edges to the subcuticular part of the skin; caudally 3 sutures are needed; cephalad 5 sutures are needed. Sutures are kept long untied. Once all sutures are placed first caudal sutures are tied; then cephalad sutures are tied. Only proximal functioning part of the loop is everted, not distal non functioning part. *Spouting* is thus created to place a proper stoma appliance.

Complications of Ileostomy

Mucosal sloughing, pseudoobstruction, later cutaneous stenosis (Bishop's collar deformity), high output, electrolyte imbalance, parastomal infection by bacteria, *candida*, ileostomy fistula, paraileostomy ulceration, ileostomy obstruction, ileostomy recession, ileostomy prolapse and hernia. Many of these complications need revision ileostomy.

CLOSURE OF ILEOSTOMY

Closure of ileostomy is done after 3 months not prior to that. In closure of loop ileostomy distal part of the bowel should be assessed by doing colonoscopy and contrast X-ray. Bowel preparation may be needed with clear liquids for 24 hours prior to surgery. Nasogastric tube and urinary catheter is passed.

Under general anaesthesia in supine position after cleaning and draping, a circumferential incision is made close to mucocutaneous junction leaving 2 mm skin margin. Transverse or vertical extension if needed should be done. These extensions will help in proper adequate mobilization of bowel proximally and distally. Bowel wall is held with Allis forceps and traction is given to facilitate the dissection between bowel margin and abdominal wall to enter the peritoneal cavity. Usually sharp dissection using no 15 blade or scissor is used to cut through the planes. Cautery usage should be carefully done only to avoid the bowel injury. Counter traction on skin margin is achieved using retractor. Traction on the bowel edge with countertraction on the abdominal wall is essential to open the planes by sharp dissection. Once abdominal cavity is reached, adhesions are released by finger dissection keeping index finger close to the abdominal wall and with sweeping action. Once mobilized loop is brought out of the wound, proximally on both sides adequate mobilization should be done to avoid tension on the ileostomy closure. Adhesions on the part of the mesentery of that particular loop are also freed carefully without tearing the mesentery. This prevents kinking, angulation and tension on the bowel wall. Mucosal eversion is reversed. Cut edge of the bowel is trimmed to remove attachments of the skin and fat on to it. Adequate bleeding from the trimmed cut edge of the bowel is essential. Bowel wall serosa is also carefully dissected off from fat and adherent tissue. This facilitates the closure of anastomosis. Any tear in the bowel wall should be checked which might have occurred during dissection. It may be confirmed by infusing the normal saline into the

lumen. Edge of the ileum should be cut properly using fine scissor. Defect in the bowel wall is closed transversely using 3 zero vicryl as interrupted sutures. Initially corner stitches are placed which are held up as stay stitches. Next middle stitch is placed to appose the defect. Further other stitches are placed at 3-5 mm gap. Usually full thickness suturing is done; but it is often advisable to place seromuscular sutures including proper bites on submucosa but mucosa is spared. This ensures accurate approximation. Often outer interrupted silk sutures are placed as additional seromuscular but it is not necessary **(Figs 21-62 and 21-63)**.

Bowel kept outside the wound is gently pushed inside without disruption. Drain (peritoneal) is usually not kept; but often is kept in practice by many. Rectus sheath is closed as interrupted single layer. Full thickness bites using nonabsorbable suture material (1 zero) is used. Skin is often kept open instead of primary suturing. Secondary suturing is done once wound granulates well after 3 weeks. Often wound heals by scarring without secondary suturing. Whenever primary skin closure is done using 1 zero polypropylene interrupted sutures, subcutaneous drain should be placed.

In difficult situation, abdominal wound is extended adequately transversely or vertically. Complete mobilization of the ileum and ascending colon is done. Resection and anastomosis is done. Anastomosis is either ileoileal or ileocolic type depending on bowel retained **(Figs 21-64 and 65)**.

Stapler closure of the loop ileostomy can be done. It is usually done as side to side.

Post-operative Care

Oral liquid is started after 48 hours. Low residue diet is used for 8 weeks. Antibiotics, heparin, urinary catheter is kept in place. Nasogastric tube is removed in 48 hours.

Complications

Anastomotic disruption and faecal fistula through the wound is the complication. Usually it settles down with conservative therapy. Occasionally it needs ileostomy again and later period resection and anastomosis.

Wound infection is common which settles with regular dressing and antibiotics.

SEROSAL PATCH TECHNIQUE

It is used in enterocutaneous fistula and intestinal perforations. In 1959 to 1963 Austin Jones and Kobald and Thal started this technique. This is useful in difficult cases. Serosa has got high ability to seal the perforations of any nature recent, chronic or with severe sepsis. But it is not routinely used; it is reserved for cases where nothing else is possible.

It is used when there is difficulty in closing duodenal stump, large perforations; enterocutaneous fistulas where in spite of proper conservative therapy patient is not responding.

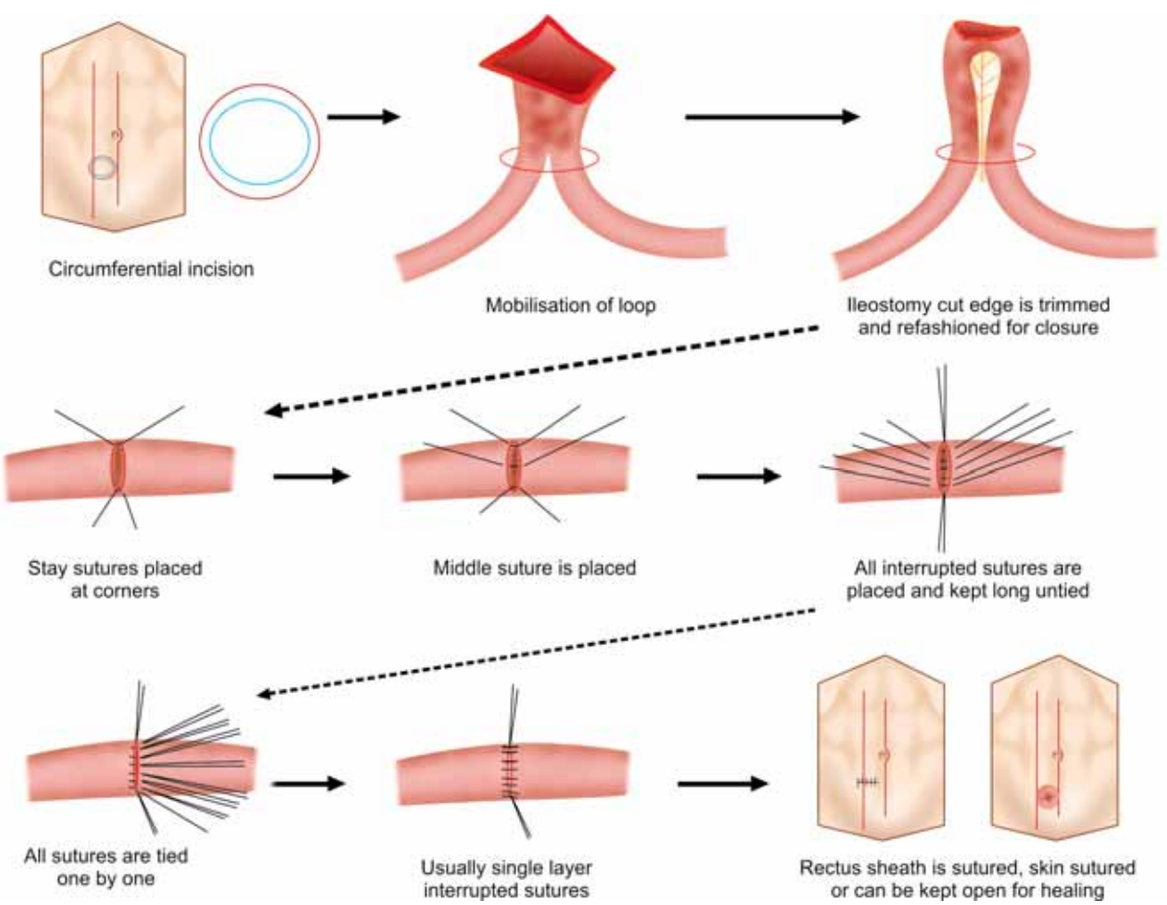
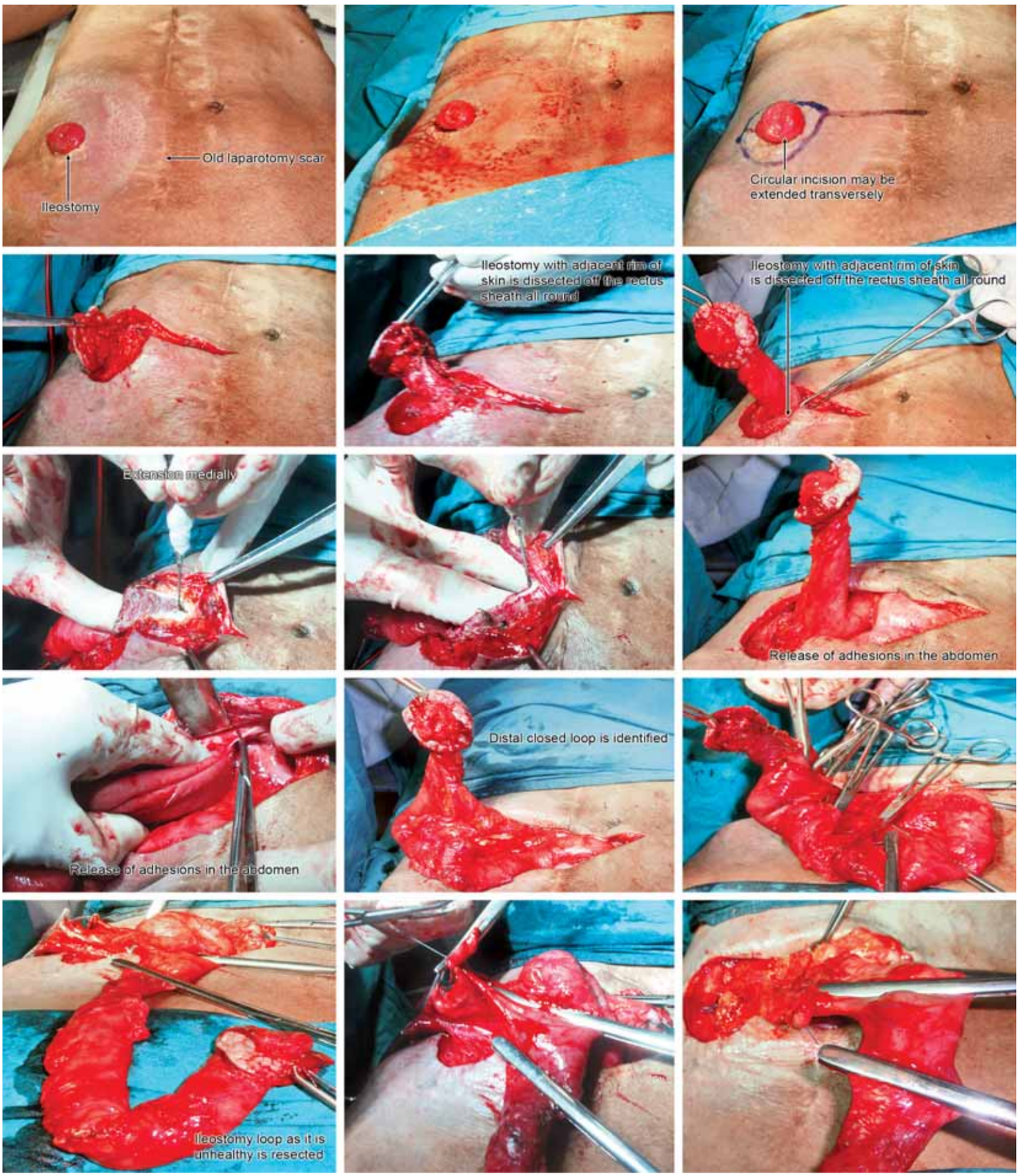
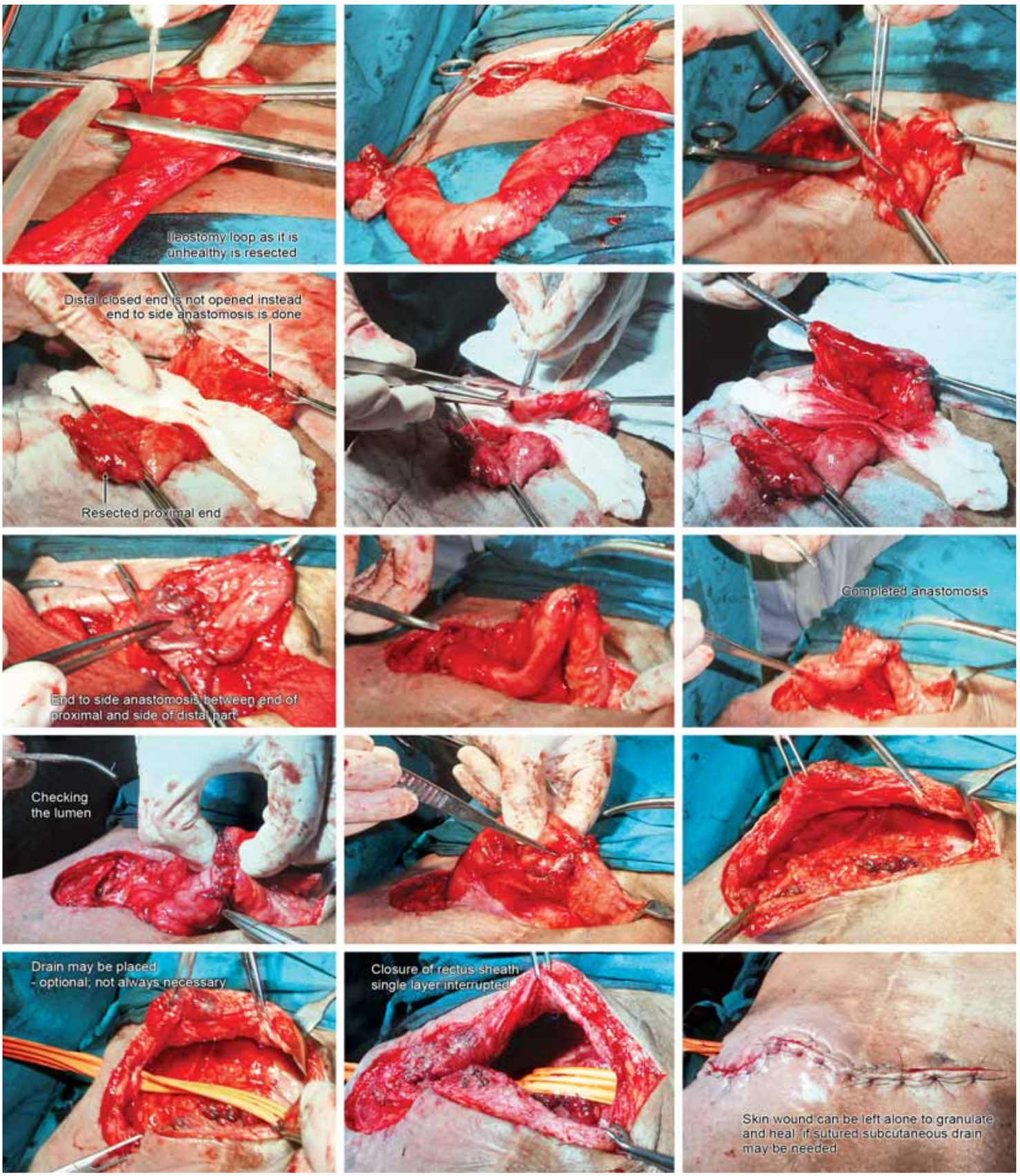

Circumferential incision
Mobilisation of loop
Ileostomy cut edge is trimmed and refashioned for closure
Stay sutures placed at corners
Middle suture is placed
All interrupted sutures are placed and kept long untied
All sutures are tied one by one
Usually single layer interrupted sutures
Rectus sheath is sutured, skin sutured or can be kept open for healing

Fig. 21-62: Technique of ileostomy closure—loop type.


Old laparotomy scar
Ileostomy
Circular incision may be extended transversely
Ileostomy with adjacent rim of skin is dissected off the rectus sheath all round
Ileostomy with adjacent rim of skin is dissected off the rectus sheath all round
Extension medially
Release of adhesions in the abdomen
Release of adhesions in the abdomen
Distal closed loop is identified
Ileostomy loop as it is unhealthy is resected

Figs 21-63(1)


Ileostomy loop as it is unhealthy is resected
Distal closed end is not opened instead end to side anastomosis is done
Resected proximal end
Completed anastomosis
End to side anastomosis between end of proximal and side of distal part
Checking the lumen
Drain may be placed - optional; not always necessary
Closure of rectus sheath single layer interrupted
Skin wound can be left alone to granulate and heal, if sutured subcutaneous drain may be needed

Figs 21-63(2)

Figs 21-63(1 and 2): Closure of the ileostomy.

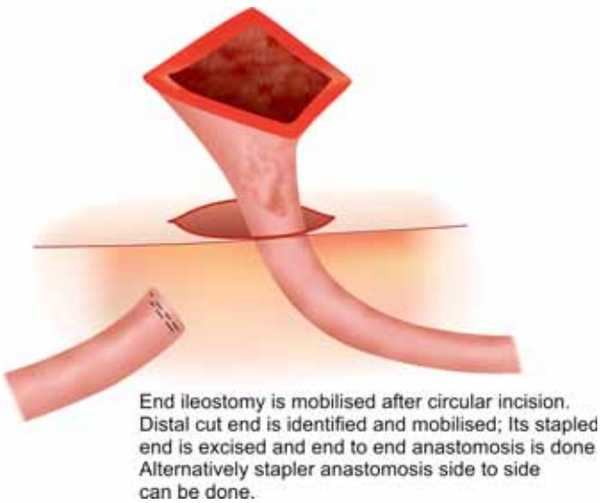

End ileostomy is mobilised after circular incision.
Distal cut end is identified and mobilised; Its stapled end is excised and end to end anastomosis is done
Alternatively stapler anastomosis side to side can be done.

Fig. 21-64: Ileostomy closure—in loop end type.

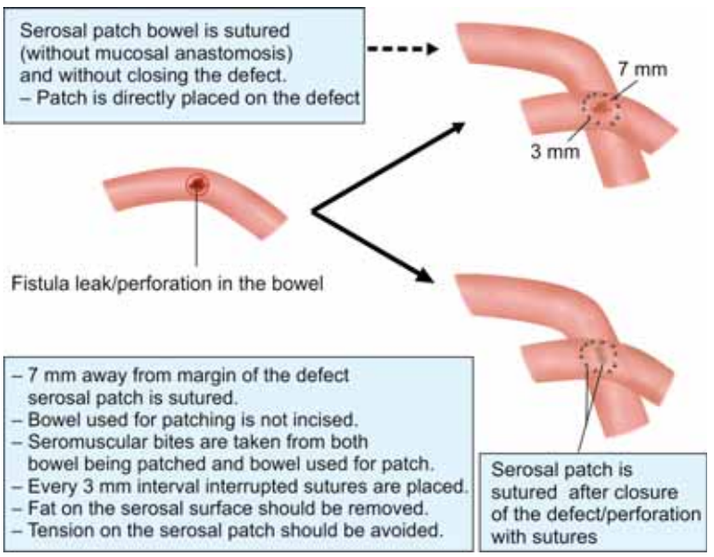

Serosal patch bowel is sutured (without mucosal anastomosis) and without closing the defect.
– Patch is directly placed on the defect
7 mm
3 mm
Fistula leak/perforation in the bowel
– 7 mm away from margin of the defect serosal patch is sutured.
– Bowel used for patching is not incised.
– Seromuscular bites are taken from both bowel being patched and bowel used for patch.
– Every 3 mm interval interrupted sutures are placed.
– Fat on the serosal surface should be removed.
– Tension on the serosal patch should be avoided.
Serosal patch is sutured after closure of the defect/perforation with sutures

Fig. 21-66: Serosal patch technique.

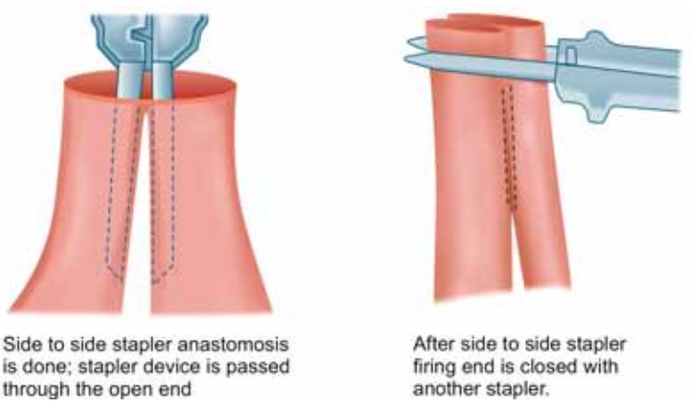

Side to side stapler anastomosis is done; stapler device is passed through the open end
After side to side stapler firing end is closed with another stapler.

Fig. 21-65: Ileostomy closure using stapler.

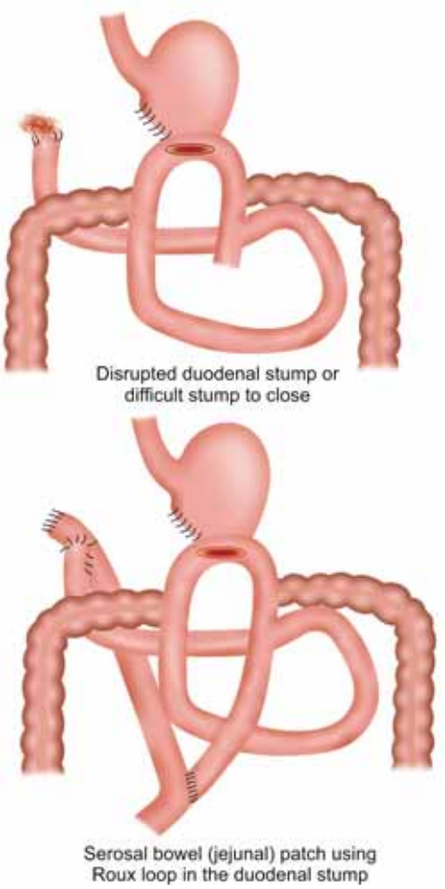

Disrupted duodenal stump or difficult stump to close
Serosal bowel (jejunal) patch using Roux loop in the duodenal stump

Fig. 21-67: Serosal patch technique for duodenal stump problems after Billroth II anastomosis.

It is used in leaking or difficult duodenal stump after Billroth II anastomosis; in duodenal perforation if closure is not possible or pyloroplasty is not possible; in disrupted already done pyloroplasty; in enterocutaneous fistula.

Procedure

Serosa of the small bowel (usually jejunum) is used. Loop (omega) or Roux loop is used. Serosal surface of the bowel is cleared of all fat by gentle dissection. Perforated site is debrided and edge is trimmed. If possible, if there is no tension perforated edge can be sutured; otherwise site is directly kept ready for serosal patch. Serosal patch is sutured 7 mm away from the edge of the defect/perforation. Interrupted seromuscular bites are taken both from the perforated bowel and the intestine which is being used for patching. 3 zero silk is used for suturing. Sutures are placed at 3 mm interval **(Figs 21-66 to 21-68)**.

Problems

It is technically demanding. Recurrence of fistula and disruption may occur.

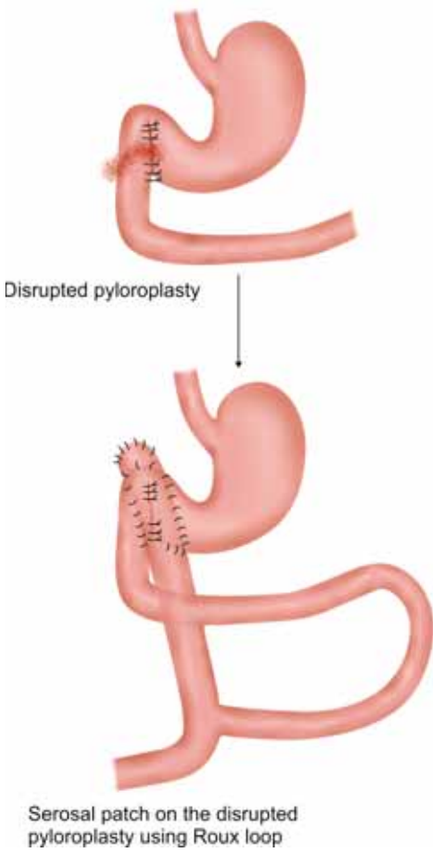


Fig. 21-68: Serosal patch technique for disrupted Finney's pyloroplasty.

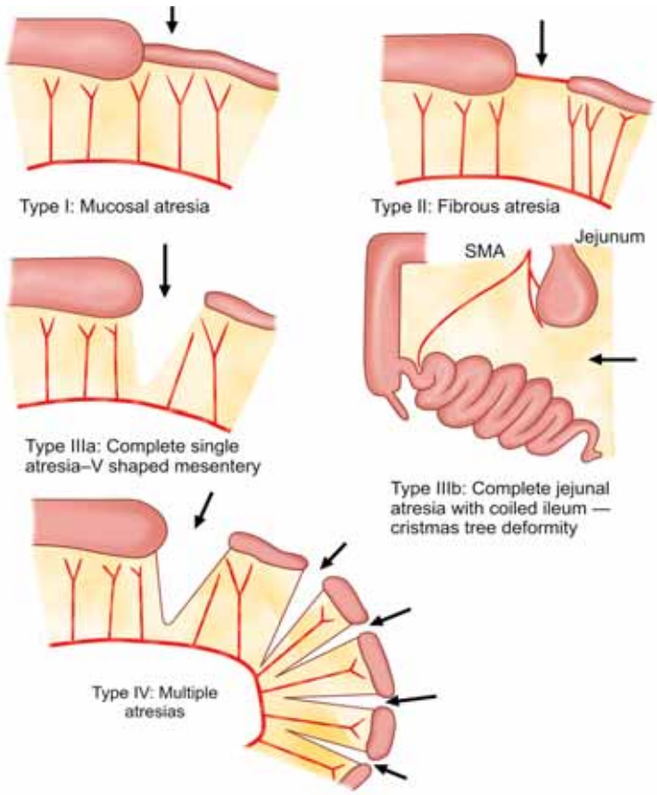

Type I: Mucosal atresia
Type II: Fibrous atresia
SMA
Jejunum
Type IIIa: Complete single atresia–V shaped mesentery
Type IIIb: Complete jejunal atresia with coiled ileum — cristmas tree deformity
Type IV: Multiple atresias

Fig. 21-69: Intestinal atresia.

SMALL INTESTINE ATRESIA (INTESTINAL ATRESIA)

It is jejunoileal atresia. It is due to intrauterine mesenteric vascular accidents (occlusion) of the segments affected. V-shaped mesentery; presence of bile pigments in the distal segments suggesting earlier period of patency—are supportive for the above theory. It is often associated with malrotation, gastroschisis, volvulus—20%. Common site is proximal jejunum; next common is distal ileum. Maternal polyhydramnios occurs in 35% of jejunal atresia. Proximal bowel wall is dilated with hypertrophy but villi are normal. Distal bowel is collapsed but with hypertrophied villi. Narrow collapsed large intestine (microcolon) is seen in proximal atresia.

Griesfield Modification of Martin's Classification of Intestinal Atresia

Type I: Membranous/mucosal with normal mesentery— 20%.
Type II: The lumen is atretic—fibrous cord between proximal and distal parts of the segment involved (only one atretic segment) but mesentery is normal—40%.
Type III (a): Atresia with complete separation of proximal and distal ends and V-shaped defect of mesentery—35%.
Type III (b): Atresia with christmas tree-shaped defect in mesentery with distal bowel being supplied by single artery—right colic/ileocolic/superior mesenteric—*apple peel atresia*.
Type IV: Multiple atresias—5% **(Fig. 21-69)**.

Treatment

Resection and anastomosis is the choice of therapy. Treatment of associated anomalies; tapering proximal jejunoplasty is done if extensive length of jejunum is involved. Prognosis depends on length of atretic bowel; multiple atresias; associated anomalies.

MALROTATION

It is interference in the process of normal rotation of midgut in fetus and its mesenteric fixation.

Stages of Normal Rotation of Midgut

Stage 1: In 4th-8th week of intrauterine period, midgut supplied by superior mesenteric artery (SMA) grows rapidly. As coelomic cavity cannot accommodate growing midgut during that period, it protrudes into the umbilical cord as *physiological hernia*.

Stage 2: In 10th-12th week, midgut migrates into coelomic cavity. First, small bowel returns towards the left side of the abdomen. Then caecocolic loop returns to left lower abdomen. It rapidly rotates 270° counterclockwise to reach right iliac fossa. Then duodenojejunal segment rotates 270° counterclockwise to reach left of SMA and behind the colon.

Stage 3: Fusion of different parts of mesentery and posterior peritoneum.

Different Errors of Rotation

Stage 1: Exomphalos major/minor or gastroschisis.

Stage 2: Errors of rotation in this stage is important and is usually considered under malrotation.

Nonrotation: Causing small bowel in right side; colon in left side; caecum in midline as suspension.

Incomplete rotation: It is the *most common type* of malrotation. Caecum is located in subhepatic right hypochondrium. *Ladd's peritoneal band* connects from caecocolic loop to posterior abdominal wall compressing the 2nd part of the duodenum. Entire midgut is hanging down along with SMA with a narrow based mesentery causing midgut volvulus.

Reverse rotation: Final 180° rotation occurs clockwise bringing colon posterior to duodenum and SMA.

Hyperrotation: Rotation up to 360° or 450° causing caecum on left side of the abdomen. Encapsulated small bowel occurs while fetal midgut returns into coelomic cavity.

Stage 3: Final defect in fixation causes mobile caecum and ascending colon leading into caecal volvulus **(Fig. 21-70)**.

Treatment

Resuscitation, antibiotics, fluid and electrolytes, blood transfusion as initial therapy **(Fig. 21-71)**.

Laparotomy through horizontal incision is done. Clockwise rotated midgut which is congested and cyanotic is identified. Untwisting of the midgut in counterclockwise direction is done. Viability of bowel is confirmed (colour, vessels in mesentery, peristalsis, on table Doppler). *Ladd's band* is divided, *large bowel is repositioned in left side.* The entire duodenum is *Kocherised* and the ligament of Treitz is divided so that *duodenum becomes straight towards right* iliac fossa. This achieves *wide root of the mesentery* and places the *small bowel in the right* side of the abdomen thus preventing further volvulus. A *complementary appendicectomy* is done—*Ladd's operation*. After laparotomy, if bowel is gangrenous, it is resected and remaining parts of the bowel are exteriorised as enterostomies. A second look operation is done to look for viability of remaining bowel and also to maintain the continuity. Often it will be extensive bowel resection leading to poor prognosis.

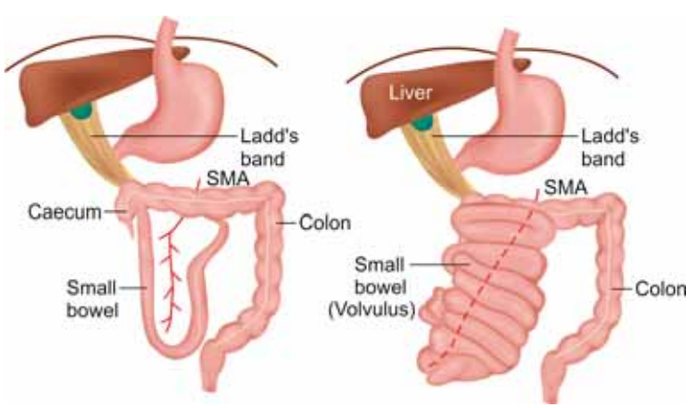


Fig. 21-70: Diagram showing incomplete gut rotation and small bowel volvulus.

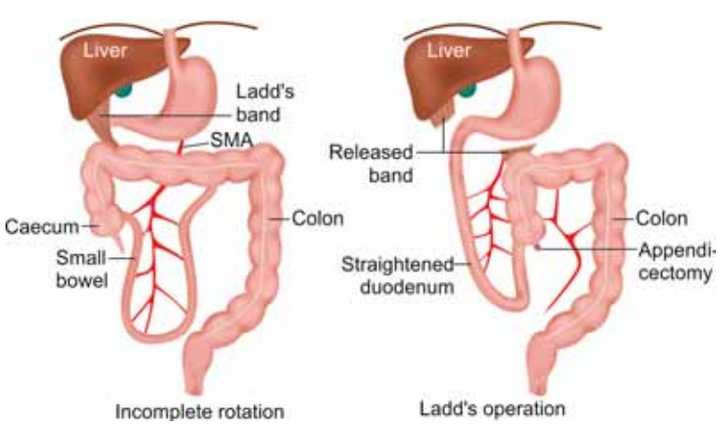


Fig. 21-71: Ladd's operation for incomplete gut rotation. Ladd's band is released. Duodenum is straightened. Appendicectomy is done.

MECONIUM ILEUS

It is neonatal manifestation of fibrocystic disease of the pancreas wherein thick meconium, which is viscid and paste like, gets collected in the terminal ileum. Because of inspissation it forms a firm bolus leading to obstruction of the ileum. Neonates present with features of ileal obstruction as well as respiratory dysfunction, exocrine pancreatic insufficiency, and high salt in the sweat (Na^+ and Cl^- more than 90 mmol/L). Meconium ileus occurs in 15% of patients with cystic fibrosis. Cystic fibrosis is an autosomal recessive disease involving bronchioles, exocrine pancreas and sweat glands.

Condition is common in Caucasians. Exocrine pancreatic insufficiency and malabsorption is seen in 90% of patients with cystic fibrosis. There is hypertrophy and dilatation of the proximal ileum containing thick, viscid, tenacious dark green meconium. Distal ileum and colon are narrow and contracted having grayish meconium pellets. Meconium gets calcified very rapidly. Gangrene, perforation, volvulus can occur in 50% of cases. Intrauterine perforation causes fetal meconium peritonitis which leads to dense adhesions and calcification in peritoneum. Fetal meconium peritonitis is sterile. Plain X-ray shows calcified meconium pellets with multiple air fluid levels which appear as 'soap-bubbles' (*Neuhauser sign*). Vomitus of the patient which does not contain trypsin, when poured on the exposed X-ray film will not digest the gelatin of the film whereas the vomitus of individual with normal pancreas will digest the gelatin of X-ray film—*very useful test.* Pilocarpine, a cholinergic drug is injected into skin to stimulate the sweating and collected sweat (100 µg sweat) is analysed for sodium and chloride. Elevated albumin level in meconium, sodium level assay in nail clipping, serum immune active trypsin assay are other investigations **(Fig. 21-72)**.

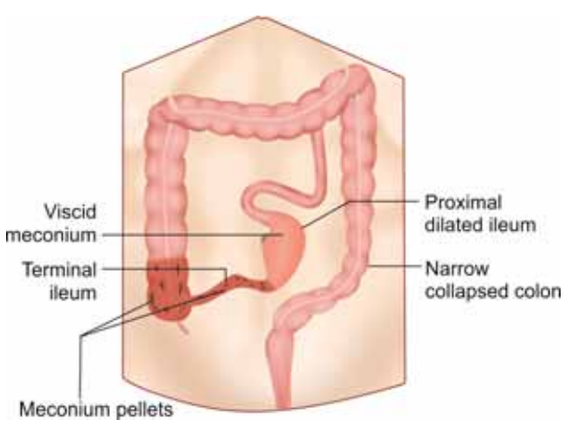


Fig. 21-72: Pathology of meconium ileus. Note the meconium pellets in the distal ileum and colon; thick viscid meconium in proximal ileum.

Treatment

Nonoperative Measures

Dissolution through enema can be tried using *gastrografin* which is hyperosmolar and contains Tween 80 as dissolving agent. *Gastrografin* is diatrizoate meglamine with Tween 80 (polysorbate 80) as dissolving agent.

Acetyl choline (2-4%) also can be used for irrigation per-anally. Acetyl choline wash through nasogastric tube also can be used—5-10 ml 6th hourly. Treatment for cystic fibrosis is needed.

Operative Measures

When patient's condition is critical with obstruction, *Bishop-Koop operation* is done. Proximal dilated segment is resected and resected end is anastomosed to side of the distal collapsed ileum. End of the distal ileum is brought out as ileostomy. Through the ileostomy gastrografin or acetyl cystine wash is given regularly to dissolve meconium pellets. This ileostomy can be kept for long time. Continuity is maintained at later period **(Fig. 21-73)**.

Santulli operation is done where proximal ileum is brought as ileostomy for irrigation using a fine tube and distal ileum is sutured to proximal ileum as end to side anastomosis **(Fig. 21-74)**.

Resection and anastomosis is ideal if patient is fit and if proximal bowel is suitable for anastomosis.

SHORT BOWEL SYNDROME (SHORT GUT SYNDROME)

It is the symptom complex after massive small bowel resection, i.e. *resection more than 70% of the bowel*. Minimum bowel required is 1.2 meters. Proximal jejunal resection is better tolerated than distal ileal resection. Ileum is more adaptive and has got capacity to increase the absorption capacity more efficiently. So in massive resections, patients with retained ileum will do better. Adaptation is better if ileum and caecum is preserved.

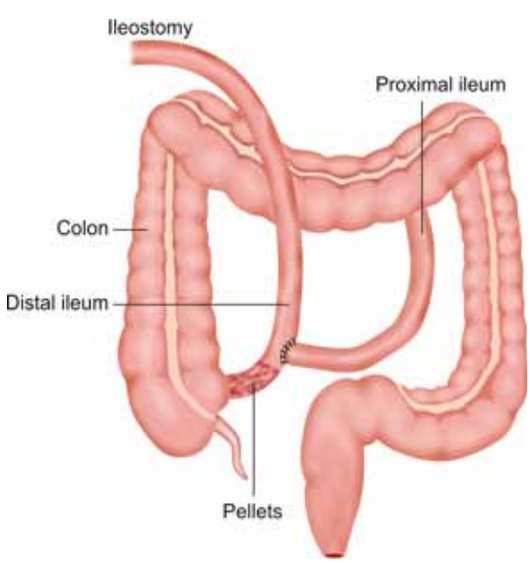


Fig. 21-73: Bishop-Koop operation. Here distal ileum is brought as ileostomy and proximal part sutured to distal bowel.

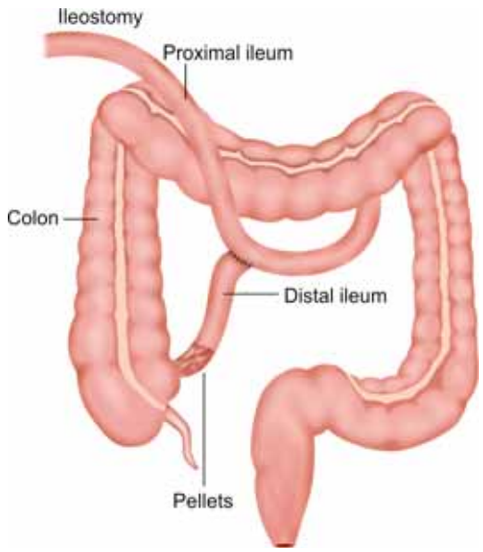


Fig. 21-74: Santulli operation done for meconium ileus wherein proximal ileum is brought out as ileostomy. Distal ileum is sutured to proximal.

Causes

Massive small bowel resection as in superior mesenteric artery ischaemia; multiple sequential resections; recurrent Crohn's disease—common cause, necrotising enterocolitis in neonates and children, intestinal atresia, midgut volvulus, radiation enteritis.

Adaptive Changes in the Retained Small Bowel

Villous hypertrophy and hyperplasia, increased absorptive surface, increased capacity of small bowel, lower transit time of bowel content are different changes.

Factors Deciding the Outcome in Short Gut Syndrome

Age: Infants tolerate massive resection better. Retaining ileocaecal valve shows better outcome as ileocaecal resection interrupts the enterohepatic circulation of bile salts which in colon gets metabolised to secondary bile salts. Secondary bile salts block the absorption of water and electrolytes. Delayed clearance of gastrin causes hyperacidity and peptic ulcer. Adaptability of the small bowel—adaptation is better if ileum and caecum are preserved. Additional colectomy increases the morbidity. In such occasion retained jejunum will function as either of two ways.

'*Net absorbers*' have adequate absorption of water and sodium and usually will have more than 100 cm of retained jejunum. '*Net secretors*' have less than 100 cm of jejunum and lot of sodium and water are secreted into the lumen from plasma. These patients should avoid hypotonic solutions like water/tea; instead should take hypertonic saline with glucose containing 90 mmol sodium/L. WHO cholera fluid is ideal (contains 90 mmol sodium/L).

Clinical features: Diarrhoea, fluid and electrolyte deficiency, severe malnutrition, recurrent bacterial enteritis.

Outcome of Short Bowel Syndrome

Severe malabsorption, severe dehydration, gallstone formation due to altered bile metabolism, urinary calculi due to increased oxalate level, water and electrolyte imbalance, diarrhoea is common, recurrent bacterial enteritis, fulminant hepatic failure often can occur, osteomalacia, tetany, hypomagnesaemia, bleeding diathesis, peripheral neuropathy.

MASSIVE BOWEL RESECTION

Resection of *more than 200 cm* of small bowel is called as massive resection. *Metabolic sequelae* in massive resection depends on—extent and anatomical site of resection, functional capacity and adaptation of the small or large bowel, cause for the resection. It causes gastrin hypersecretion, increased parietal cell mass in stomach, peptic ulceration; increased endocrine pancreatic secretion; hypoalbuminaemia, oedema. *Resection of more than 100 cm of distal ileum* causes diarrhoea and steatorrhoea (steatorrhoea is faecal fat > 6 g/day), increases bile lithogenicity, causes deficiency of vitamins A, D, E, K; colonic bacteria converts unabsorbed fatty acids and conjugated bile salts into hydroxy fatty acids and deconjugated bile salts. *Ileum* maintains enterohepatic circulation of bile salts, absorption of vitamin B12 and vitamin D. Resection of middle part of small bowel is better tolerated. *Removal of ileocaecal valve* reduces the intestinal transit time; reduces absorption of vitamin B12, calcium, magnesium, zinc; increases diarrhoea and contamination of shortened small bowel by bacteria. In massive resection, *colonic bacteria* degrade fatty acids into lactate and short chain fatty acids; lactate reduces colonic pH which inhibits bacteroides; due to this acid resistant anaerobes will increase in colon which produces large amount of D lactate which is absorbed causing *D lactic acidosis* presenting with confusion, ataxia and nystagmus. *TPN* was introduced by Dudrick. It is very useful in short gut syndrome.

Treatment

Early Phase

Total parenteral nutrition.

Fat and fibre free but protein rich liquid diet with essential fatty acids; diarrhoea is controlled by loperamide/codeine phosphate; oral cholestyramine to bind bile salts is needed in massive resection which includes ileum; parenteral vitamin B12 injection regularly; H2 antagonists/PPIs/somatostatin (to reduce secretions from stomach, liver and pancreas); octreotide reduces the secretion and reduces GI motility; fluid and electrolyte management; control of diarrhoea.

Late Phase

Enteral nutrition is used to stimulate intestinal adaptation; TPN supplement—often permanently required; *lome parenteral nutrition* is universally used method in western countries. But in Asian countries it is not yet practicable. Hormones and glutamine administration are under trial.

Surgical techniques to delay the intestinal transit time or small bowel transplantation are under trial but with less success. *Reversal of 10 cm intestinal segment* to delay transit time can be useful. *Intestinal lengthening* to delay transit time and increase the absorption surface is done. *Small bowel transplantation*, ideal but graft rejection and failure is the problem. Antiperistaltic colonic interposition into the small bowel segment also tried. Regeneration of intestinal mucosa over denuded serosa is a new method. Longitudinal splitting of the intestine and closing of these as separate tubes which are anastomosed to each other to achieve lengthening—*Binachi's surgery*. Mucosal *stem cell transplantation using enterocytes* without lymphoid tissue. Seeded mucosal autografts in prosthetic tubes are other newer methods on trial.

APPENDIX

SURGICAL ANATOMY OF APPENDIX

It is a worm like diverticulum, located at the terminal end of the caecum where three taeniae join, about 2 cm below the ileocaecal orifice. Usually it is around 2-20 cm in size but can be variable (9/10 cm average). Size of its lumen is that of matchstick. Diameter of appendix is 3-8 mm; diameter of lumen is 1-3 mm (matchstick). It is longer in children. *Base of the appendix is located 2 cm below the junction of the transtubercular and right lateral planes. McBurney's point is only site of maximum tenderness in appendicitis* **(Figs 21-75 and 21-76)**.

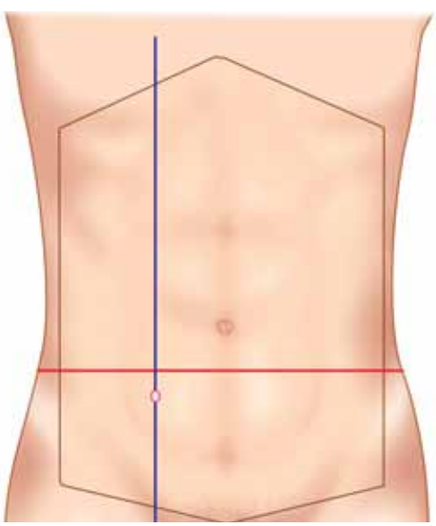


Fig. 21-75: Base of the appendix is located 2 cm below the junction of the transtubercular and right lateral planes.

Mesoappendix is extension of the mesentery containing appendicular artery, a branch of ileocolic artery. Artery runs behind the terminal part of the ileum and enters the mesoappendix near base where it gives a recurrent anastomotic branch to posterior caecal artery. Artery ends in the wall of the appendix near tip. Often an accessory appendicular artery *(of Seshachalam)* may be present. Thrombosis of these vessels leads to gangrenous appendicitis **(Fig. 21-77)**.

Venous drainage is through appendicular, ileocolic, superior mesenteric and portal vein.

Nerve supply: T9 and T10 sympathetic nerves supply appendix through coeliac plexus.

Lymphatic drainage: mainly it is to ileocolic nodes. Often drainage may occur through appendicular nodes.

Mucosa of appendix is lined by columnar cells with crypts. Submucosa contains numerous lymphatic aggregations (follicles*) ('Abdominal Tonsil')*. Opening of the appendix into caecum is guarded by *'valve of Geralch'* **(Fig. 21-78)**.

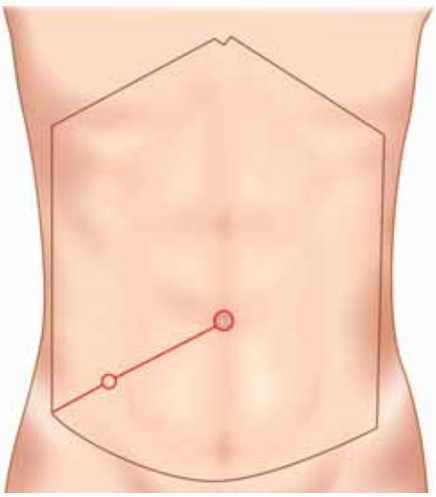


Fig. 21-76: Mc Burney's point is only site of maximum tenderness in appendicitis. It at the junction of lateral 1/3rd and medial 2/3rd of right spinoumbilical line.

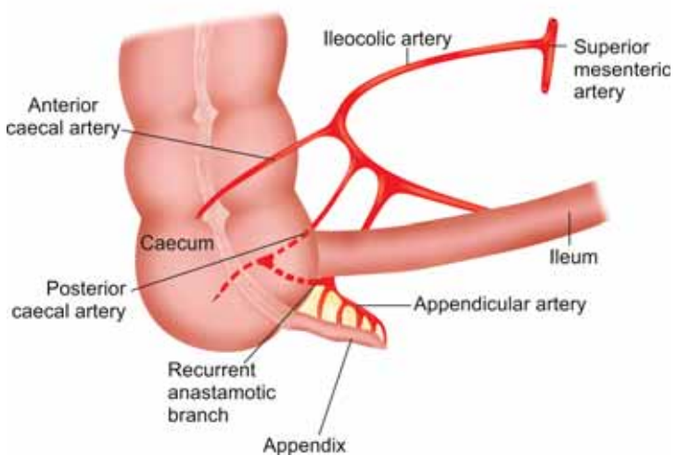


Fig. 21-77: Appendicular artery.

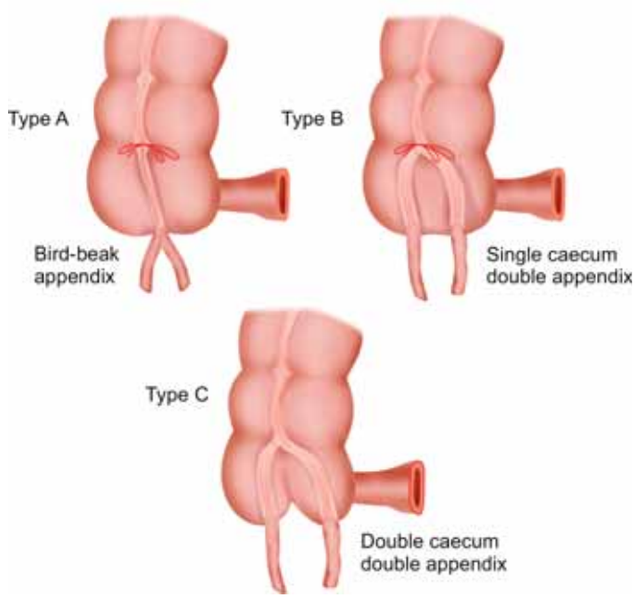


Fig. 21-78: Wallbridge classification of duplication of appendix.

Duplication of appendix
(Wallbridge classification)
Type A: Partial duplication in a single caecum.
Type B: Two separate appendices in a single caecum.
Type C: Double caecum with each one having one appendix.

Different Positions are

Most common position *is retrocaecal (65-75%). Next common is pelvic (21-31%). Other sites are:* Preileal (anterior) —rare (1%); Postileal (splenic)—rarest (0.4%); Paracaecal; Subcaecal (2.2%); Subhepatic.

Often it may be in subserosal plane leading to difficult dissection during appendicectomy. In *situs inversus* appendix is on *the left side* **(Fig. 21-79)**.

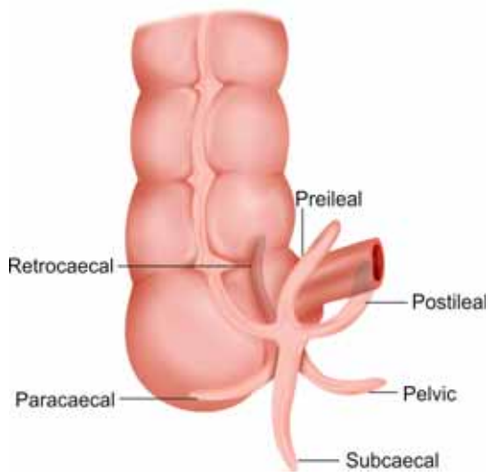


Fig. 21-79: Different positions of the appendix.

APPENDICECTOMY

Reginald Fitz from Boston coined the term appendectomy in 1886. Chester McBurney started early surgery for acute appendicitis with muscle splitting incision (1884-1889).

Indications

- Acute appendicitis.
- Recurrent appendicitis.
- Appendicitis in pregnancy—done in 2nd trimester ideally.
- Appendicectomy as a part to give colonic lavage (Doodley's lavage). Appendicectomy along with other procedures—in correcting the malrotation of the gut (Ladd's procedure).
- Appendicectomy in carcinoid tumour involving the tip of appendix and tumour size less than 2 cm.
- Appendicectomy is done in *Munchausen syndrome*—a psychological condition.

Contraindications for Appendicectomy

- Appendicectomy is contraindicated in appendicular mass when formed after an attack of appendicitis. Here appendicectomy is done after 6 weeks as interval appendicectomy.
- Appendicectomy is not done in acute phase of Crohn's disease; however, it should be done if appendix and caecum is diseased.

Investigations

- Total leucocyte count is increased.
- U/S is done to rule out other conditions like ureteric stone, pancreatitis, ovarian cyst, ectopic pregnancy and also to confirm appendicular mass or abscess **(Fig. 21-80)**.

Sonographic Criterias for Appendicitis (85% specificity)
Noncompressible appendix of size > 6 mm AP diameter,
hyperechoic thickened appendix wall > 2 mm—target sign.
Appendicolith.
Interruption of submucosal continuity.
Periappendicular fluid.
Caption: U/S showing dilated noncompressible appendix.

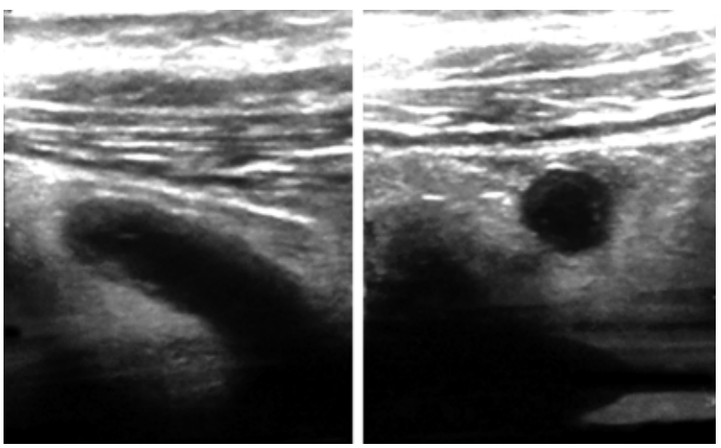


Fig. 21-80: Ultrasound of the appendix.

- Contrast CT scan is very much useful when diagnosis is difficult especially in old people. Dilated appendix; dilated lumen; thickened wall; nonfilling of the lumen by contrast or air; periappendicular fluid collection; presence of mass/abscess/associated pathology like carcinoma can be identified. It has 95% sensitivity and specificity with 95% accuracy. *Dirty fat thickened mesoappendix*, appendicular *phlegmon*, appendicular *faecolith* and thickened caecum funneling contrast into the orifice of the appendix as *arrowhead sign*—are all relevant features in CT scan.
- MRI is very useful in diagnosing appendicitis in *pregnancy*.
- *C-reactive protein,* even though nonspecific increases in acute phase. *99mTc HMPAO labeled leucocyte* imaging may give guidance in deciding the management.
- Laparoscopy is the most useful method **(Fig. 21-81)**.

Fig. 21-81: Calcified appendix/faecolith in plain X-ray.

Preparation

- Preoperative diagnosis by US abdomen; CT scan; total leucocyte count and by clinical features.
- Nil per orally for 6 hours prior to surgery.
- Preparation of skin of entire abdomen as possibility of extension of the incision should be kept in mind.
- Fitness for anaesthesia; blood sugar and serum creatinine estimation should be done.
- Urinary catheter is passed in laparoscopic appendicectomy or in difficult appendicectomy or in appendicitis with peritonitis where laparotomy is needed. In regular appendicectomies patient is asked to pass urine to empty the bladder before coming to operation theatre.
- Nasogastric tube is passed in peritonitis, burst appendicitis or with suppuration.
- Preoperative intravenous antibiotics should be started—amoxycillin, metronidazole or higher antibiotics depending on the need of individual case basis.

Types of Appendicectomy

- **Open appendicectomy**: Good old method. Here entire peritoneal cavity cannot be visualised. Often it may require extension of incision or converting into formal laparotomy **(Fig. 21-82)**.
- **Laparoscopic appendicectomy**: It is the gold standard approach for appendicectomy. Incision is small; entire peritoneal cavity can be seen which is important especially in females. Recovery is faster in this type.
- **Laparoscopic assisted appendicectomy:** Peritoneal cavity is visualised through laparoscope and appendix is delivered outside under vision through umbilical port or 10 mm working port. Mesoappendix and stump is dealt like in open appendicectomy. It is faster and meantime diagnosis is also confirmed. But it is often difficult to bring out the appendix with mesoappendix outside as mesoappendix may get torn.
- Appendicectomy can be done through **single incision laparoscopic surgery (SILS)**.
- **Interval appendicectomy** is done after initial conservative treatment for appendicitis or appendicular mass.
- **Incidental appendicectomy** is done along with some other abdominal procedures. Nowadays it is not practiced unless genuinely indicated.
- **Retrograde appendicectomy** is a type of dissection (not approach) done when tip is difficult to identify or to dissect. Here base of appendix is identified, dissected, mesoappendix adjacent to base is ligated or fulgurated using bipolar cautery. Base is crushed; transfixed using 2 zero vicryl and dissection is proceeded towards tip by repeated clamping and ligating tissue close to the appendix and ligating repeatedly until tip is dissected and appendix is freed entirely (serial clamping, division and ligation).
- **Elective appendicectomy** is nothing but interval appendicectomy done after recovering from an attack of acute appendicitis.
- **Emergency appendicectomy** is doing appendicectomy at the time of acute appendicitis.

Note:

- There is no role for prophylactic appendicectomy.
- But removal of normal appendix in an exploration for presumed appendicitis is accepted based on following reasons:

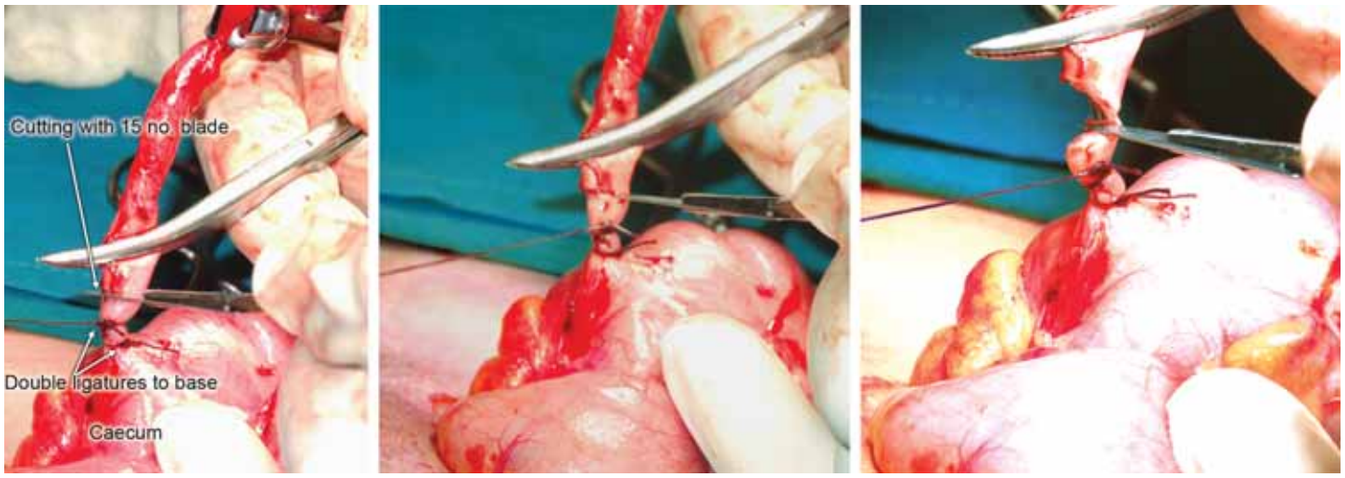


Fig. 21-82: Open appendicectomy.

- Early acute appendicitis (catarrhal/mucosal) on gross inspection is difficult to determine accurately; so grossly normal looking appendix still can have early appendicitis.
- It avoids future diagnostic dilemma in chronic pain in right iliac fossa. Pain may be due inflammatory bowel disease or gynaecologic conditions.
- A scar in right iliac fossa in any patient is assumed by surgeon that appendicectomy is done.
- Long kinked appendix or presence of faecolith may justify appendicectomy.

OPEN APPENDICECTOMY

Anaesthesia: However, even spinal anaesthesia is satisfactory general anaesthesia is ideal.

Incision

- *McBurney's incision* is used (McArthur; Gridiron). McBurney's point is junction of lateral 1/3rd and medial 2/3rd of right spinoumbilical line. At this point perpendicular to this line, incision of 5 cm in length is made 2.5 cm on each side. It is muscle splitting incision. Gridiron is a frame of cross beams to support a ship during repairs.
- *Lanz crease incision* is curved horizontal incision of 5 cm in length. Deeper dissection is same as McBurney's incision. It is cosmetically better as it is in the crease line.
- *Rutherford Morrison's muscle cutting incision:* It is usually modification done in an originally placed McBurney's incision as an extension to have better approach. Here internal oblique and transverse abdominis muscle are cut laterally. It is often done in higher or difficult or subhepatic appendix.
- *Fowler-Weir (Fowler-Davis; Rockey-davis) approac*h: Here extension of the original McBurney's incision is done medially and below by cutting lateral part of the rectus sheath. It is used in pelvic appendix or to feel the right ovary properly.
- *Right paramedian or lower midline incision:* It is used in case of peritonitis due to burst appendicitis **(Fig. 21-83)**.

Procedure

Skin is incised. Outer Camper fascia with subcutaneous fat is incised. Inner membranous scarpa's layer is also incised. Often superficial epigastric and superficial circumflex veins may require to be ligated. External oblique aponeurosis is visualized. It is incised laterally using blade. Medially it is cut along the line of incision using scissor or cautery. Cut edges are held using haemostats. Two Langebeck retractors are placed deep to the aponeurosis to visualize internal oblique muscle. Internal oblique muscle is split in the line of fibers using curved haemostat (curved medium sized artery forceps). Direction of the tip of the instrument should be laterally to prevent inadvertent opening of the rectus sheath and muscle and also to avoid injuring the inferior epigastric vessels. Similarly transversus abdominis muscle is split to reach the peritoneum. Often two fingers are passed deep into the wound and stretched away from the wound line to increase the space underneath. Often extraperitoneal fat may be present which needs careful blunt dissection with finger. Small vessel bleeding can occur which should be controlled using cautery. It confirmed that the bowel is not close under the peritoneum by filling peritoneum with two fingers. Peritoneum is opened by an oblique incision using blade or scissor; fluid if exudes should be collected for culture. Omentum at the site under the peritoneum suggests that appendix is inflamed. Peritoneum incision is extended along the line of skin incision (wound) to enter the peritoneal cavity.

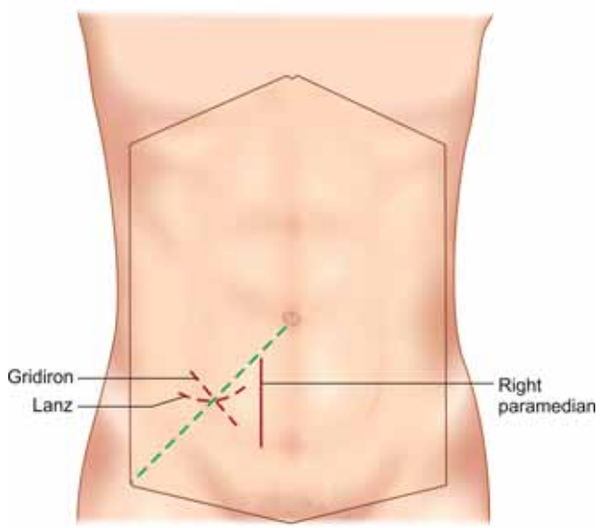


Fig. 21-83: Different approaches for open appendicectomy.

Caecum is located in the right iliac fossa which is identified by the presence of 3 taeniae. Often summit of the sigmoid colon when it is redundant will be towards the right iliac fossa and may be mistaken for caecum and leads into futile search for appendix. Once taeniae of caecum is identified; caecum is held and gently pulled towards the wound without causing serosal tear. Caecum is held using Babcock's forceps. Base of the appendix will be identified. By putting the index finger inside the peritoneal cavity one can gently feel tubular structure which has got blind end and connects to caecum. But fallopian tube in females may be mistaken for that. Once the base of appendix is identified it is held with another Babcock's forceps. Gentle continuous traction with careful finger dissection makes entire appendix to be delivered through the wound outside. Whenever adhesions are present sharp dissection with scissor is better to prevent tear in the base of the appendix or in the caecum. Adhesions anywhere other than mesoappendix part are avascular and will not bleed much by sharp dissection. Careful judicious cautery dissection is allowed but one should not cause cautery injury to caecum or base which may lead to late necrosis, perforation and peritonitis which is life threatening. During dissection bowel should be held using non toothed forceps.

In females by passing right index finger, right ovary and fallopian tube should be palpated to confirm that they are normal. If there is fluid it should be collected. If there is blood one should suspect ectopic gestation and in such situation appendix will look grossly normal. It is also important to pull out terminal ileum for the presence of Meckel's diverticulum; and also to inspect and palpate ileal mesentery for enlarged lymph nodes.

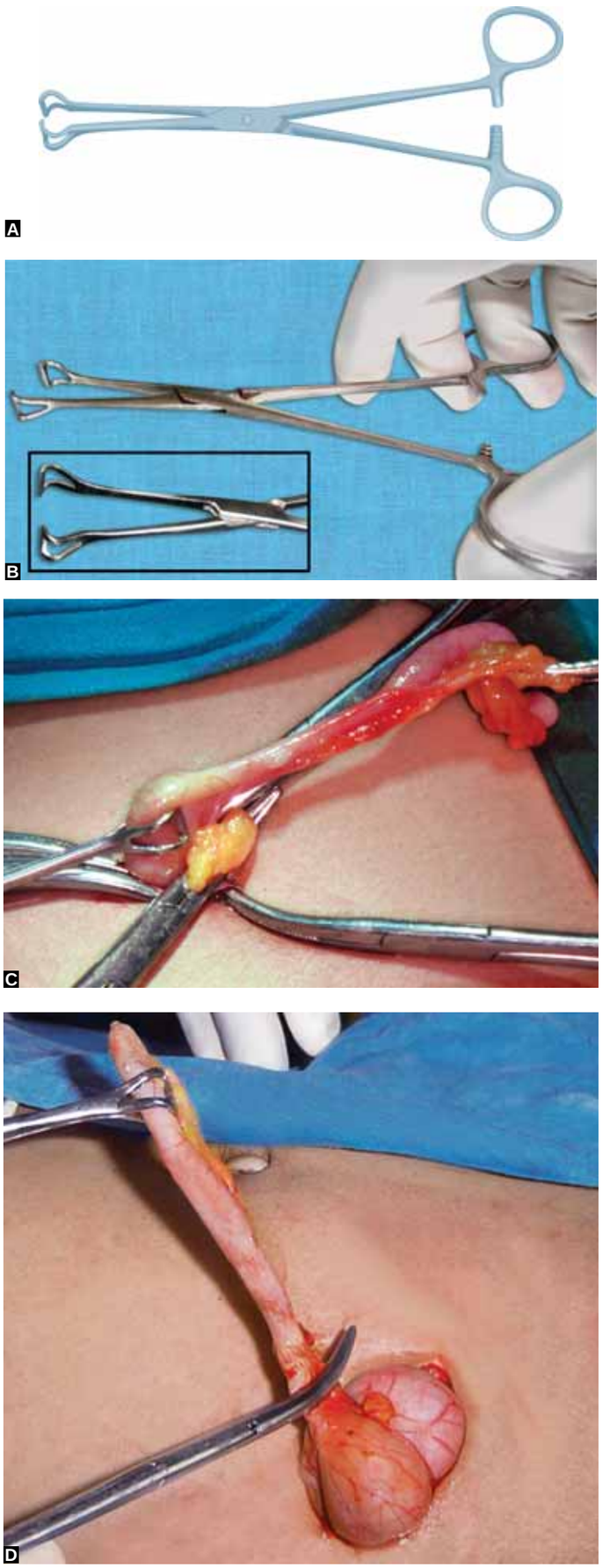
Mesoappendix is often thick, oedematous and friable. Appendicular artery can be often seen through light transillumination which is dissected, clamped with haemostats, cut and ligated using 2 zero silk or vicryl (first ligation can be done by passing two ligatures and then can be cut). If it is difficult to identify appendicular artery which is a branch of ileocolic artery then mesoappendix clamped at several places up to the base and transfixed using silk or vicryl. Accessory appendicular artery when present should also be dealt similarly **(Figs 21-84A to D)**.

Appendix is held with Babcock's with proper visualization of the base of the appendix with adequate caecal wall. Base, 3-5 mm from the caecal junction is crushed using curved artery forceps (haemostat) and released and applied again 1 cm distally. Crushed part of the base of appendix is transfixed using figure of eight suture by 2 zero vicryl suture. Crushing the base was good old practice, which is done to appose the mucosal surface firmly. But now it is argued that crushing is not necessary and transfixation is done without crushing the base. Additional simple (not transfixation) ligature using vicryl or silk is done 2 mm proximal to this to have double ligation of the base. Appendix is cut between distally applied artery forceps and transfixation ligature using no 15 blade. Stump is cleaned with normal saline or povidone iodine solution. Two ligatures are safer to prevent giving way and it is practiced commonly; evidence suggests one strong proper ligature at the base is sufficient enough to hold **(Fig. 21-85)**.

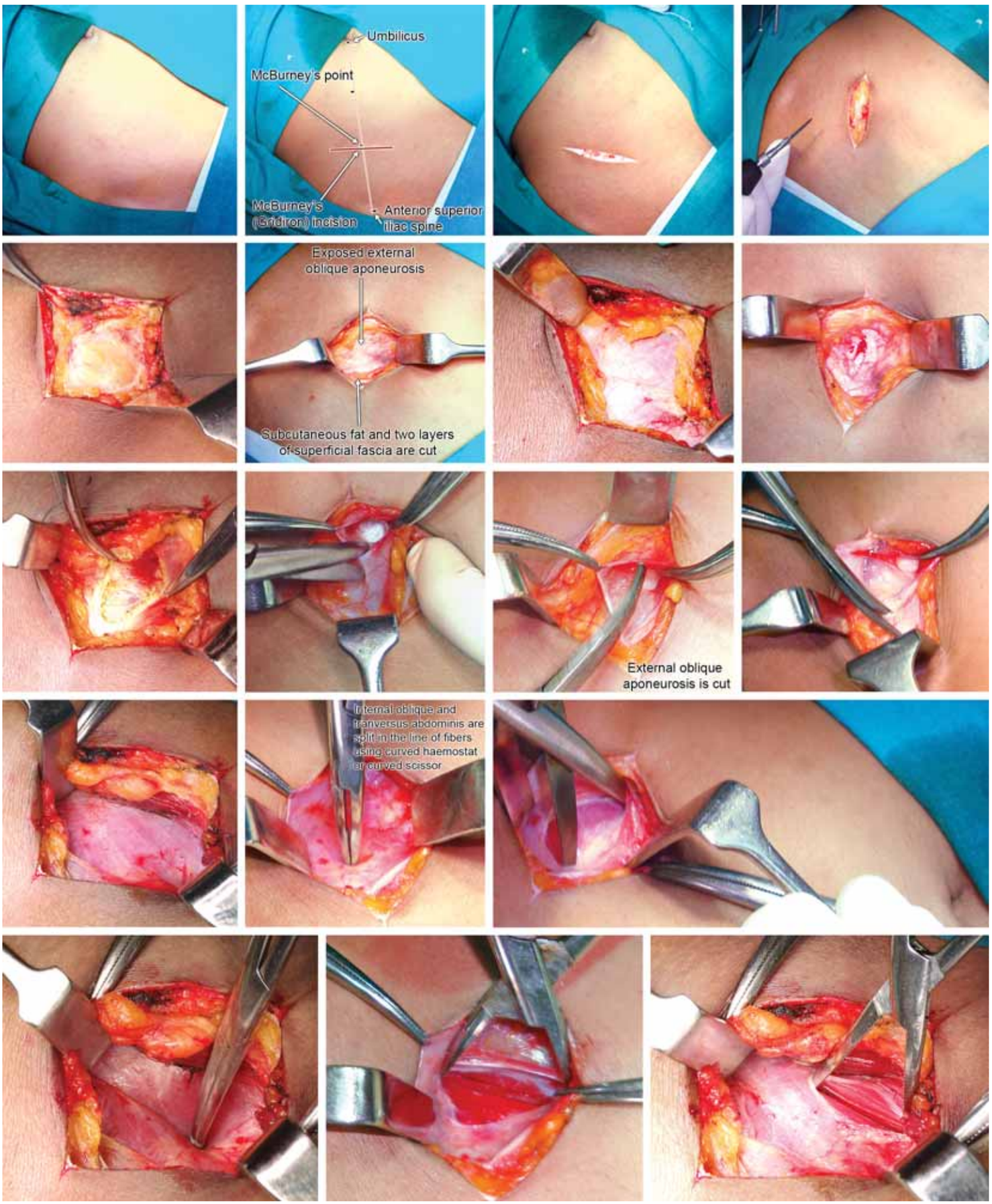
Base of the appendix can be ligated with two firm ligatures using silk or vicryl without any transfixation also, like what is practiced in laparoscopic appendicectomy **(Fig. 21-86)**.

Invagination or Burial of the Appendix Stump

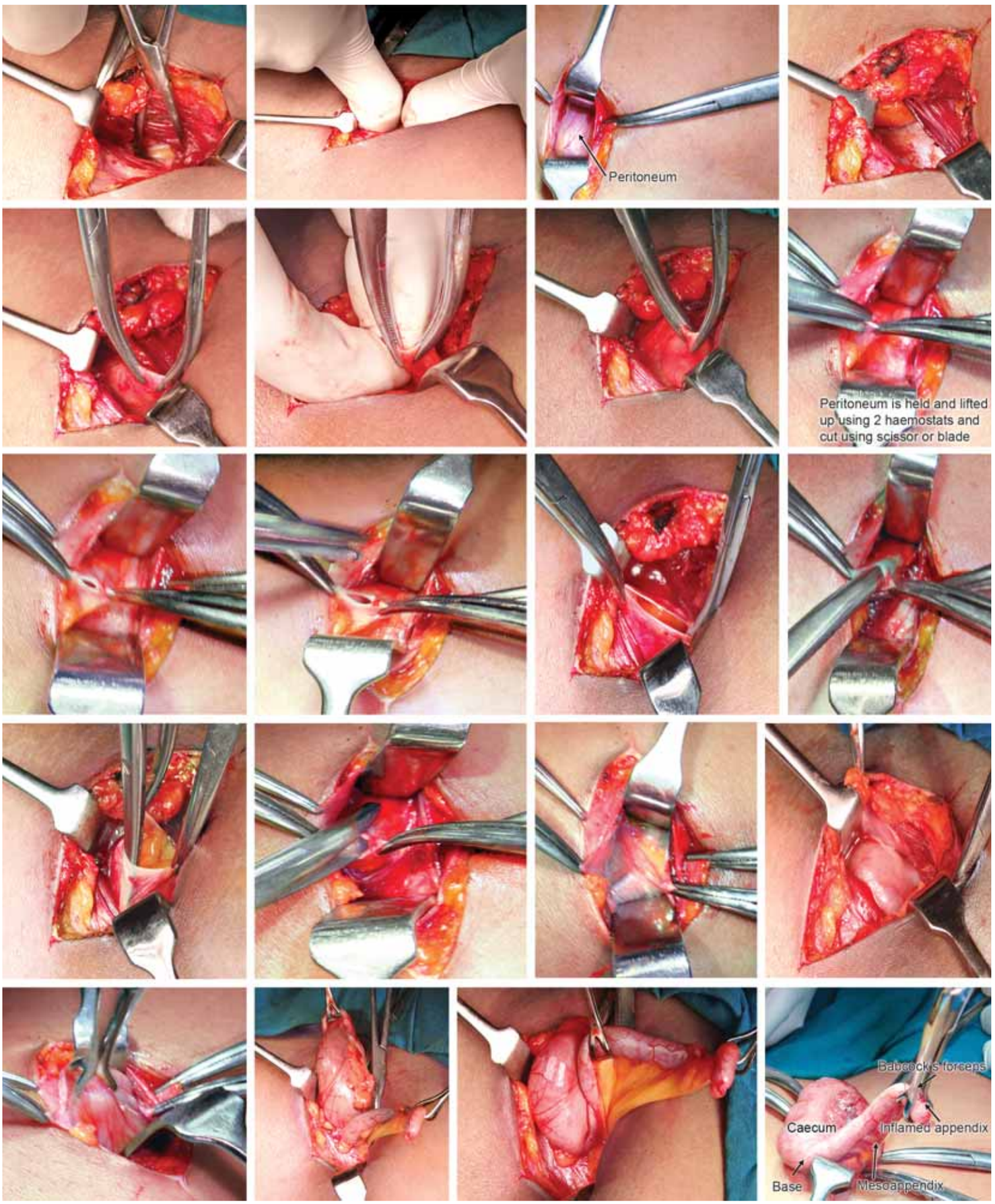
Burial of the stump can be done by various methods. Need for invagination or burial and its advantages are controversial. It was earlier thought that burial prevents the exposure of the stump to free



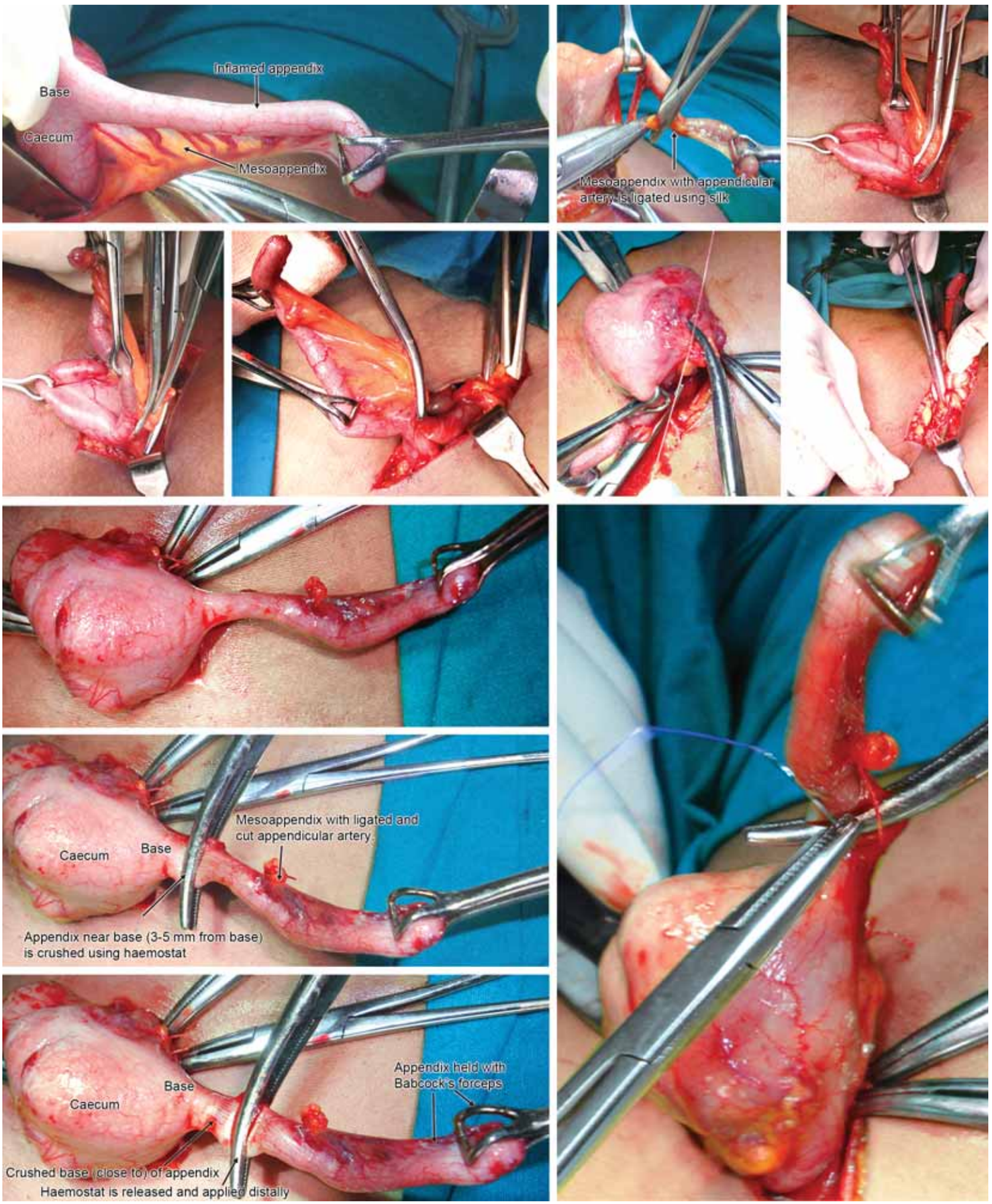
Figs 21-84A to D: Babcock's instrument is used to hold appendix and caecum during appendicectomy. Caecum should be held at taenia.


Umbilicus
McBurney's point
McBurney's (Gridiron) incision
Anterior superior iliac spine
Exposed external oblique aponeurosis
Subcutaneous fat and two layers of superficial fascia are cut
External oblique aponeurosis is cut
Internal oblique and transversus abdominis are split in the line of fibers using curved haemostat or curved scissor

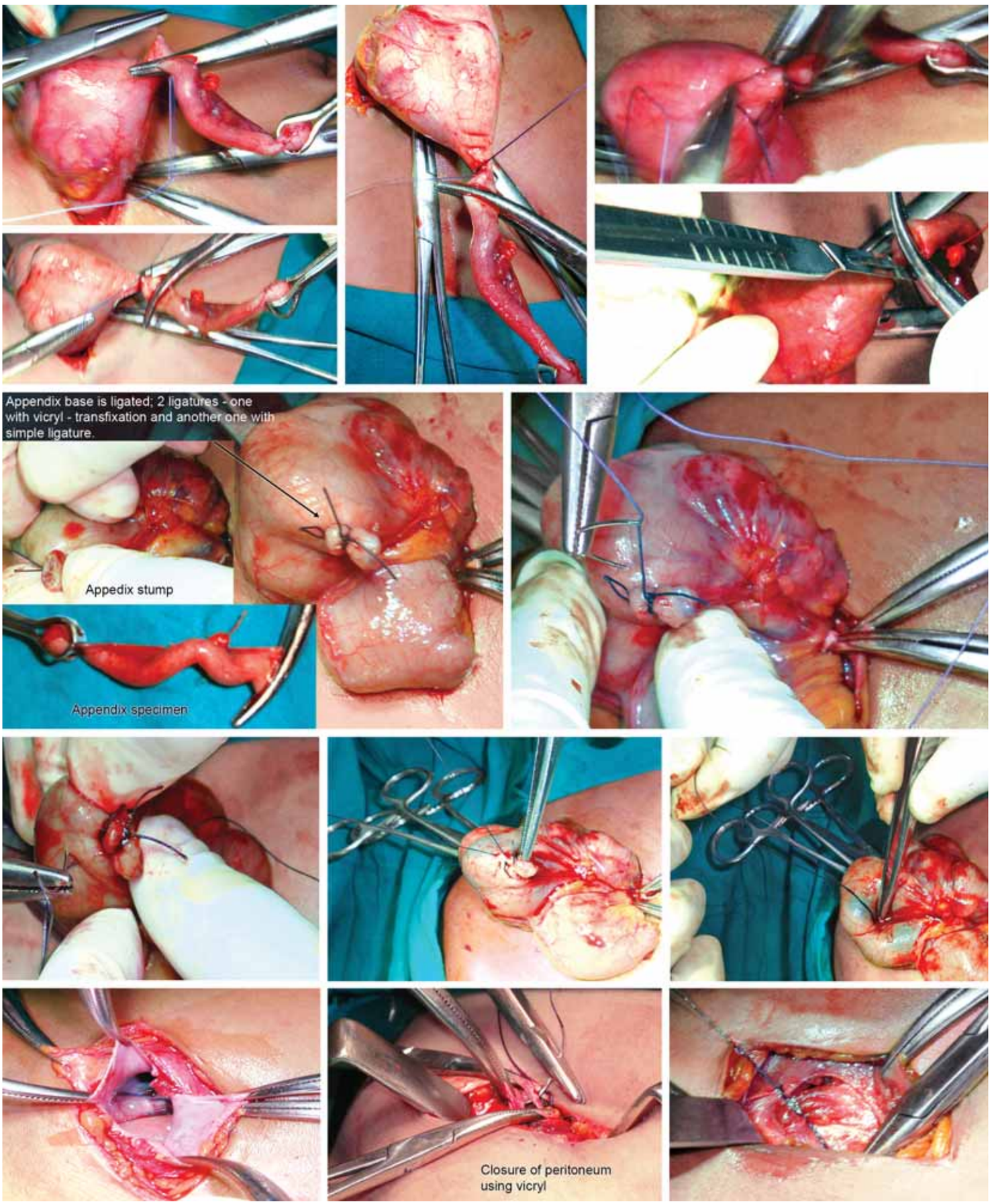
Figs 21-85(1)


Peritoneum
Peritoneum is held and lifted up using 2 haemostats and cut using scissor or blade
Babcock's forceps
Caecum
Inflamed appendix
Base
Mesoappendix

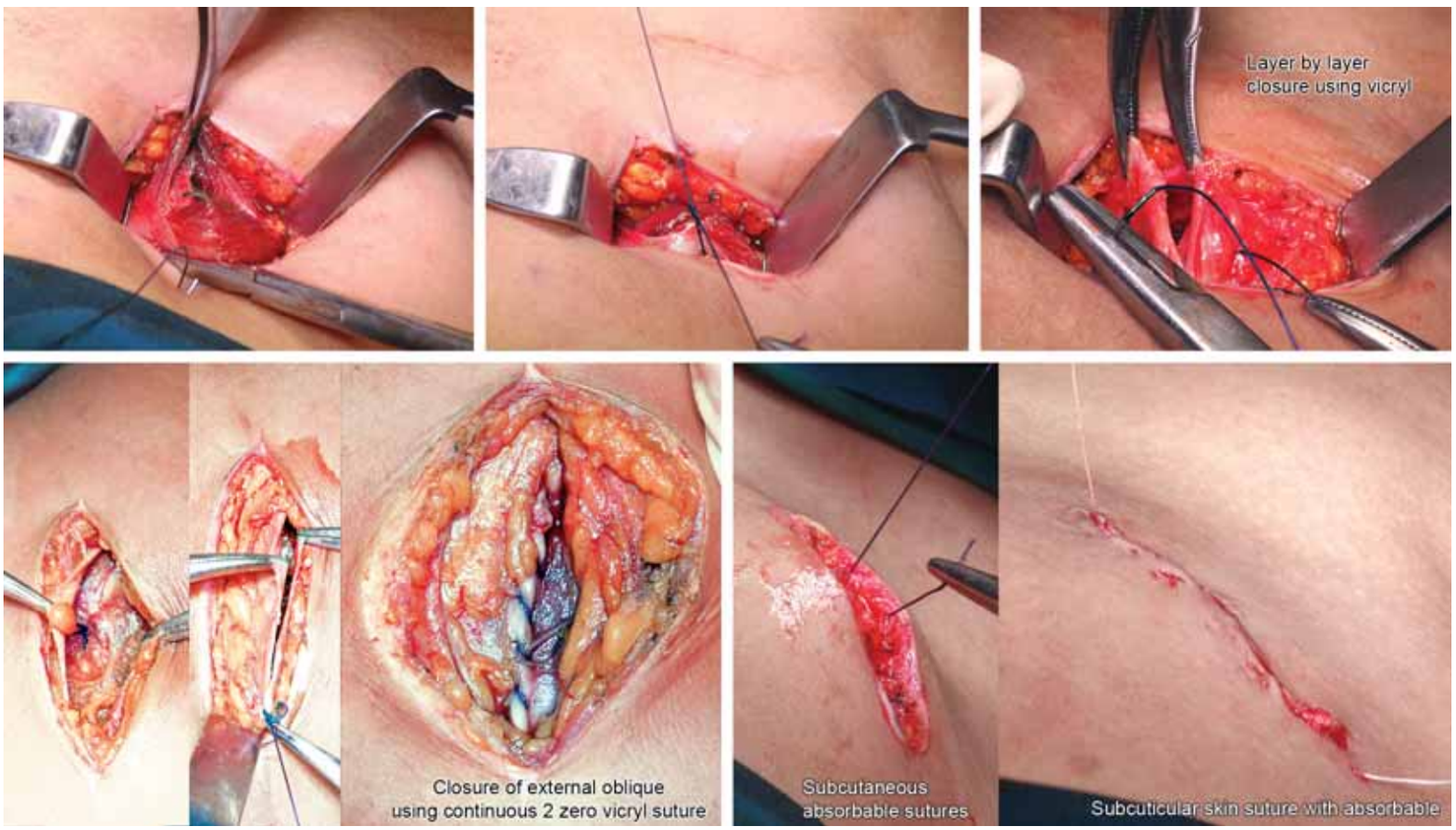
Figs 21-85(2)


Inflamed appendix
Base
Caecum
Mesoappendix
Mesoappendix with appendicular artery is ligated using silk
Mesoappendix with ligated and cut appendicular artery
Caecum
Base
Appendix near base (3-5 mm from base) is crushed using haemostat
Appendix held with Babcock's forceps
Base
Caecum
Crushed base (close to) of appendix
Haemostat is released and applied distally

Figs 21-85(3)

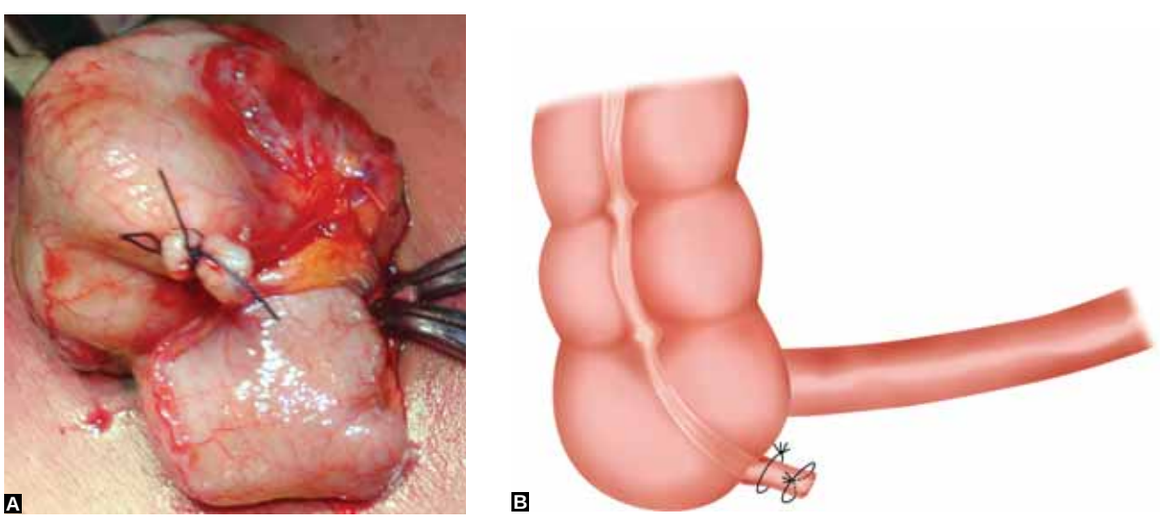

Appendix base is ligated; 2 ligatures - one with vicryl - transfixation and another one with simple ligature.
Appedix stump
Appendix specimen
Closure of peritoneum using vicryl

Figs 21-85(4)



Figs 21-85(4)

Figs 21-85(1 to 4): Technique of open appendicectomy.



Figs 21-86A and B: Ligation of the stump of the appendix.

peritoneal cavity which may lead into adhesion/band or sepsis. But present antisepsis, antibiotics use proved it is not so and there is no need to invaginate the stump. There is a debate that burial itself may precipitate abscess formation by creating closed cavity within the stump - serosa area. But again it is also controversial; however, present accepted trend/method is not to use invagination/burial; but place two ligatures with one of them may or may not be transfixation.

Burial when used is done by various methods—Simple 2-3 seromuscular Lembert interrupted sutures or purse string sutures. Purse string suture is taken using 2 zero silk or vicryl. Bites are taken circumferentially around the base starting from one point 5-10 mm away from the base on the caecal wall beginning from a taenia and ending (last bite) again at same taenia usually last bite passes beyond the first seromuscular caecal bite. Ends of the suture material are kept long with small haemostats. It is usual practice to take seromuscular invagination purse string circumferential sutures before transfixing the appendix but after freeing the appendix from mesoappendix. Many surgeons also practice taking seromuscular caecal purse string sutures

after transfixation and cutting the appendix. Whatever the way it does not make much difference until burial/invagination is proper and adequate. Once appendix stump is cut purse string suture is gently tied towards the base; in the meantime, assistant will push the stump deep to serosa using a haemostat or non toothed forceps. Burial knot is placed.

Normal saline wash is given to the cavity and suction is done **(Fig. 21-87 to 21-89)**.

If appendix is perforated and there is pus around the appendix drain (tube/corrugated) is placed in the right iliac fossa. But its use is controversial and questioned **(Figs 21-90 to 21-92)**.

Wound is closed in layers: Peritoneum with continuous 2 zero vicryl. Transversus abdominis and internal oblique with 2 or 3 interrupted vicryl apposition sutures. Sutures should be loose and fascia covering the muscle should be included (not just muscle bundle). External oblique aponeurosis is closed using continuous vicryl suture. Skin is closed with interrupted nonabsorbable suture (polypropylene/polyethylene) suture or absorbable 3 zero subcuticular suture. Sutures are removed in 7 days. If there is infection skin wound can be left open until it granulates. When infection comes under control it is closed by secondary suturing.

COMPLICATIONS AFTER APPENDICECTOMY

- *Paralytic ileus* is due to sepsis and bowel handling. It usually subsides in 2-3 days.
- *Reactionary haemorrhage* due to slipping of ligature of the appendicular artery can be life threatening. Tachycardia, palor, dropping haemoglobin and PCV are the indicators. Emergency re-exploration with transfusion of blood is needed. Clots are removed. Bleeding artery is identified and ligated securely.

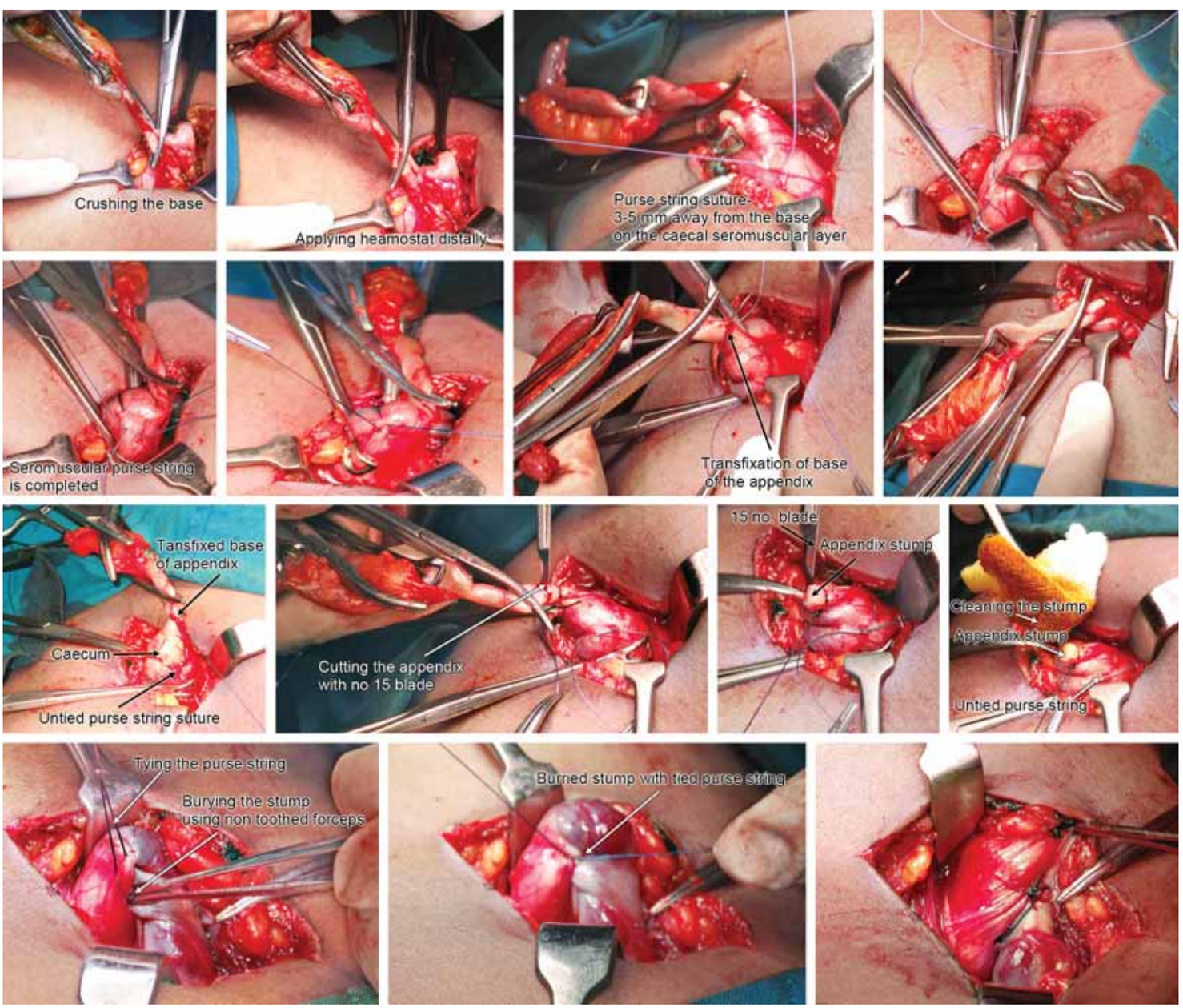


Fig. 21-87: Invagination of appendicular stump using purse string suture.

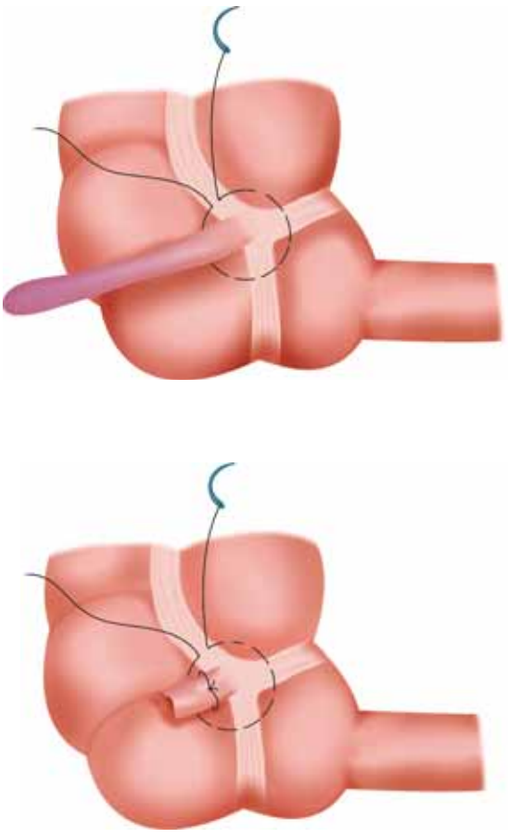
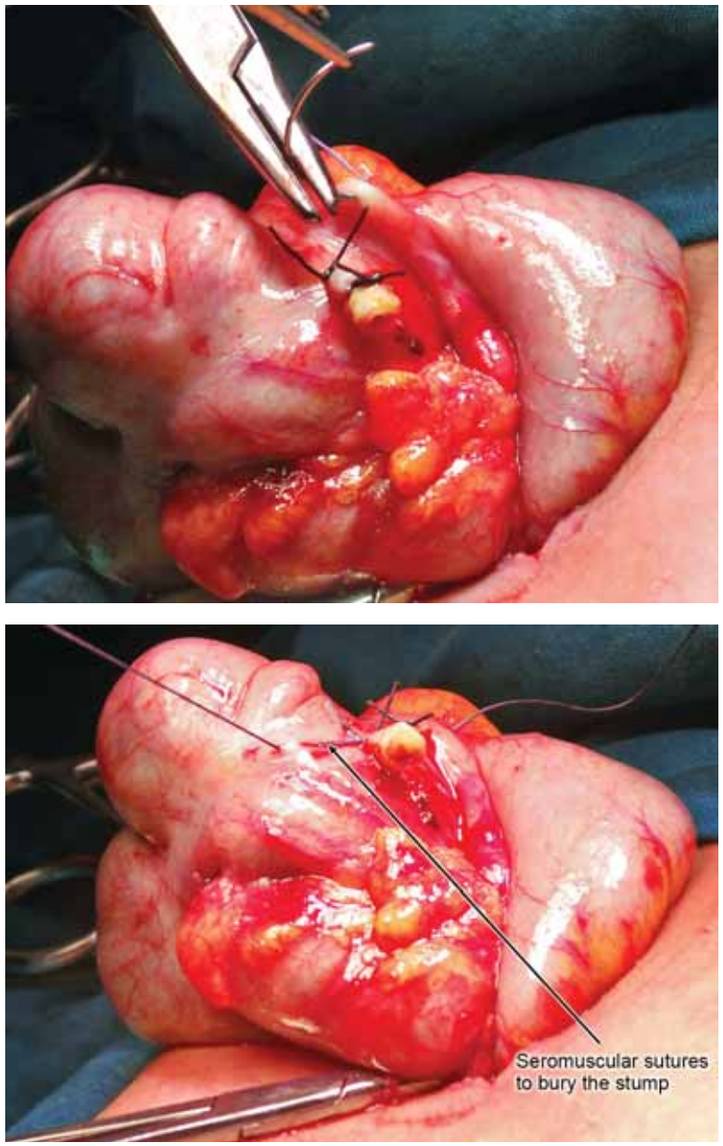


Fig. 21-88: Purse string suture is passed using vicryl or silk by taking bite from taenia then seromuscular bites 5 mm away from the base of appendix circumferentially to reach same taenia again; appendicectomy is done then purse string suture is tied to invaginate the stump of appendix.

- *Residual abscess* (pelvic, paracolic, local, subdiaphragmatic) can occur. Its severity depends on the virulence and load of the bacteria. It is initially treated with antibiotics. If it persists or progresses, CT scan is done to confirm it and later appropriately drainage is done depending on the location of the abscess.
- *Pylephlebitis (Portal pyaemia)* is nowadays rare due to availability of proper antibiotics. However, it can occur if there is immunosuppression. It presents with fever, chills, jaundice and tender, smooth, soft palpable liver. It is treated with adequate antibiotics.
- *Adhesions, kinking* and intestinal obstruction can cause recurrent spasmodic/colicky pain with vomiting. It is initially treated conservatively; but may require laparoscopic adhesiolysis later.
- *Right inguinal hernia (direct)*—due to injury to ilioinguinal nerve can occur.
- *Wound sepsis* 10%, faecal fistula can occur. Wound is laid open and later secondary suturing is done in case of wound sepsis. Faecal fistula usually subsides in few weeks. If there is distal obstruction or specific causes like tuberculosis or malignancy fistula will persist which should be dealt appropriately **(Fig. 21-93)**.
- *Respiratory problems*, DVT can occur.



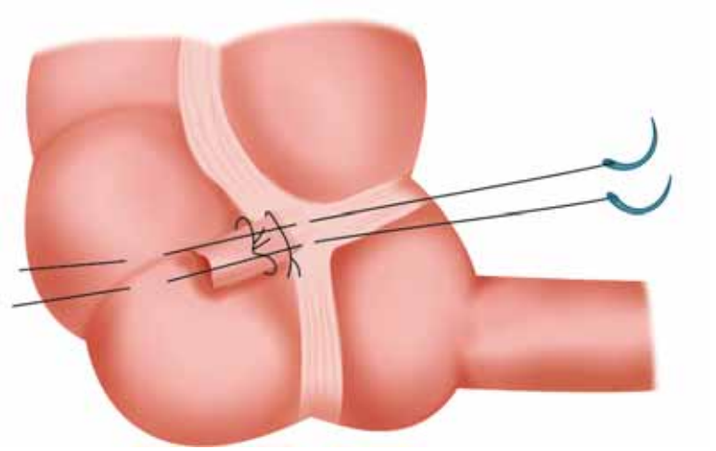


Fig. 21-89: Invagination of stump of appendix using seromuscular Lembert suture.

Fig. 21-90: Suppurative appendicitis.

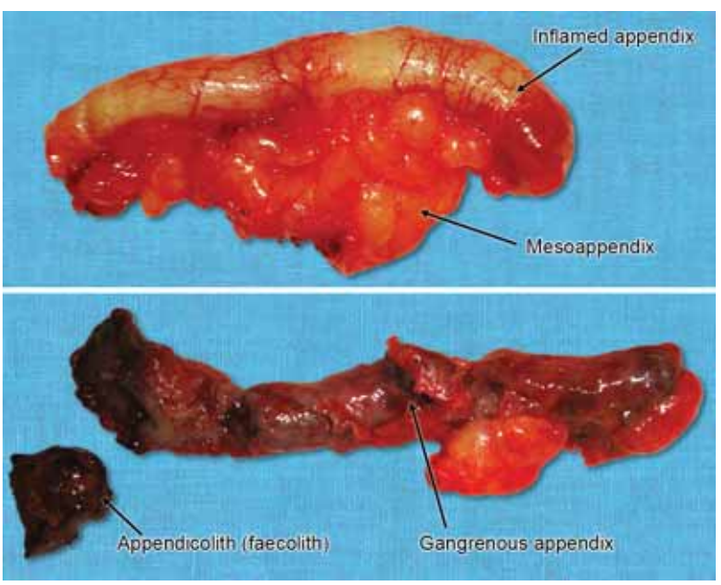


Fig. 21-92: Appendicectomy specimen.

FAECAL FISTULA AFTER APPENDICECTOMY

Causes

It can occur when appendicectomy is done in gangrenous/perforated/friable base appendix. It can occur after drainage of appendicular abscess. It can occur if appendicectomy is done/attempted in appendicular mass. If there is underlying additional pathology like Crohn's disease/carcinoma/ileocaecal tuberculosis/actinomycosis during appendicectomy, fistula can occur **(Fig. 21-94)**.

Fig. 21-91: Placing drain after appendicectomy. Ideally tube drain is placed.

Features

Faeculent, foul smelling discharge from either main wound or drain site.
Features of infection, with skin excoriation.
Features suggestive of cause.

Investigations

CT fistulogram to delineate the track.
CT scan abdomen to find out the other pathology.
Other relevant investigations, Hb%, albumin level, etc.

Treatment

Initially conservative—antibiotics, IV fluids, dressing, zinc oxide cream over the skin, observation.

Most of the time fistula subsides, provided there is no distal obstruction by adhesions or kinking or specific causes like carcinoma or tuberculosis. If persists even after 6 weeks, resection of ileocaecal segment and anastomosis is done.

TROUBLES IN APPENDICECTOMY

During surgery if appendix is found normal, other cause for symptoms should always be looked for like Meckel's diverticulum, Crohn's disease, ovarian/pelvic causes in females, malignancy, etc.

Appendicular tumour may be found. If it is in the tip, appendicectomy is sufficient. It could be carcinoid tumour. If it is in the base right hemicolectomy is done.

Absence of appendix—a rare occasion can occur. Caecum and taeniae should be traced properly before finalising it.

Appendicular abscess/pelvic abscess formation may create difficulty in managing the situation.

Malignancy in the caecum if identified on table—right hemicolectomy should be done.

Fig. 21-93: Wound infection after appendicectomy; secondary suturing is done at a later period.

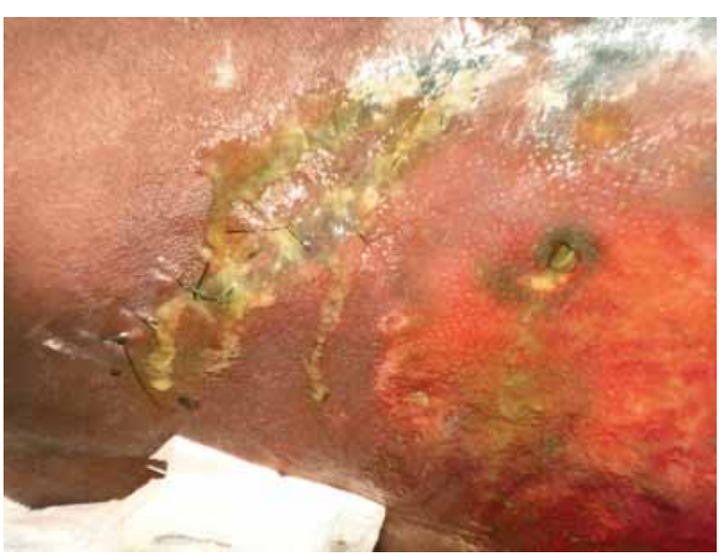


Fig. 21-94: Faecal fistula after appendicectomy.

If Crohn's disease is identified during surgery, appendicectomy can be done with care, if base of the appendix is normal. But in rare occasion where appendix is involved by Crohn's disease, appendicectomy should not be done but treated only with antibiotics and steroids, otherwise fistula can develop.

Mortality rate of appendicectomy is less than 1%. Morbidity and complications are more after surgery for perforated appendicitis.

Surgical site infection is 5% in uncomplicated appendicitis; 20% in perforated appendix after surgery.

Small bowel obstruction postoperatively is 1% with simple appendicitis; 3-5% in perforated appendicitis after surgery.

More than 50% of obstruction occurs in first year of postoperative period. In children with appendicitis, there is poor localisation and so peritonitis is common. So conservative therapy should be avoided. Surgery is the only choice of treatment otherwise early peritonitis is the danger. Appendicular mass is initially treated with *Ochsner Sherren* regime. After 6 weeks, *interval appendicectomy* is done.

Children, old age, faecolith, laxative abuse, diabetes mellitus, immunosuppression and pelvic appendix are high-risk factors for perforation in appendicitis. In pelvic and retrocaecal appendicitis, adjacent ureteral inflammation can occur in which urine on analysis shows blood cells and pus cells. Incidence of removal of normal appendix is 30%. *Stump appendicitis* is inflammation and infection in the remaining portion of the appendix stump after appendicectomy. It is a rare entity. If on table during surgery normal appendix is found, it is called as '*Lily white appendix*'. Then other pathology like Meckel's deventicular, ileal/mesenteric lymph node/ovarian disease should to be looked for.

Appendicitis is the commonest acute abdominal condition found in pregnancy, their site of pain and features vary. They need appendicectomy by laparotomy. Laparoscopic appendicectomy is under trial in pregnancy. It is more common in 1st and 2nd trimester. Guarding and rebound tenderness will be absent. Risk of premature labour is 15%. Fetal death is 5%; but if appendix busts it raises to 29%. Maternal mortality raises to 10 times after 6 months **(Fig. 21-95)**.

SMALL INCISION OPEN APPENDICECTOMY

Often many surgeons do open appendicectomy using a very small incision of 1.5 to 2.0 cm in length. Even though cosmetically it is good, due to availability of laparoscopic appendicectomy this procedure should be avoided. And also it is a blind forcible procedure which is

Fig. 21-95: Appendicectomy in pregnancy—it is usually done through laparotomy.

against surgical principle as appendix is pulled out through the wound forcibly and mesoappendix also tied forcibly with traction. There are chances of tearing of the mesoappendix, and serosa of the caecum. Moreover, once mesoappendix and stump of the appendix are tied and pushed into the peritoneal cavity, it is impossible to visualize the stump for its security and integrity making the entire procedure as presumption and blind **(Fig. 21-96)**.

Procedure

Procedure is done under general anaesthesia; a small incision of 2 cm is made in MacBurney's point. Skin, superficial fascia, external oblique, internal oblique and transversus abdominis are separated accordingly. Peritoneum is identified and is held using haemostat. Once peritoneum is opened its edges are held securely with 4-6 artery forceps (haemostats). These arteries should never be removed until appendicectomy is complete and peritoneum is closed. Using Babcock's appendix is gently pulled out into the wound with traction. Caecum is also pulled out to identify the base of the appendix. Caecum is pushed back into the peritoneal cavity with base being held using Babcock's forceps. Mesoappendix is clamped and ligated up to the base. Base is transfixed using vicryl. Another simple ligature is also placed to the base. After cutting the appendix stump is pushed back into the peritoneal cavity. Peritoneum is closed using purse string vicryl suture. Muscles apposed using one or two vicryl sutures. External oblique is closed. Skin apposed using absorbable subcuticular suture.

LAPAROSCOPIC APPENDICECTOMY

History

In 1983, Semm from Germany did first incidental laparoscopic appendicectomy. In 1987 Schrieber reported laparoscopic appendicectomies in women in acute appendicitis.

Principles and Indications

Laparoscopic appendicectomy is a relatively controversial topic as most of the surgeons including those in the West still favor open appendicectomy in all cases. The main point of concern especially for cases that present late or those with burst appendix is the failure to give adequate peritoneal toileting and the formation of abscesses in the peritoneum. This fear can be alleviated by the use of thorough irrigation with antiseptic solution and insertion of drain through lateral port for evacuation of debris. It is still recommended that the beginner have a low threshold for conversion if he finds that the appendix is not visualized, is very friable, is perforated or the peritoneum is severely contaminated. Even though most experienced surgeons are capable of taking out the appendix via a very small incision there are situations where laparoscopic appendicectomy scores over open procedure. These are:

- Vague chronic abdominal pain where diagnostic laparoscopy culminates in an appendicectomy.

Fig. 21-96: Small incision open appendicectomy technique.

- Right iliac fossa pain in young women where the cause is of doubtful appendicular or ovarian/fallopian tube origin.
- Patients with atypical pain where there is chance of abnormal position of appendix such as subhepatic or in situs inversus.
- Obese individuals where a large incision may be required to access the abdomen.
- Diabetics where there is a chance of wound infection.
- Interval appendicectomy where recovery and discharge is faster in laparoscopic appendicectomy.

Note:

In spite of all these debate laparoscopic appendicectomy has become gold standard due to its added advantages compared to disadvantages.

Cases which should be taken up with caution (preferably by an experienced laparoscopic surgeon) are:

- Patients who are poor risk for general anesthesia.
- Patients whose abdominal scan shows formation of abdominal mass
- Patients with previous lower abdominal surgery
- Patients with stump appendicitis or burst appendix.

Ideal case for a beginner would be a young adult with pain of less than 48 hours of duration when you will find a turgid appendix which is still mobile in the peritoneal cavity without much of omental adhesion and pus formation. The routine work up of the patients is done as for open surgery. Consent is taken for laparoscopic surgery as well as for conversion in each case irrespective of the nature of the case. A nasogastric tube is not routinely placed if open access technique is used but it is used if surgeon uses Veress needle to create pneumoperitoneum. Catheterization is done to evacuate the bladder. It may be discontinued for routine cases when the surgeon has got enough experience to cut down the operating time. In these cases the patient is asked to void just before the procedure to keep the bladder empty.

Advantages of Laparoscopic Appendicectomy

- It allows thorough exploration of the contents of the peritoneal cavity especially in females. It also facilitates treatment for additional pathology identified like ovarian cyst in same sitting.
- It allows easier approach in subhepatic appendix and appendix in situs inversus.
- It allows lesser hospital stay (24 hours); can be done as day care surgery in uncomplicated cases.
- Pain in postoperative period is less with faster recovery period and also early return to work. Trauma of access is less.
- It reduces/prevents the incidence of wound complications.
- It is cosmetically better and avoids unnecessary laparotomy.

Disadvantages of Laparoscopic Appendicectomy

Technical difficulties in mobilizing the appendix; clearing the adhesions; cauterizing the mesoappendix; placing ligatures around appendix; extraction of the appendix.

One should always take prior consent for conversion into open appendicectomy.

Contraindications

It is relatively contraindicated in previous lower abdominal surgery, pregnancy with appendicitis, malignancy, palpable appendicular mass, immunosuppressed individual, comorbid status.

Instruments

1. Veress needle.
2. 10 mm port- 2 in no.
3. 5 mm port -1 in no.
4. 30° camera; xenon light source; 3 chip camera; monitor; CO_2 cylinder; CO_2 insufflator;
5. Maryland dissector.
6. Babcock dissector.
7. Bipolar forceps.
8. Scissors.
9. Suction irrigation.
10. Endoloops.
11. Endo bag.

Position of the Patient and Operating Room Setting

The patient is in supine position with Trendelenburg position to start with. Once the ports are in place and surgeon is ready to proceed with actual procedure the patient's right side it tilted up so as to clear right iliac fossa of small bowel. This can be done by tilting the table or placing a sand bag under the patient.

Monitor is kept on foot end towards right. Surgeon stands on left side facing downwards. Camera surgeon will stand on right side of the surgeon or diagonally opposite side (right side) depending on the convenience. Scrub nurse will stand on right side at distal end. Additional monitor may be placed on the left side, left of the surgeon to facilitate the proper view of the video images to people standing on the right side.

Laparoscopic appendicectomy is done under general anaesthesia **(Fig. 21-97)**.

Procedure

The first trocar (10 mm or 5 mm depending on the telescope being used) is inserted via a periumbilical incision. Access to the peritoneum can be gained by either insertion of Veress needle followed by trocar or direct insertion of trocar by open Hasson's method. After insertion of the first port, the telescope is inserted and entire abdominal cavity is inspected. 10 mm 30^0 camera is always better; but zero degree is sufficient to do usual appendicectomies. After this the attention is directed towards the right iliac fossa. Adequate tilt is required to clear the small bowel from the field. The secondary ports are inserted under direct vision so as to prevent injury to underlying bowel. The positions of the working trocars vary widely from person to person and from case to case. It is better for the surgeon to place the trocars according to the findings inside the abdomen. The position of the appendix can vary widely and also the amount of adhesions depends on factors such as number of previous attacks and duration of present attack.

The first port is inserted via an 11 mm infra umbilical incision either by open or closed technique. Subsequent two 5 mm ports are placed under vision. One port is commonly in the midline between umbilicus and pubic symphysis. The other is variable. Some surgeons prefer another port at the level of the umbilicus in the right almost in the anterior axillary line while others place it in right iliac fossa. Many other surgeons also in West like the working port to be placed in left iliac fossa. The point for consideration here is that the basic triangulation which is preferred in performing laparoscopy should be maintained. Any of the above mentioned port placement is correct as long as the surgeon is comfortable and performs a safe surgery. One

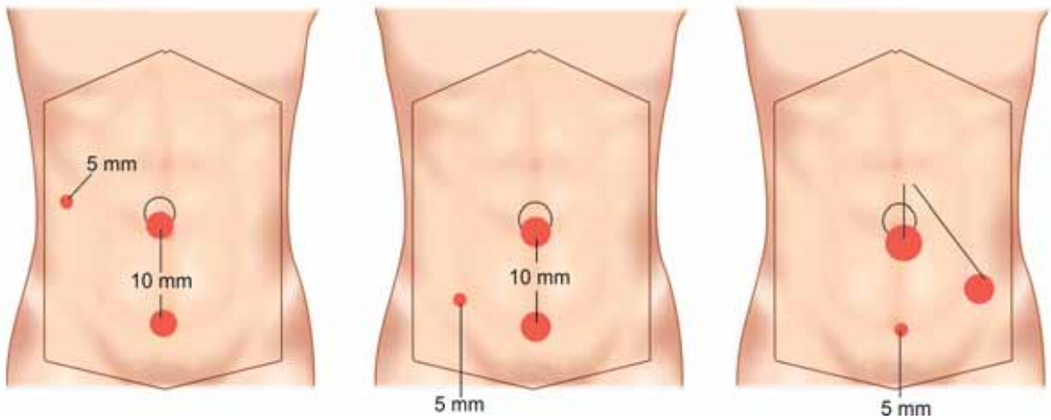


Fig. 21-97: Approaches for laparoscopic appendicectomy.

should not go in with a fixed idea for the ports as very often the surgical field demands alteration in the port placement. If endoloops are used as ligatures, left sided two additional working ports suffice (10 mm and 5 mm); if intracorporeal ligatures or transfixation are used then one port on midline below the umbilicus or in left iliac fossa and other on the right iliac fossa is a need to facilitate taking needle bites and putting ligature. Working ports are inserted always under vision. Additional 4th 5 mm working port can be used in difficult appendicectomies which will facilitate retraction of bowel or holding the appendix.

The left hand Babcock's forceps is used to hold the appendix and right hand Maryland dissector is used to trace the entire length of the appendix and reach the base of the appendix. Different energy source can be used to coagulate and divide the mesoappendix. For the basic set up and also most often bipolar coagulation forceps is adequate for the process.

Bipolar forceps is applied to the free edge of the mesoappendix and curved scissors is used to divide the same. This dissection is continued up to the base of the appendix. Harmonic scalpel may ease and quickens the job.

Use knot pusher to place three ties around the base of appendix. Grasping the appendix through the loop is an easy method to do this. Preformed endoloops can also be used. Many surgeons place intracorporeal ligatures using vicryl often with transfixation. Stump should have two ligatures in situ after appendicectomy. If faecolith is present it should be milked distally towards body using Maryland forceps **(Fig. 21-98)**.

After this the base of the appendix is secured with preformed endo loop or suture passed via the knot pusher. Three ties are placed. Between proximal most ligature and 2nd ligature gap should be less than 5 mm. The appendix is divided using curved sharp scissor between 2nd and 3rd ligatures. Intestinal stapling device can be used to cut and close the stump with two rows of staples. But stapling is not very popular and not cost effective. Specimen is removed through 10 mm working port using an extraction bag or finger of no 7.5 or 8 sterile gloves or using sterile condom **(Fig. 21-99)**.

If the appendix is friable or is badly infected then specimen retrieval bag should be used to prevent infection at port site. A thorough wash is given to the area using normal saline. A good look at the pelvis should be done before finishing the procedure. Choice of leaving a drain is dictated on case to case basis. It is recommended to close all fascial defects made by 10 mm ports as lot of subsequent hernias are been reported. Difficulty arises whenever there is a phlegmon or abscess or perforation. Subserosal appendix should be identified by incising the serosa carefully. Postileal, subhepatic and situs inversus appendix should be remembered **(Fig. 21-100)**.

A rapid recovery from ileus is noted in almost all patients when compared to open appendicectomy and early commencement of oral intake is not associated with higher complications. The patient is usually discharged within 48 hrs of surgery.

After putting telescope through umbilical port, if appendix mobilization looks easier and not a very turgid appendix, then both working ports can be 5 mm. In such occasions after cutting, appendix is extracted through the umbilical 10 mm port. 5 mm telescope is attached to the camera can be used to visualize extraction procedure.

Key steps

1. Camera port at umbilicus.
2. Two working ports one in midline and one in right flank.
3. Divide the mesoappendix after cauterizing with bipolar forceps.
4. Secure the appendix with endoloop.
5. Divide and retrieve appendix. Use endobag, if needed.
6. Wash the area.
7. Keep drain if needed.

Complications

- Injury to bowel, vessels while passing the ports.
- Complications of pneumoperitoneum.
- Accidental cautery injury to bowel, vessels and other vital structures.
- Bleeding, bowel perforation, peritonitis.
- Slipping of ligature, leak, peritonitis, fistula formation.

All complications need re-evaluation with US/CT abdomen; total count; liver function tests; platelet count. Higher generation antibiotics may be needed and one should not be hesitant to use it to control/prevent distressing septicaemia. Reopening if needed should be done at the earliest. Re laparoscopy can be ideal to observe what went wrong and amount of collection in the peritoneal cavity. Laparotomy with adequate midline incision should be done. Any pus collection should be drained. Perforation should be identified, is usually located in the caecum or ileum; it is closed using interrupted silk sutures. Adhesions, bands should be released. Thorough normal saline wash is given. Resection of the ileocaecal segment may be needed occasionally. Occasionally ileo transverse colon bypass anastomosis may be considered if caecal and appendicular stump area looks unhealthy. Proper assessment of the problem and proper

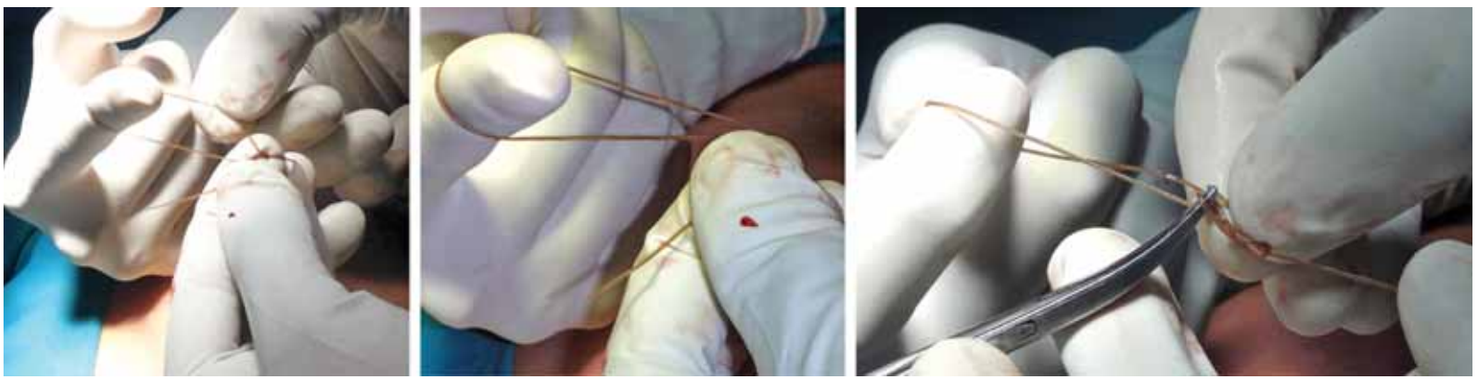


Fig. 21-98: Creating the Roeder's knot.

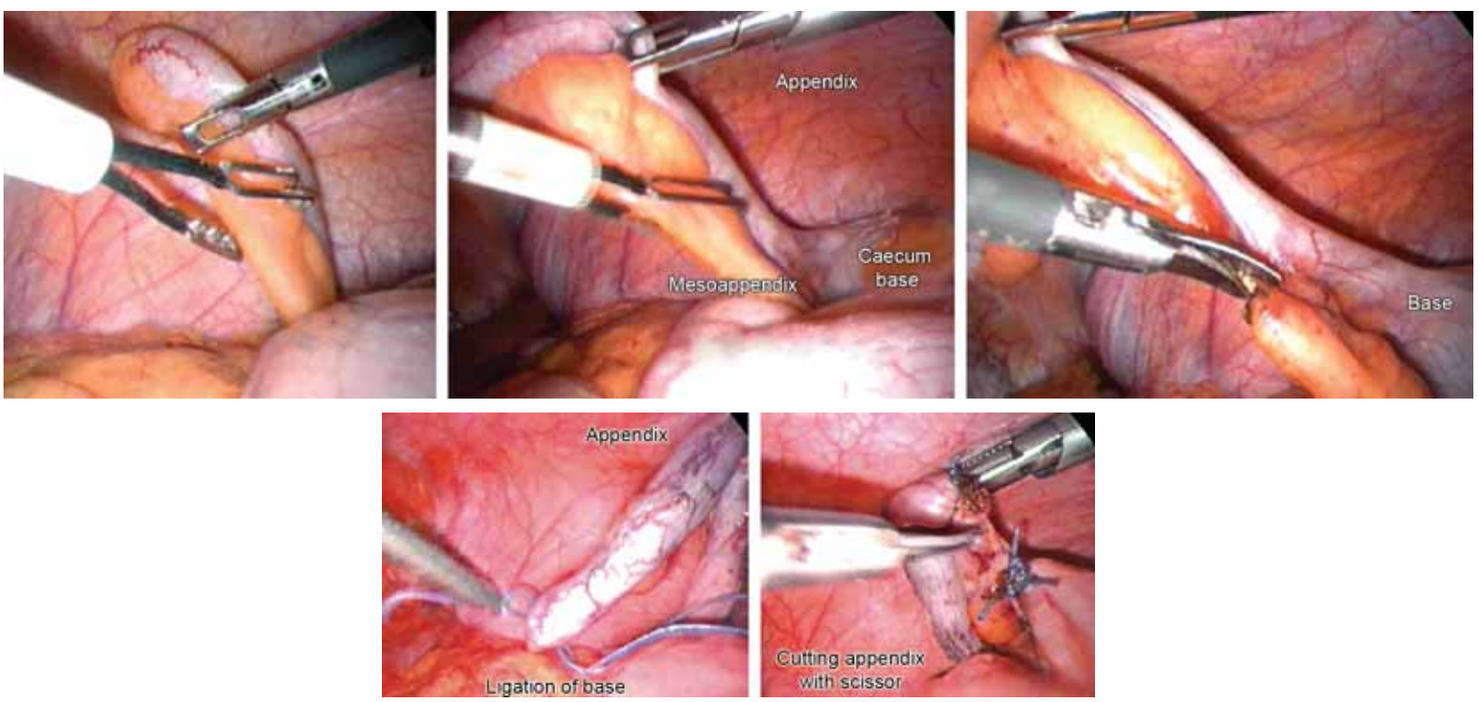


Fig. 21-99: Suturing of base in laparoscopic appendicectomy.

decision on table should be taken to achieve an optimum recovery as 3rd reopening after 2nd will be more troublesome and often may be disastrous. So all possible options should be kept in mind to achieve complete control of the problem.

Note:

It is ideally always better to use bipolar cautery while dissecting the mesoappendix. Additional precaution should be taken while cauterizing close to the caecum adjacent to base of the appendix.

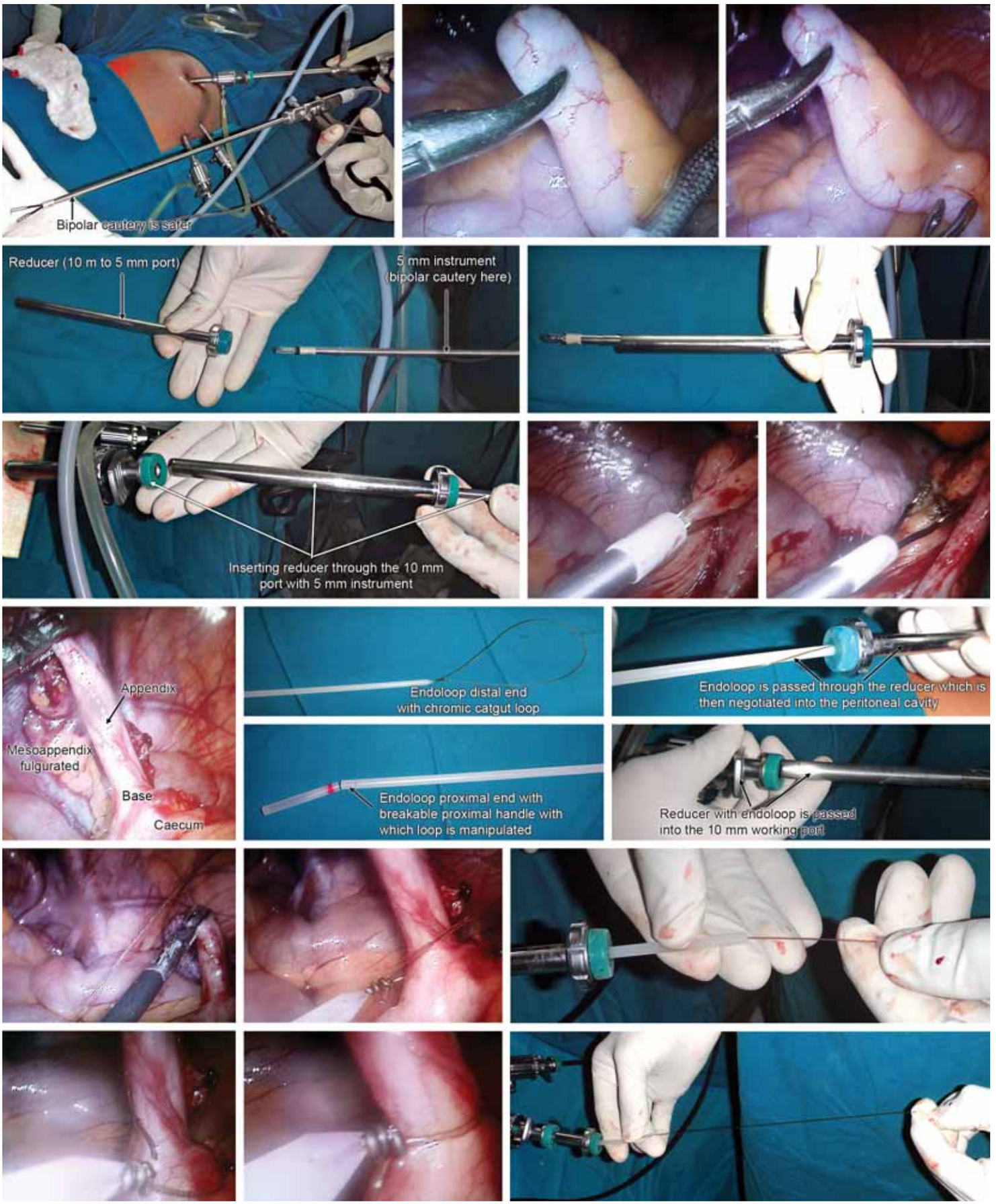
When uncomfortable, conversion to open procedure should be done without hesitation; otherwise one should call and request another laparoscopic surgeon for help.

LAPAROSCOPY ASSISTED APPENDICECTOMY

This technique combines the advantage of visualization of internal anatomy and confirmation of appendicitis and also fast completion of the procedure by open method. The inflamed appendix is brought out to the exterior via a 10 mm trocar and the procedure of appendicectomy is carried out as in open surgery. The first trocar is placed around the umbilicus **(Fig. 21-101)**.

After inspection of the abdomen the nature of the appendix is assessed. Appendix which is around 6-8 mm, turgid, freely mobile in the peritoneal cavity and having minimal non purulent fluid collection in RIF are easily and ideally removed via this approach **(Fig. 21-102)**.

In these cases it is easy to apply some amount of traction on the appendix to deliver out these through the trocar wounds. It is important to assess how much traction the appendix can take (as a friable appendix can get cut when traction is applied). Such appendix which is very turgid and friable should be removed by division inside the peritoneal cavity as already described. The appendix is delivered through the umbilical port after mobilization or is brought out through a port placed in right iliac fossa. The position of the second trocar in right iliac fossa is variable and is dictated by the position of the base of the appendix which is seen on the inside. The tip of the appendix is grasped with a Babcock forceps on a reducer and delivered out of the wound. The gas flow to the abdomen is stopped


Bipolar cautery is safer
Reducer (10 m to 5 mm port)
5 mm instrument
(bipolar cautery here)
Inserting reducer through the 10 mm
port with 5 mm instrument
Appendix
Mesoappendix
fulgurated
Base
Caecum
Endoloop distal end
with chromic catgut loop
Endoloop is passed through the reducer which is
then negotiated into the peritoneal cavity
Endoloop proximal end with
breakable proximal handle with
which loop is manipulated
Reducer with endoloop is passed
into the 10 mm working port

Figs 21-100(1)

Figs 21-100(2)

Figs 21-100(1 and 2): Laparoscopic appendicectomy.

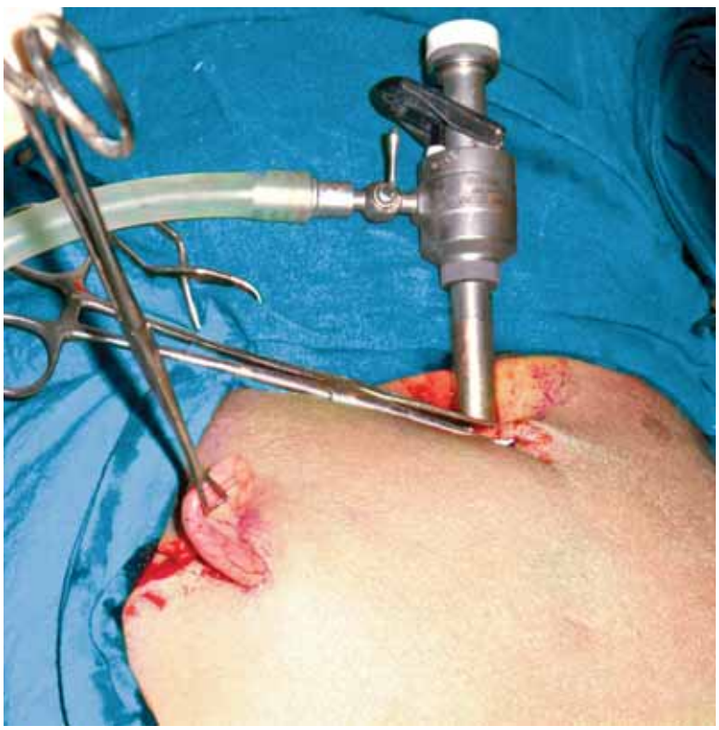


Fig. 21-101: Laparoscopic assisted appendicectomy.

and the pneumoperitoneum is evacuated. This step is important to facilitate the delivery of the appendix through the wound. After this the procedure is same as for open appendicectomy. The mesoappendix is ligated and divided up to the base of the appendix and then appendicectomy is carried out. The stump is inspected for bleeding and caecum is pushed back into the abdomen. Pneumoperitoneum is recreated and the appendicular stump is again inspected to make sure that there is no bleeding. The pelvis can be washed with normal saline if a collection is seen. The right paracolic gutter is also inspected for any purulent collection and wash is given to the area. Keeping a drain is not a routine practice but the operating surgeon is the best judge to assess the same. Keeping a drain through the trocar site is simple and this can be removed after 24 hours. This is reassuring for surgeons performing initial few cases of laparoscopic appendicectomy.

Key steps

1. Camera port at umbilicus.
2. Second port over the base of the appendix.
3. Grasp the tip of the appendix with Babcock.
4. Evacuate pneumoperitoneum.
5. Deliver the appendix out via the working port.
6. Proceed with a routine appendicectomy.
7. Check the abdomen after procedure.

APPENDICULAR ABSCESS

It occurs due to suppuration in an acute appendicitis or suppuration in an already formed appendicular mass. Abscess commonly *occurs in retrocaecal* region but often can occur in subcaecal, preileal lumbar or postileal regions. *Pelvic abscess is also common after an attack of acute appendicitis* **(Fig. 21-103)**.

Features

High fever, features of toxicity with a soft, tender, swelling dull to percuss swelling in right iliac fossa which lies towards right lateral and lower side with clear upper margin but indistinct lower margin**.** U/S confirms the diagnosis.

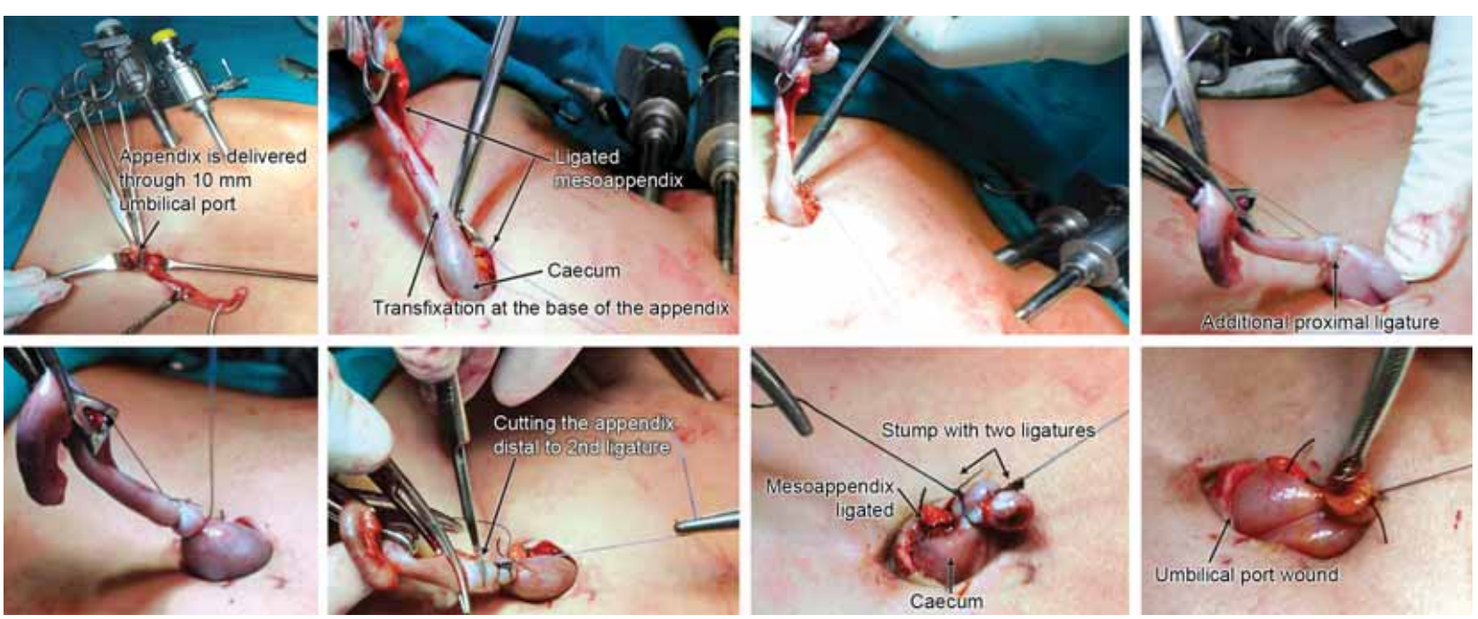


Fig. 21-102: Laparoscopic assisted appendicectomy - technique.

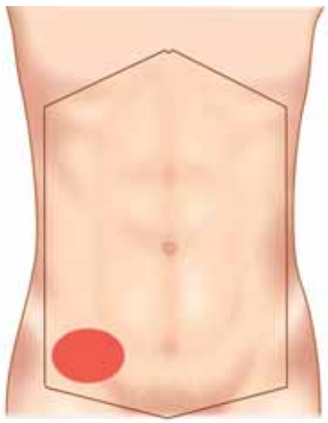


Fig. 21-103: Appendicular abscess.

Treatment

Antibiotics are started. US or CT guided catheter drainage initially followed by interval appendicectomy in 12 weeks is quiet useful.

If patient is not responding then under general anaesthesia, incision is made in the lower lateral aspect of the swelling above the inguinal ligament. Skin, external oblique muscle is cut. Abscess cavity is opened and pus is drained *extraperitoneally*, which is sent for culture and sensitivity. Wound is closed. A drain is placed through a separate incision. Antibiotics are continued. *Interval appendicectomy is done after 3 months.*

Recent study has confirmed that immediate appendicectomy in appendicular abscess showed higher rates of complication and hospital stay compared to initial percutaneous/open drainage followed by interval appendicectomy at 12 weeks.

Chapter

22

Surgeries of Liver and Biliary System

A. LIVER

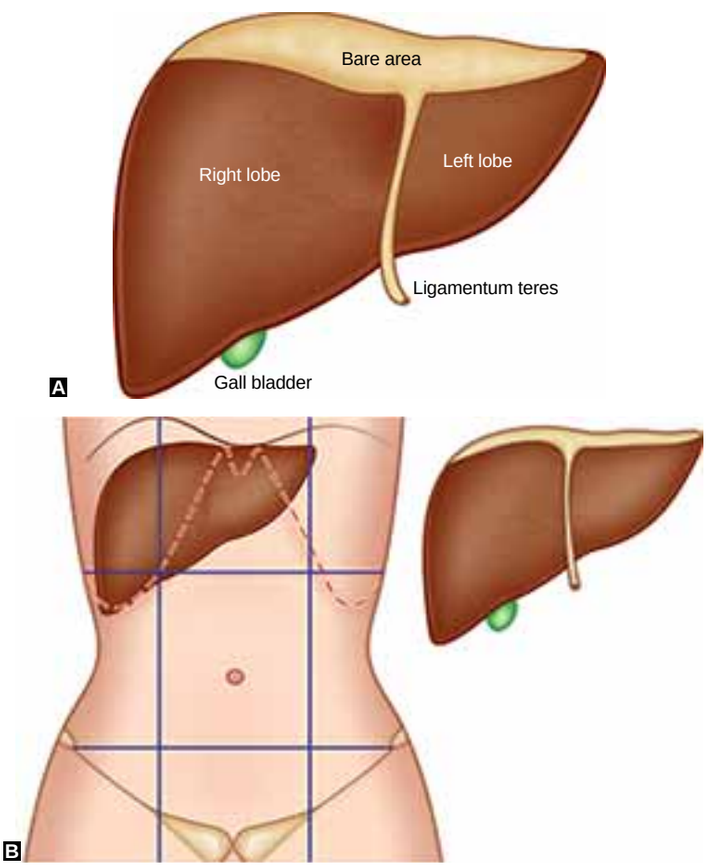
- Surgical anatomy
- Liver resection
  - Principles and indications
  - Left hepatectomy
  - Right hepatectomy
  - Extended hepatectomy
  - Segmetectomies and non-anatomical resections
- Liver transplantation
- Surgical treatment of portal hypertension
- Surgical treatment of hydatid cyst

SURGICAL ANATOMY

The liver has always been noted to have the power of regeneration even from the time of Greek mythology where Prometheus was chained to a rock and an eagle would feast on his liver and it would regenerate each night in time for the eagle's return. It is a unique organ which can regenerate as well as be replaced with transplantation. Surgery of the liver is both easy and tough at the same time.

Grossly liver can be divided into right, left, quadrate and caudate lobes. It weighs around 1500 g. It is the largest gland of the body. It extends downwards from 5th intercostal space mainly on the right side partly on the left side. It is wedge-shaped like a pyramid of 4 sides. The falciform ligament divides the liver into right and left lobe on the diaphragmatic surface and ligamentum teres divides the same on the inferior surface. The quadrate lobe is situated between the gallbladder fossa and the porta hepatis. And the caudate lobe is situated between the inferior vena cava, the porta and fissure carrying ligamentum venosus. This division, however, does not represent the functional anatomy of the liver **(Fig. 22-1)**.

Different peritoneal attachments of the liver are called as ligaments of the liver which are important in initial mobilization of the liver. Anterior and posterior reflections of the liver are called as anterior and posterior coronary ligaments. Between these two lies the 'bare area' without peritoneal coverage and is directly related to the diaphragm. On right and left side two reflections join and form right and left triangular ligaments. Anteriorly it reflects on the superior surface of the liver and abdominal wall and forms falciform ligament; in between folds of falciform ligament, embryonic left umbilical vein



Figs 22-1A and B: Anatomy of liver—surface and gross.

forms round ligament/ligamentum teres; it also forms a fissure in the liver to separate liver into apparent right and left lobes **(Fig. 22-2)**.

On the visceral surface, it extends as fissure for the ligamentum venosum. Between ligamentum venosum and gallbladder lies the quadrate lobe; between it and porta hepatis posteriorly lies the caudate lobe. At porta hepatis peritoneum extends as lesser omentum extending into the stomach and duodenum as hepatogastric and hepatoduodenal ligaments. Free right margin of the lesser omentum contains common bile duct, hepatic artery and portal vein with foramen Winslow communicating lesser sac into free peritoneal cavity **(Figs 22-3 and 22-4)**.

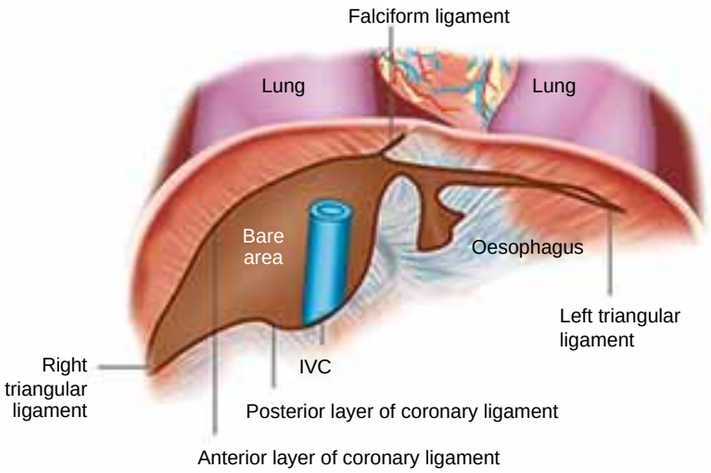


Fig. 22-2: Inferior surface of the diaphragm showing bare area; IVC position; coronary ligament; right and left triangular ligaments.

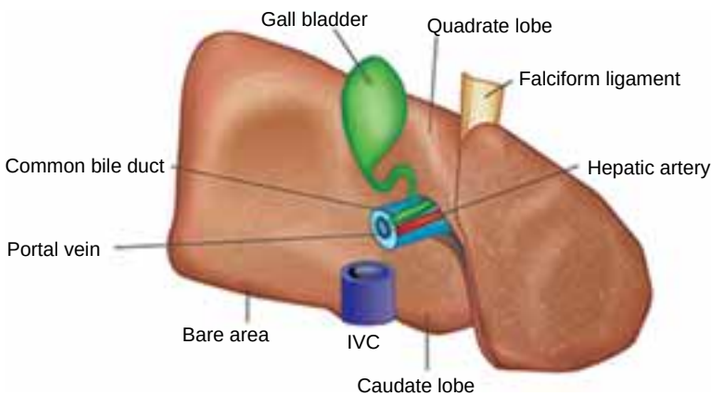


Fig. 22-3: Visceral surface of the liver.

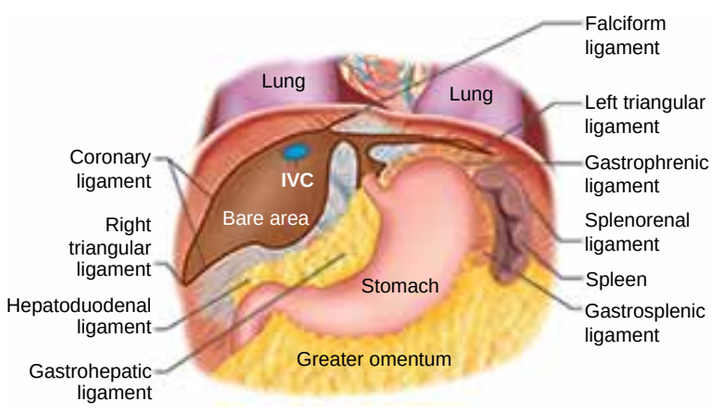


Fig. 22-4: Peritoneal reflections and ligaments of the liver.

True left lobe contains left lateral and medial segments; each is divided into superior and inferior subsegments. Right lobe is divided into anterior and posterior segments by invisible imaginary intersegmental fissure; each again is divided into superior and inferior subsegments **(Fig. 22-5)**.

Caudate lobe is indirect contact with IVC at its left side; it is often divided into right and left parts and caudate process. Caudate lobe

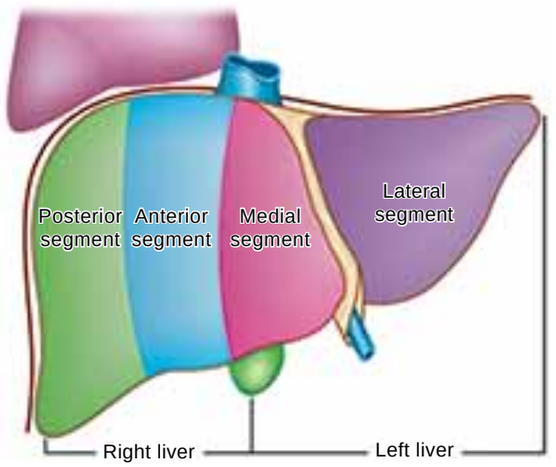


Fig. 22-5: Right lobe of liver (right liver) contains anterior and posterior segments; left lobe (left liver) contains medial and lateral segments.

derives its connections from bile duct, hepatic artery and portal veins of both right and left lobes. Caudate lobe is a separate region as such. It is segment 1, and is anatomically and functionally separate from right and left livers. It is behind the liver hilum and in front of retrohepatic IVC. Caudate lobe proper is called as *spigelian lobe*. In front, it is fused to segment 4; right side to segments 6 and 7. It is not draining into the hepatic veins; but drains directly into the retrohepatic IVC at its left front aspect. It derives its portal blood supply from three branches from main, right and left portal veins. Three branches arise from right and or left hepatic arteries. Ducts from caudate lobe run in front of the portal branch vein to drain into right or left hepatic duct or both.

Left lobe may be diminished in size as anomaly. Usually right lobe is 2/3rd of total liver mass. *Riedel's lobe* is an elongated tongue of liver extending from the right lobe to or below the umbilicus. It presents as an asymptomatic right upper abdomen unexplained mass in a middle-aged lady **(Fig. 22-6)**.

Grossly liver has got diaphragmatic and visceral surfaces. Diaphragmatic surface has got anterior, superior, posterior and right parts. Anterior part is related to diaphragm, costal margins, xiphoid process, and anterior abdominal wall; its inferior margin has got a deep notch for ligamentum teres and a wider notch for gallbladder. Superior part is related to diaphragm and is separated from right pleura and lung, pericardium, left pleura and lung. Posterior part is related to diaphragm and ribs; bare area and sulcus for IVC is located

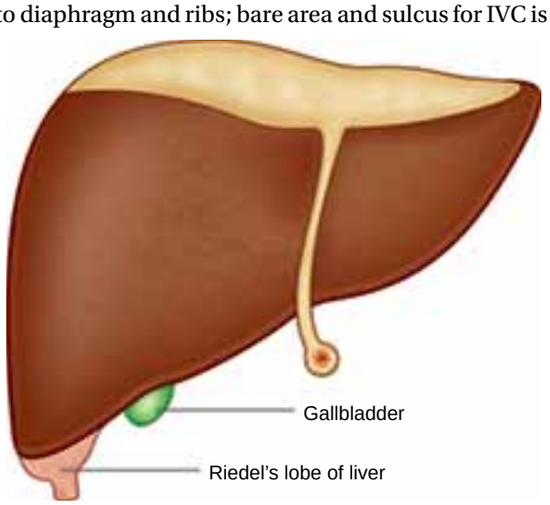


Fig. 22-6: Riedel's lobe of liver. It is common in females; presents as unexplained mass.

here. Right part is related to diaphragm, right pleura and lung, 7th to 11th ribs. Visceral surface is related to hepatic flexure and transverse colon in front; hepatorenal pouch (Morrison's) right kidney and right adrenal behind; gallbladder in gallbladder fossa of liver; 1st and 2nd part of the duodenum; oesophagus and stomach.

All the surgical techniques are based on the functional anatomy of the liver. The foundation of which was laid by J Cantlie in 1898 when he described *Cantlie's line* which passes to the left of the gallbladder fossa to the left of inferior vena cava. *Claude Couinaud* then divided into 8 functional units based on separate vascular and biliary pedicle (in clockwise direction). This has laid the foundation to all anatomical resection of liver. At the hilum, the right portal vein pursues a very short course (1–1.5 cm) before entering the liver. Once entering the hepatic parenchyma, the portal vein divides into a right anterior sectoral branch that arches vertical in the frontal plane of the liver, and a posterior sectoral branch that follows a more posterolateral course. The right portal vein supplies the anterior (or anteromedial) and posterior (or posterolateral) sectors of the right lobe. The branching pattern of these sectoral portal veins subdivides the right liver into 4 segments—segments V (anterior and inferior) and VIII (anterior and superior) form the anterior sector, and segments VI (posterior and inferior) and VII (posterior and superior) form the posterior sector. In contrast to the right portal vein, the left portal vein has a long extrahepatic length (3–4 cm) coursing beneath the inferior portion of the quadrate lobe (segment 4B) enveloped in a peritoneal sheath (the hilar plate.) Upon reaching the umbilical fissure, the left portal vein runs anteriorly and superiorly within the liver substances, and gives off horizontal branches to the quadrate lobe medially (segments IV A (superior) and B (inferior)) and to the left lateral segment (segments III (inferior) and II (superior)). The caudate lobe (segment I) is neither part of the left nor right lobes, though it lies mostly on the left side. To avoid confusion and bring uniformity in nomenclature of hepatic surgeries, the International Hepato–Pancreato–Biliary Association (IHPBA) which promotes understanding of causes, investigation and treatment of liver, pancreas and biliary tree disorders in 2000, during the recent World Congress of IHPBA in Brisbane presented their recommendations (for example, right hemiliver = right hepatectomy, right anterior section = right anterior sectionectomy, segments 1–9 = segmentectomy) **(Figs 22-7 to 22-9)**.

Blood Supply

Hepatic Artery

Hepatic artery supplies around 20% of total inflow to the liver. The anatomy of hepatic vasculature is standard only in about 60% of the patients. Several anomalous vessels supply segments of liver where they are termed as replaced hepatic arteries. The hepatic artery is one of the three branches of celiac trunk arising from the aorta at L1 vertebral level. The common hepatic artery typically passes forward for a short distance in the retroperitoneum where it then emerges at the superior border of the pancreas and left side of the common hepatic duct. After arising

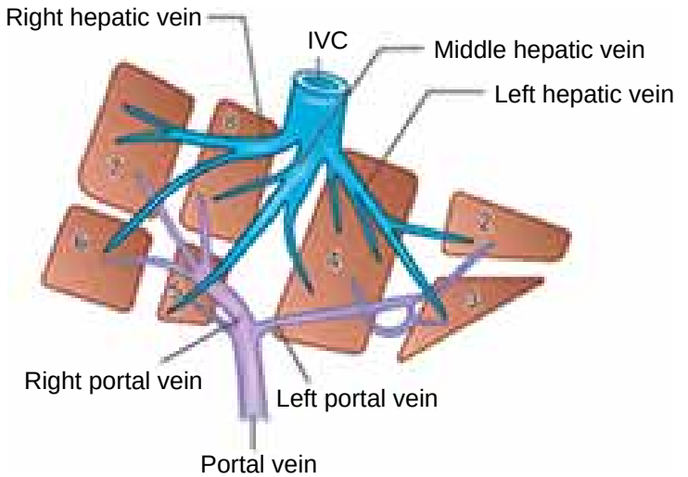
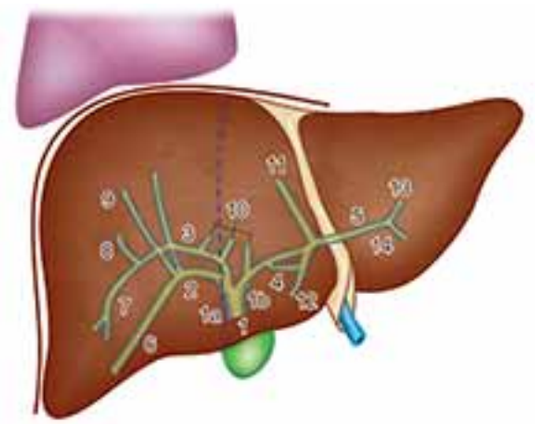


Fig. 22-7: Cantlie's line and Couinaud's segments in liver. Caudate lobe is segment 1.



1. Common hepatic duct
   1a - Rignt hepatic duct
   1b - Left hepatic duct
2. Anterior branch
3. Posterior branch
4. Medial branch
5. Lateral branch
6. Anteroinferior
7. Posteroinferior
8. Posterosuperior
9. Anterosuperior
10. Caudate branch
11. Medial superior
12. Medial inferior
13. Lateral superior
14. Lateral inferior

Fig. 22-8: Distribution of biliary tree intrahepatically and portal plate.

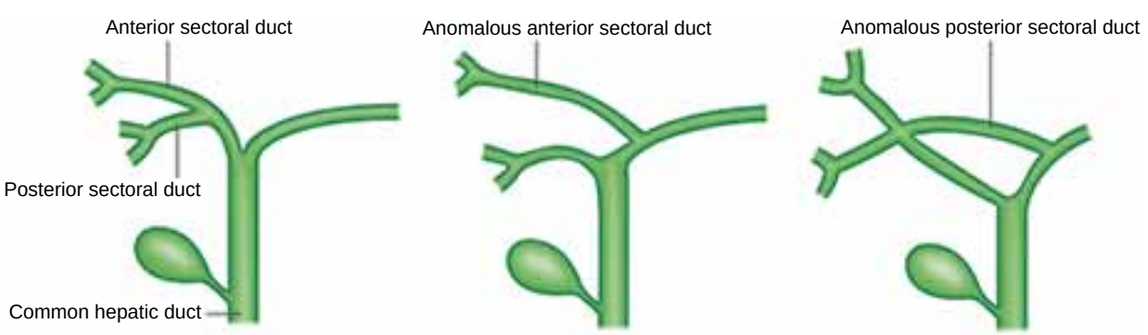
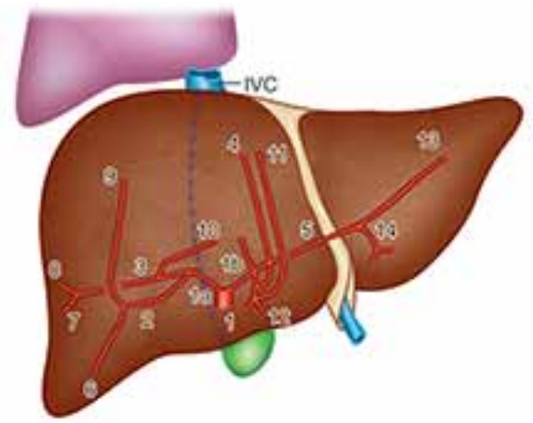


Fig. 22-9: Usual pattern and anomalies which can occur in sectorial ducts in the liver.

from the celiac axis, the common hepatic artery turns upward and runs lateral and adjacent to the common bile duct. The gastroduodenal artery that supplies the proximal duodenum and pancreas is typically the first branch of the common hepatic artery. The right gastric artery takes off shortly thereafter and continues within the lesser omentum along the lesser curve of the stomach. At this point, the common hepatic artery is referred to as the proper hepatic artery. The proper hepatic artery courses towards the hilum, and soon divides into the right and left hepatic arteries. Prior to the bifurcation, a small cystic artery branches off to provide blood supply to the gallbladder **(Fig. 22-10)**.



1. Common hepatic duct
   1a - Rignt hepatic duct
   1b - Left hepatic duct
2. Anterior branch
3. Posterior branch
4. Medial branch
5. Lateral branch
6. Anteroinferior
7. Posteroinferior
8. Posterosuperior
9. Anterosuperior
10. Caudate branch
11. Medial superior
12. Medial inferior
13. Lateral superior
14. Lateral inferior

Fig. 22-10: Arterial supply of the liver—distribution of hepatic artery.

The proper hepatic artery bifurcates earlier than the common bile duct and portal vein. In 80% of cases, the right hepatic artery courses posterior to the common hepatic duct before entering the hepatic parenchyma. In 20% of cases, the right hepatic artery may lie anterior to the common hepatic duct. Upon reaching the hepatic parenchyma, the right hepatic artery branches into right anterior (segments V and VIII), and right posterior sectoral branches (segments VI and VII). The posterior sectoral branch initially runs horizontally through the hilar transverse fissure (of Gunz), normally present at the base of segment V and adjacent to the caudate process. The left hepatic artery runs vertically towards the umbilical fissure where it gives off a small branch (often called the middle hepatic artery, also often it arises from right hepatic artery) to segment IV, before continuing on to supply segments II and III. Additional small branches of the left hepatic artery supply the caudate lobe (segment I), although caudate arterial branches may also arise from the right hepatic artery.The most common hepatic arterial anomaly involving a replaced vessel is a replaced right hepatic artery (25%). In this situation, the replaced right hepatic artery usually arises from the superior mesenteric artery and runs lateral and posterior to the portal vein within the hepatoduodenal ligament. In rare instances, the entire common hepatic artery, or its individual branches may arise directly off the celiac trunk or aorta.

Middle hepatic artery is an extrahepatic arterial branch originates at liver hilum from right hepatic artery (45%) or left hepatic artery (25%) or when there is anomaly of either of right or left hepatic arteries then it arises from normal of the two branches. It is present in 70% of individuals and supply segment 4.

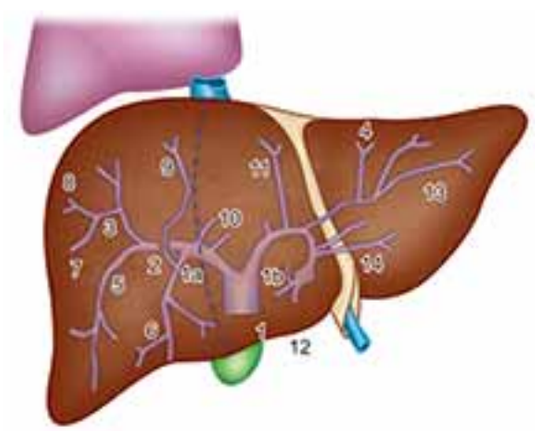
Hepatic arteries are not end arteries; translobar and subcapsular collateral circulation can exist. Right gastric and gastroduodenal may maintain hepatic blood flow. Hepatic artery ligation needs cholecystectomy.

Portal Venous System

The portal vein contributes about 80% of total inflow to the liver. The portal vein is formed by a union of the superior mesenteric vein (SMV) and splenic vein behind the neck and body of the pancreas. In up to one third of all individuals, the inferior mesenteric vein may also join this confluence. Venous tributaries from the pancreas may also drain directly into the portal vein, and generally correspond to the arterial supply. More precisely, there are anterior, posterior, superior and inferior pancreatic vessels. Access to the portal vein is typically obtained by identifying the superior mesenteric vein on the inferior surface of the pancreas. In some circumstances, it is necessary to first locate the middle colic vein within the transverse mesocolon and follow it inferiorly to the SMV **(Figs 22-11 and 22-12)**.

Right portal vein lies in front of the caudate lobe entering the right liver across the hilar plate divides into right anterior and posterior branches, right anterior branch runs vertically, divides into descending branch to segment 5 and ascending branch to segment 8. Right posterior branch runs horizontally and posterolaterally to supply segment 6 and 7. Right portal vein gives a branch to right side of caudate lobe. Left portal vein runs in portal plate for 3 cm and turns towards front and left in the umbilical fissure to join the round ligament anteriorly. It supplies segment 4 from its right side and segment 2 and 3 from its left side. Anatomical variations are common especially in right portal vein. Left portal vein is commonly extraparenchymal. Portal vein and hepatic artery branches to segment 4 can be isolated in the umbilical fissure outside the liver capsule. The left portal vein is narrower and longer compared to right portal vein. It divides into medial and lateral branches, each divides into superior, inferior branches; left portal vein gives a branch to left side of caudate lobe.

Reduction in portal blood flow increases the hepatic arterial flow but reduction in hepatic arterial flow will not increase the portal flow. Portal vein ligation can cause atrophy of liver.



1. Portal vein
   1a - Right portal vein
   1b - Left portal vein branch
2. Anterior branch
3. Posterior branch
4. Medial branch
5. Lateral branch
6. Anteroinferior
7. Posteroinferior
8. Posterosuperior
9. Anterosuperior
10. Caudate branch
11. Medial superior
12. Medial inferior
13. Lateral superior
14. Lateral inferior

Fig. 22-11: Portal venous system—intrahepatic course.

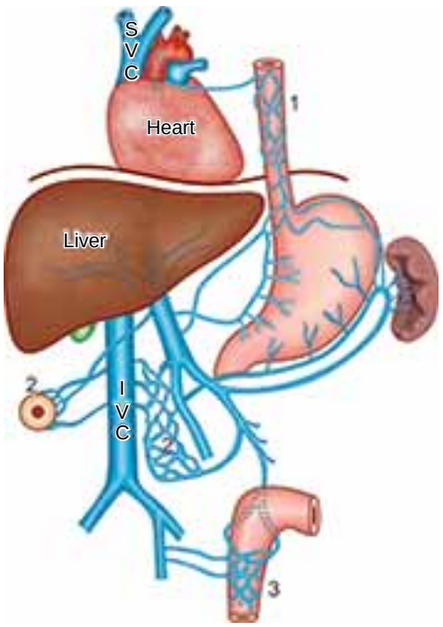
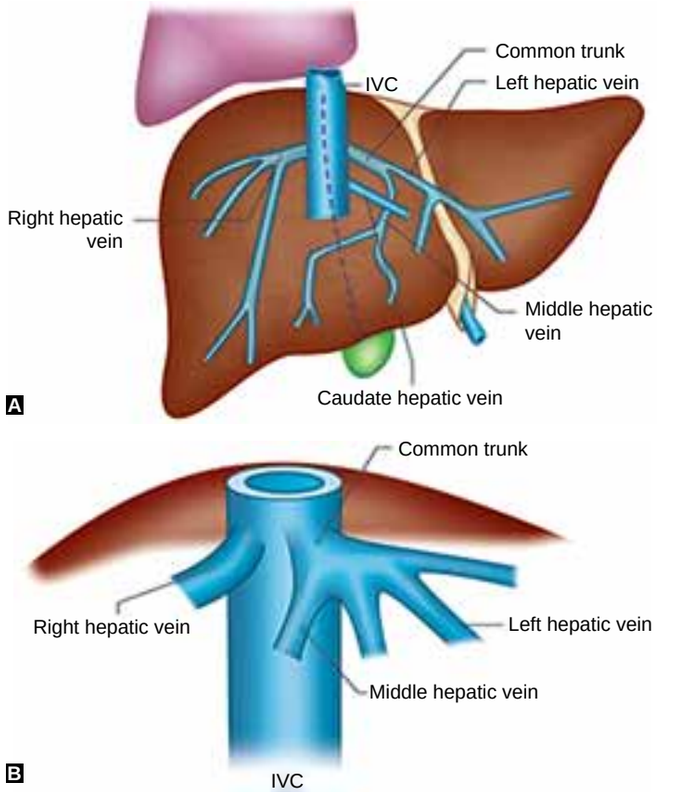


Fig. 22-12: Anatomical sites of porta systemic collaterals. 1. Lower end of oesophagus; 2. Around umbilicus; 3. Around anorectum.

Hepatic Veins (Outflow)

The three major hepatic veins (right, middle and left) comprise the main outflow tract for the liver, although additional veins (5–20) of varying size are always present as direct communications between the vena cava and the posterior surface of the right lobe. Uniquely, the caudate lobe (segment I) drains principally through direct communications with the retrohepatic vena cava. The right hepatic vein lies within the *right scissura* (or right segmental fissure) and divides the right lobe into a posterior (segments VI and VII) and anterior (segments V and VIII) sector. The middle hepatic vein lies within the *main hepatic scissura* separating the right anterior sector from the quadrate lobe. The middle hepatic vein occupies the plane separating true right and left lobes and does not follow the branches of the biliary tree. The middle hepatic vein drains from segments 5 and 6 (right anterior) and segment 4 (left medial section). The left hepatic vein lies within the *left scissura* in line with or just to the right of the falciform ligament. Left hepatic vein is formed by veins from segment 2 (transverse branch) and segment 3 (sagittal branch) **(Fig. 22-13)**.

The right hepatic vein drains directly into the suprahepatic vena cava, while the middle and left hepatic veins join to form a short common trunk of 1 cm in length prior to entry. Venous branches from segment 4 drains into middle hepatic vein but can drain left hepatic vein as a variation. Segment 4 vein is often called as umbilical vein but is misnomer. The umbilical vein represents an additional alternative site of venous efflux. It is located beneath the falciform ligament and eventually terminates in the left hepatic vein, or less commonly in the confluence of the middle and left hepatic veins. Large accessory right hepatic vein can often be present which drains to the vena cava directly. The caudate lobe has independent venous outflow directly draining into IVC. All three major hepatic veins (right, middle, left) drain into suprahepatic part of IVC. Suprahepatic IVC with junction of the three major hepatic and phrenic veins joining the IVC is enclosed with thick fibrous sheath extending from diaphragm. Division of this sheath is necessary to expose the major hepatic veins. In right hepatectomy, after mobilization of the liver, this sheath has to be identified and divided before parenchymal transection. There is also a fibrous band extending from the posterior part of retrohepatic IVC at the level of junction with right hepatic vein called as *Makuuchi IVC*



Figs 22-13A and B: Distribution of hepatic veins—outflow/venous drainage of liver.

ligament which courses from dorsal edge of left side of the caudate lobe and right liver. Left and middle hepatic veins in left hepatectomy are usually approached after parenchymal dissection. Ligation of one hepatic vein is not necessarily to proceed with hepatic resection.

Hepatic Plate

It is fibrous sheath continuing from the Glisson's capsule, covering hepatic artery, portal vein and bile duct. Portal pedicle contains these three structures with lymphatics. Bile duct and hepatic artery are closely bounded together. Portal vein is separated by these two by separate loose areolar fascial sheath. Hilar plate is bounded above by segment 4 and right by cystic plate and left it continuous as umbilical plate. Umbilical plate contains left hepatic duct left hepatic artery and left sided portal vein. Middle hepatic artery is also located in umbilical plate.

Anatomical speciality

- Arterial anomalies occur up to 60% of times mostly with right hepatic artery but replaced left hepatic artery in lesser omentum (from left gastric) must also be looked for.
- Each segment is supplied by portal triad and drained by hepatic vein based on which segmentectomy can be performed.
- Glisson's capsule invests within hepatic parenchyma along with separate portal triad leading to Glissonian approach to resection.
- Vascular control is fundamental to safe liver resection.

Lymphatic Drainage of Liver

Superficial lymphatics lie on the surface of the liver deep to peritoneal coverings. Deep lymphatics drain into the right middle

phrenic nodes; nodes of porta hepatis; these portal hepatis nodes in the transverse fissure are closer to portal vein and hepatic artery than bile duct.

LIVER RESECTION

In 1888, Langenbuch successfully removed solid left lobe tumour. Tiffany from America in 1890 removed a left lobe mass lesion. Keen removed a cystic lesion, angioma and a primary carcinoma of liver. In 1952, Lortat –Jacob and Robert designed thoracoabdominal approach and extrahepatic ligation of vascular pedicle to control bleeding prior to parenchymal dissection. In 1953, Quattelbaum described breaking of the liver tissue by finger fracture/digitoclasia. Finger or handle of knife is used for liver transection. In 1956, Finberg and associates started parenchymal dissection using back of scalpel. In 1958, Tien Yu Lin et al. started the technique of dividing the tissue between thumb and fingers; once resistant structures are felt (either vessel or ducts), they are ligated on both sides and divided.

Indications

Benign Neoplasms

- Hemangiomas
- Adenomas
- Focal nodular hyperplasia
- Cystadenoma

Malignant Tumours

- Primary
  - Hepatocellular carcinoma
  - Cholangiocarcinoma
- Metastatic tumours from
  - Colorectal cancers
  - Noncolorectal and neuroendocrine tumours
- Tumours directly invading liver
  - Adrenal, renal, gastric, colonic, retroperitoneal and IVC sarcoma
- Gallbladder carcinoma
- Hilar cholangiocarcinoma

Benign Conditions

- Intrahepatic biliary stricture/fistulae
- Intrahepatic biliary stones
- Recurrent pyogenic cholangitis
- Caroli disease
- Liver cysts/polycystic liver disease
- Parasitic cysts

Trauma

Liver Resection in Living Donors for Transplantation (Fig. 22-14)

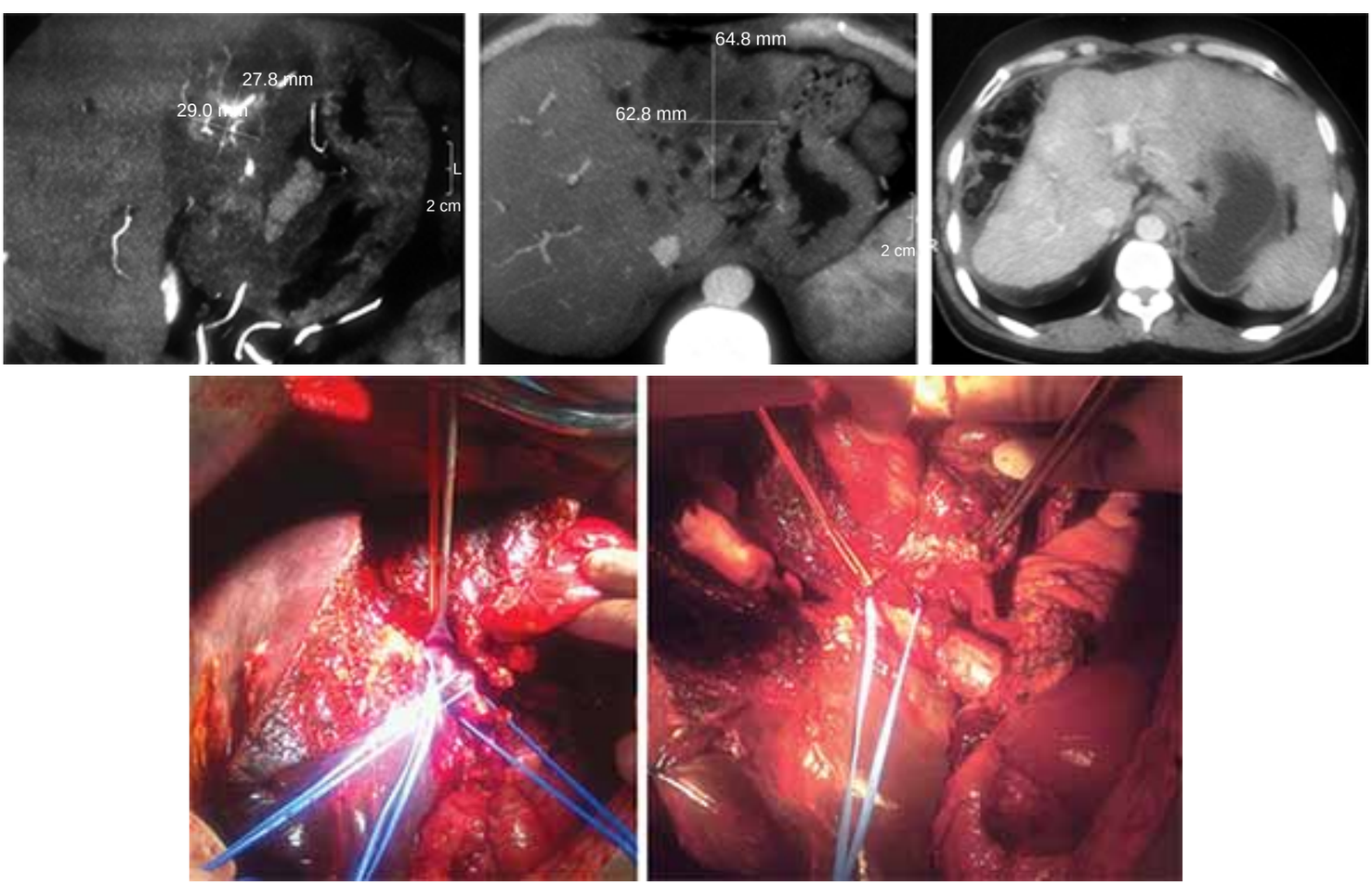


Fig. 22-14: CT and operative picture of cholangiocarcinoma undergoing resection (By Dr Arunkumar Mch Gastro, Kochin).

General Considerations in Liver Resection

Case selection and perioperative management of patients with liver disease is as important as performing a safe surgery of liver. With advances in critical care management and surgical advances, it is now, however, possible to subject patients to liver resection in conditions like liver cirrhosis. Pre-operative assessment of patients must include good pre-operative imaging and volumetry (in case of major resection). High resolution triphasic CT scan should be obtained to delineate the portal anatomy, biliary anatomy and hepatic venous anatomy. Detailed discussion on hepatic imaging is beyond the scope of this book and only surgical aspect of liver resection is discussed. Major liver resection can be done only in patients who fall under CTP (Child-Turcotte-Pugh)—A class. Patients who are CTP B should be assessed carefully and additional ICG clearance may be needed to decide upon surgery. A minimum clearance of 10% is required for patients undergoing major resection. Patients who are CTP C class are generally not fit for any type of liver resection. A minimum of 30% of functional liver must be left behind (FLR—future liver remnant) for adequate recovery of the patient. This value can be higher than 40% in case of cirrhotics in whom the volume of liver does not co relate with functional liver. In cirrhotic patients, pre-operative portal vein embolization (2 weeks prior) is a good strategy to induce compensatory hypertrophy of remnant liver in order to increase the FLR.

Liver resection is classified as *anatomical and non-anatomical*. Anatomical is along the functional segmental anatomy of parenchyma with defined boundaries. When resection is done without taking into consideration of the segments is called as non-anatomical. Anatomical resections are termed as sectionectomy/segmentectomy; hepatectomy/hemihepatectomy. Hepatectomies are right and left. Sectionectomies are left lateral; left medial; right anterior; right posterior. Resection of three consecutive sections is called as trisectionectomy. Extended right hemihepatectomy includes middle hepatic vein with the part of segment 4. Extended left hemihepatectomy included middle hepatic vein with part segments 5 and 8.

Resection of three or more liver segments is called as *major* hepatic resection. Middle hepatic vein is the landmark between right and left liver. It begins in gallbladder fossa and ends in IVC either after joining left hepatic vein as common trunk or independently. It receives hepatic veins from segments 5 and 8 on right side and segment 4a and 4b from left side. Major resection is done when tumour is more than 5 cm or when tumour is close to liver hilum involving the portal pedicles. Major hepatic resection is often done in selected patients with en bloc removal of part of IVC or right adrenal gland or diaphragm or right kidney or duodenum.

In right hepatectomy when remnant liver in left lobe is inadequate then preoperative right portal vein embolization is done to induce the hypertrophy of left liver which is future remnant liver.

Evaluation in Liver Resection

Multidetector CT scan is ideal imaging method in terms of assessing the resectability and CT volumetry of the remnant liver. *Urata formula* is used to estimate the liver volume. It is important in cirrhotics. If liver volume is less than 40% in cirrhotics then major resection becomes high risk. Hepatic angiogram is not necessary unless MDCT shows vascular anomalies.

Assessment of liver and kidney function (LFT/RFT) is important. *Child–Pugh grading* is done to decide the selection of the patient for resection.

Indocyanine green (ICG) clearance test is more valuable than Child's grading or prothrombin time or platelet count. But high ICG retention rate can occur if there is partial compression of portal vein or bile duct.

Screening preoperatively for other comorbid diseases is also essential.

Vascular Control

The crux of good liver surgery lies in haemostasis. Liver vascular control has two components—*inflow control and outflow control.*

Pringle Manoeuvre

The inflow to the liver can be controlled using the *Pringle manoeuvre*. As described in anatomy, the whole hepatic pedicle including the artery lies in the free border of hepatoduodenal ligament. Here it can be encircled using an umbilical tape or vascular tape by making a window in the lesser omentum. The tape is threaded over a red rubber catheter and clamped. Tightening the clamp allows to stop inflow to the liver (Pringle's Manoeuvre (PM). The PM has relatively little general haemodynamic effect and no specific anaesthetic management is required. However, bleeding can still occur from the backflow from the hepatic veins and from the liver transection plane during unclamping.The other concern is the ischaemic-reperfusion injury to the liver parenchyma, especially in patients with underlying liver diseases. The Pringle's manoeuvre can be applied either continuously or intermittently. Continuous occlusion is safely applied for up to 60 minutes in healthy liver and for up to 30 minutes in diseased liver (fatty liver/cirrhosis). In intermittent Pringle's manoeuvre, the inflow is occluded for 15 minutes followed by 5 minutes of reperfusion. There is no difference in blood loss during surgery in both the manoeuvres however, there is more ischaemic injury to the liver in patients with pre-existing liver disease.

Hemihepatic clamping (half-Pringle manoeuvre) interrupts the arterial and portal inflow selectively to the right or left liver lobe that is to be resected. It can be performed with or without prior hilar dissection. It can also be combined with simultaneous occlusion of the ipsilateral major hepatic vein. The advantage of this technique is that it avoids ischaemia in the remnant liver, avoids visceral congestion and allows clear demarcation of the resection margin. The disadvantage is that bleeding from the parenchymal cut surface can occur from the non-occluded liver lobe. Segmental vascular clamping entails the occlusion of the ipsilateral hepatic artery branch and balloon occlusion of the portal branch of a particular segment.

It is often claimed that Pringle manoeuvre prepares the liver for eventual ischaemia—ischaemic preconditioning. Now newer gadgets like ultrasonic dissector allows liver transection without Pringle manoeuvre.

Total Vascular Exclusion (TVE)

Total vascular exclusion (TVE) combines total inflow and outflow vascular occlusion of the liver, isolating it completely from the systemic circulation. It is done with complete mobilization of the liver, encircling of the suprahepatic and infrahepatic IVC, application of the Pringle manoeuvre, and then clamping the infrahepatic IVC followed by clamping of the suprahepatic IVC. Occlusion of the IVC leads to marked reduction of venous return and cardiac output, with a compensatory 80% increase in systemic vascular resistance and 50% increase in heart rate and thus, not every patient can tolerate it. TVE

can be applied to a normal liver for up to 60 minutes and for 30 minutes in a diseased liver. Lumbar veins will not be present in retrohepatic IVC. Right adrenal vein needs ligation.

Retrocaval ligament bridging the segments 6 and 7 should be completely divided to expose right hepatic vein. Hepatic veins should be exposed only after proper inflow control.

Parenchymal Transection

Maximum blood loss during liver surgery occurs during parenchymal transection. The toughest structure in the liver is the Glisson's capsule. The rest of the liver does not have much connective tissue and parenchyma is packed within lattice of biliary radicles and vascular structures. Even though the segments have independent vascular supply, there is still bleeding from adjacent side when inflow occlusion is not applied. Portal veins are less fragile than hepatic veins. The advance in surgical instrumentation has definitely made parenchymal transection easy. Though the simplest of techniques is sufficient energy sources may be needed in certain cases. The choice of device, however, remains personal and also depends on availability as many of these devices are expensive to procure and maintain **(Fig. 22-15)**.

The main modality of parenchymal transection are:

1. Kelly clamp and bipolar forceps
2. Water jet dissection—contact method
3. Cavitron Ultrasonic Surgical Aspirator (CUSA)—contact method
4. Ultrasonic dissection
5. Bipolar vessel sealer
6. Staplers
7. Finger fracture—compression method
8. Electrocautery and laser—thermal method
9. Suture ligation

Before starting parenchymal dissection, stay sutures are taken on either side of line of parenchymal transection. This aids greatly in applying traction especially in the initial dissection. Capsule of the liver is marked/scored along the line of planned resection with cautery. Parenchymal transection better begun at relatively thin liver at free edge.

Kelly Clamp and Bipolar Forceps

A small clamp (Kelly) is used to crush parenchyma between its blades in order to isolate vessels and bile ducts. Fine branches of Glisson's tree or tiny tributaries of hepatic veins (<3 mm) are coagulated using a bipolar forceps and are cut by scissors. Bipolar forceps cautery is equipped with a channel for water dripping, which prevents adhesion of debris to the cautery blades. Bigger identified vessels or bile ducts (>3 mm) are ligated or clipped on the remnant liver slice before cutting.

Water Jet Dissection

A jet of water (saline) is used for dissection of liver parenchyma. The saline is delivered on parenchyma at 30–50 atmospheric pressure which washes off soft tissue leaving behind more resilient biliary radicles and vessels. The device tip also hosts a suction device which clears the field for further dissection. The biliary radicles and vessels are either cauterized or ligated depending on their size as mentioned earlier. The device is held near but not in contact with liver parenchyma and dissection is done using gentle paintbrush-like strokes.

Cavitron Ultrasonic Surgical Aspirator (CUSA)

The device delivers ultrasonic shock to the tissue in contact with the vibrating tip and the tissue is then suctioned off the field by an inbuilt suction at the tip of the device. The ultrasonic probe divides parenchymal cells (because of their high water content) by the cavitational effect with less injury to structures with a high content of fibrous tissue, e.g. bile ducts and blood vessels. These structures are taken down using clips or suture ligation in the usual way. CUSA is more precise but slow. It acts as a mechanical disrupter and suction; it is useful in hilar area dissection. Ultrasonic dissector may damage hepatic veins when power is kept very high; so power should be set between 40–60% with short range amplitude **(Fig. 22-16)**.

Ultrasonic Cutting Devices

These devices have two blades at the tip of which one moves at high frequency (55 KHz) against the other producing sealing and cutting effect due to protein denaturation. Many companies now make these devices each one similar to the other. In practice, the device works partly like the Kelly crushing technique. When the Jaws of the device are approximated, they crush the parenchyma and then the small biliary radicles and vessels are sealed. Additional ties or bipolar may be required if the parenchyma is divided in fast cutting mode.

Bipolar Vessel Sealer

Bipolar vessel sealing device is also an excellent tool for parenchymal transection. The jaws initially act as a Kelly clamp in crushing liver tissue and then the biliary and small vascular channels are coagulated. The larger (10 mm) instrument has got an inbuilt blade which can then be used to divide the sealed tissue. The smaller (5mm) jaw blade does not have an inbuilt blade, and hence, tissue is divided by sharp dissection using scissors or electrocautery.

Stapling Devices

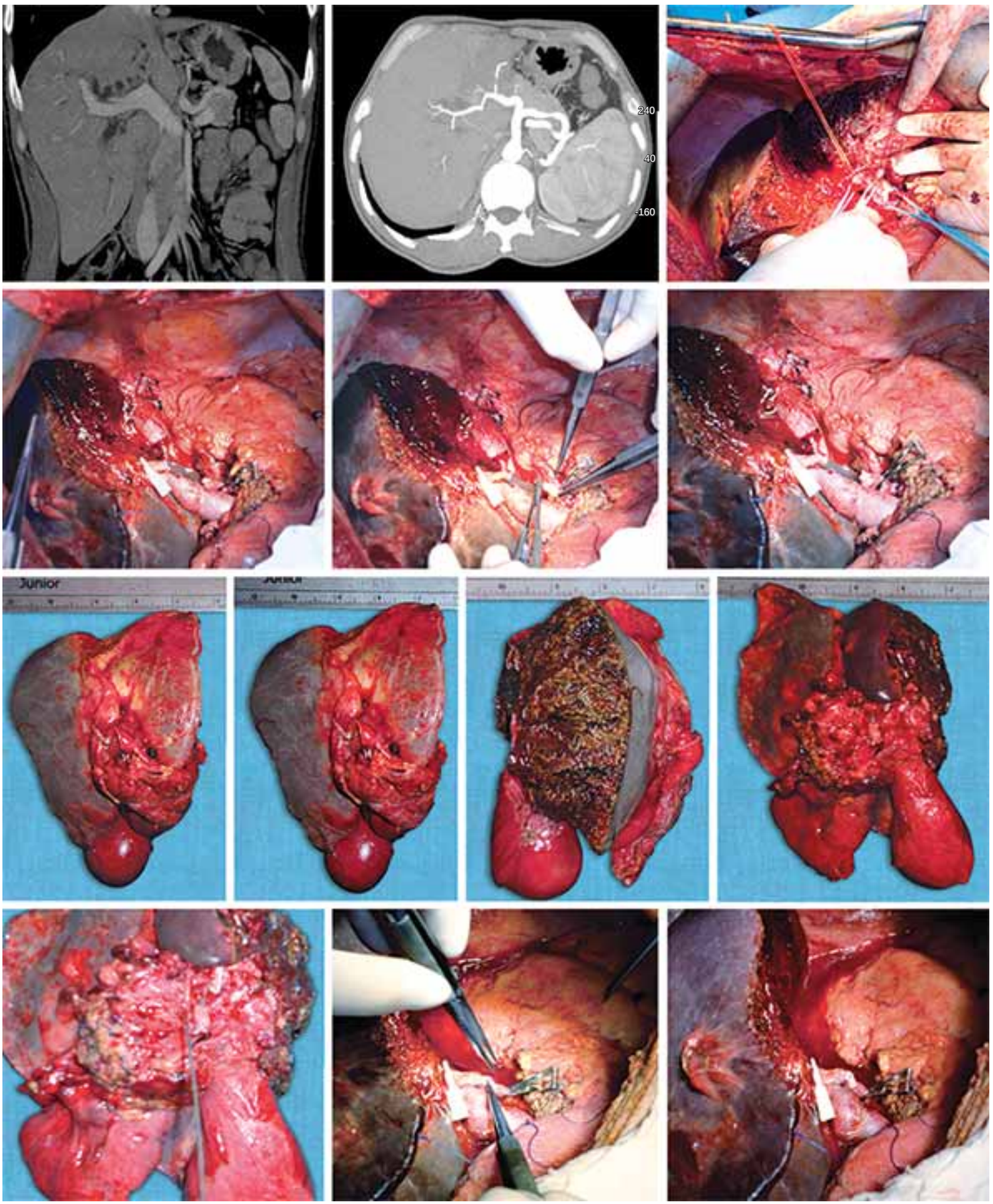
Vascular load of stapler (same as those used in GI surgery) can also be used for liver transection. These, however, are used mainly towards the posterior part of dissection where one encounters the hepatic veins. This helps to take the hepatic veins within the liver parenchyma which reduces the risk of vascular complications when compared to extrahepatic take of the hepatic veins. The jaws are approximated and stapler is fired across the tissue after making sure the field is clear and no inadvertent tissue is caught in the stapler.

Finger Fracture

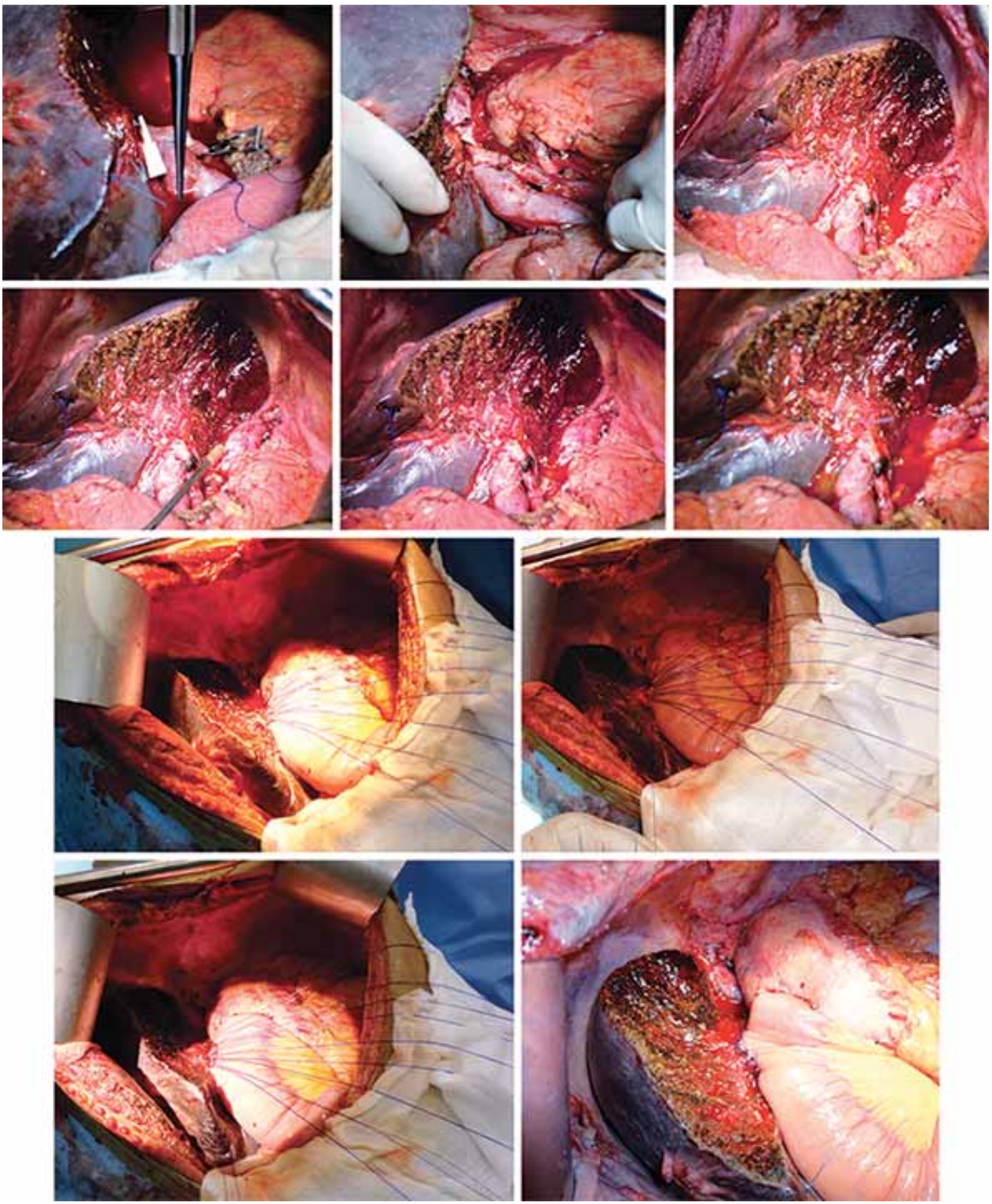
It is pinching and compressing about 1 cm of parenchyma between thumb and forefinger. It disrupts the normal liver with preserving the vascular and ductal structures. Both surgeon and assistant do finger fracture together.

Suture Ligation

Any structure more than 2 mm in liver needs suture ligation or clipping. Circumferential and adequate length exposure is essential prior ligation. Fine silk, vicryl or metal clips can be used. All small portal



Figs 22-15(1)



Figs 22-15(2)

Figs 22-15(1 and 2): Cholangiocarcinoma—arterial resection (By Dr Arunkumar Mch Gastro, Kochin).

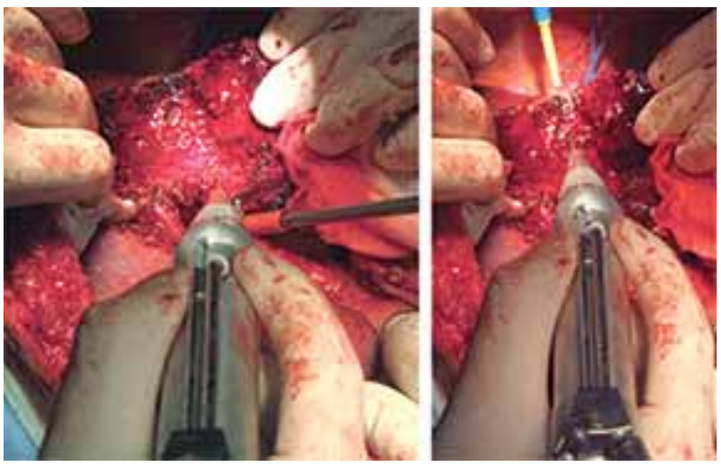


Fig. 22-16: Cavitron ultrasonic surgical aspirator (CUSA).

and hepatic branches should be ligated on either side and divided in between. Avulsion of small hepatic veins can bleed significantly. Avulsed hepatic vein opening should be identified using suction and carefully sutured using 5 zero polypropylene suture material.

Argon Beam Coagulator

Argon beam coagulator can be used to control small bleeds on the surface. It is also used to stop bleeders on the surface of middle hepatic vein through tiny holes.

Preservation of Hepatic Ducts

It is very important to preserve the hepatic duct of the remnant; for that entire biliary tree until entering the liver parenchyma should be dissected especially in liver parenchyma. Branches are isolated; but ligation is done only after major part of parenchymal transection. Parenchyma around major duct is dissected using CUSA device. Choledochotomy and cannulation may safely identify the ductal anatomy.

Incisions used for Liver Resection

Patient is in supine position with both upper limbs on the side of the table or at least right side should be on the side of the table. Warming devices should be placed on the body. Perioperative antibiotics are given. Bilateral subcostal incision with an upper midline extension; thoracoabdominal incision; extension as sternotomy are different incisions used.

Mercedes Benz incision, Makuuchi J incision and bilateral roof top bucket handle incision—are different incisions used to expose field adequately **(Fig. 22-17)**.

Upper hand or Thomson retractor is used to elevate the rib cage; additional retractors are used in abdominal cavity. All perihepatic attachments are released – both triangular ligaments and falciform ligament. Mops are placed between diaphragm and liver to displace the liver downwards **(Figs 22-18 to 22-21)**.

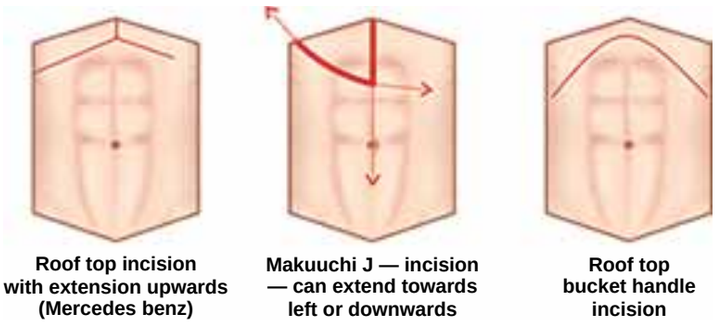

Roof top incision with extension upwards (Mercedes benz)
Makuuchi J — incision — can extend towards left or downwards
Roof top bucket handle incision

Fig. 22-17: Incisions used to approach liver for resection and other procedures.

Nomenclature for liver resection

Segments	*Brisbane–2000*	*Couinaud–1957*	*Goldsmith and Woodburne–1957*
V-VIII	Right hemihepatectomy	Right hepatectomy	Right hepatic lobectomy
IV-VIII	Right trisectiontectomy	Right lobectomy	Extended right hepatic lobectomy
II-IV	Left hemihepatectomy	Left hepatectomy	Left hepatic lobectomy
II, III	Left lateral sectionectomy	Left lobectomy	Left lateral segmentectomy
II, III, IV, V, VIII	Left trisegmentectomy	Extended left hepatectomy	Extended left lobectomy

Starlz nomenclature—Entire right liver with complete resection of segment 4 is right trisegmentectomy; entire left liver with complete resection of segments 5 and 8 is left trisegmentectomy.

Indications	*Contraindications*
• Primary/secondary malignancy from gallbladder or colorectum or carcinoids • Benign tumours of liver • Parasitic/non-parasitic cysts—hydatid cysts/simple liver cysts • Refractory abscess/Caroli disease/RPC • LDLT • Klatskin's tumour • Trauma to liver	• Acute hepatitis–viral/alcoholic • Severe chronic hepatitis • Poor liver reserve • Severe portal hypertension • Severe coagulopathy • Severe thrombocytopenia—platelet count less than 30,000/-

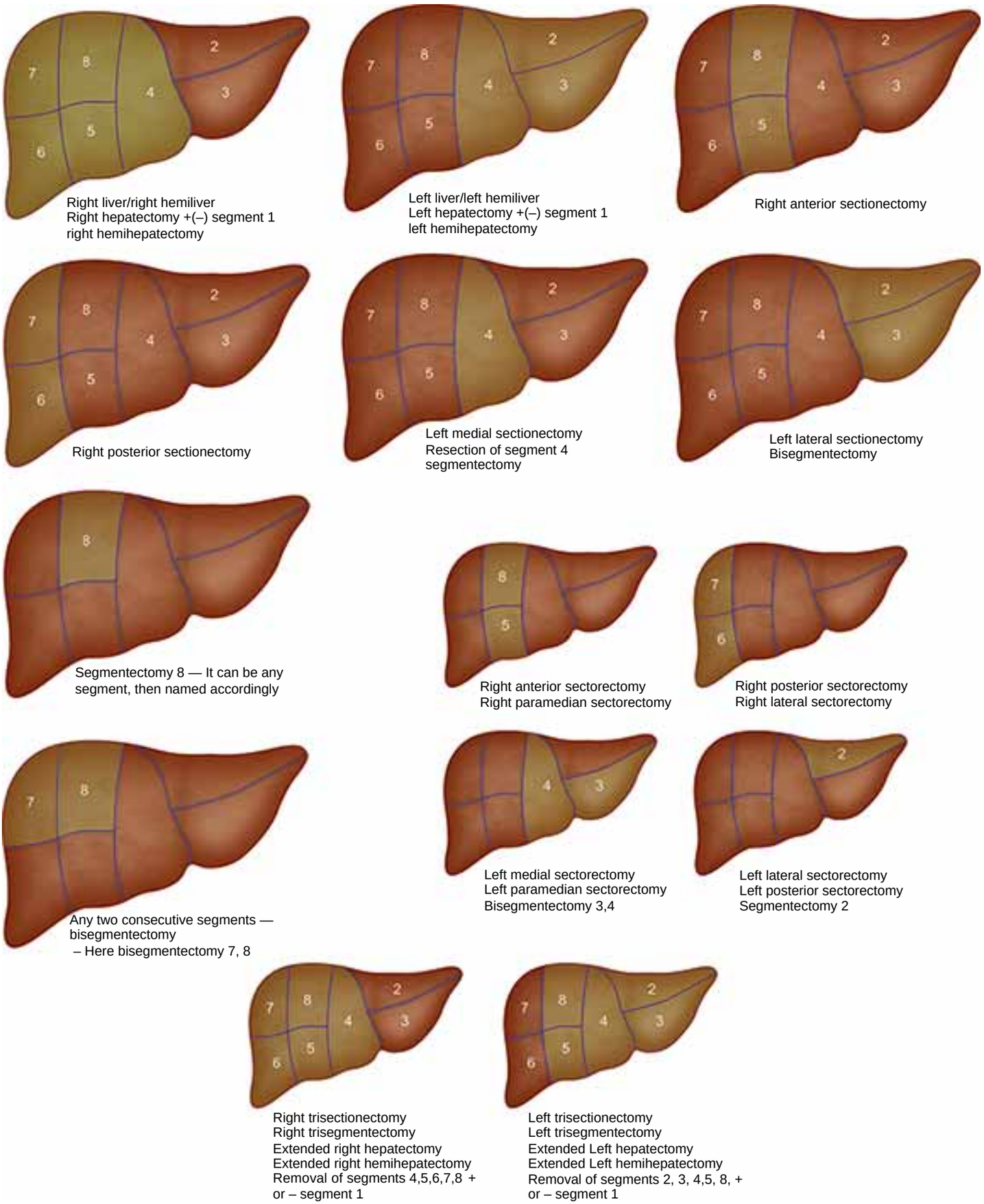
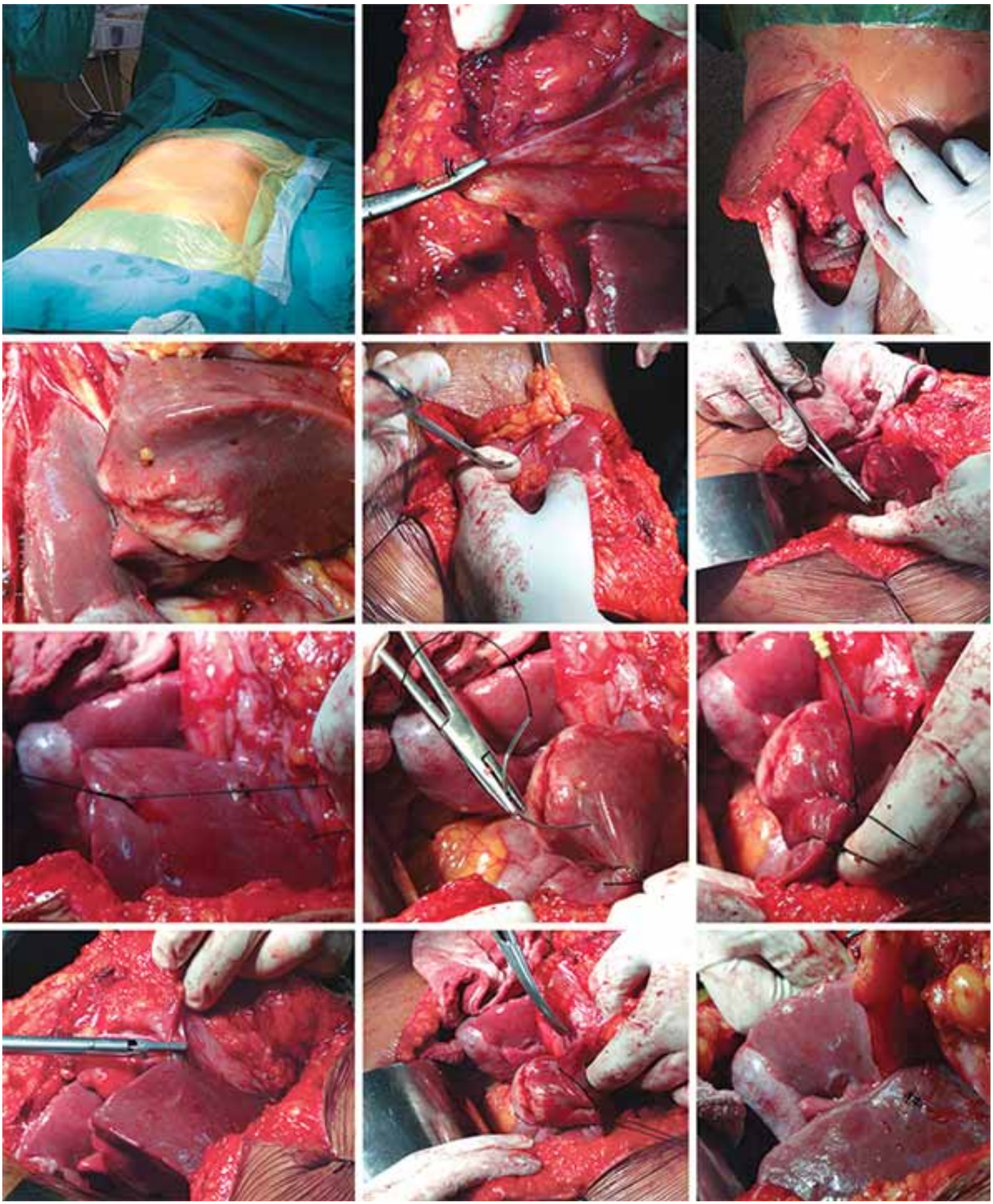
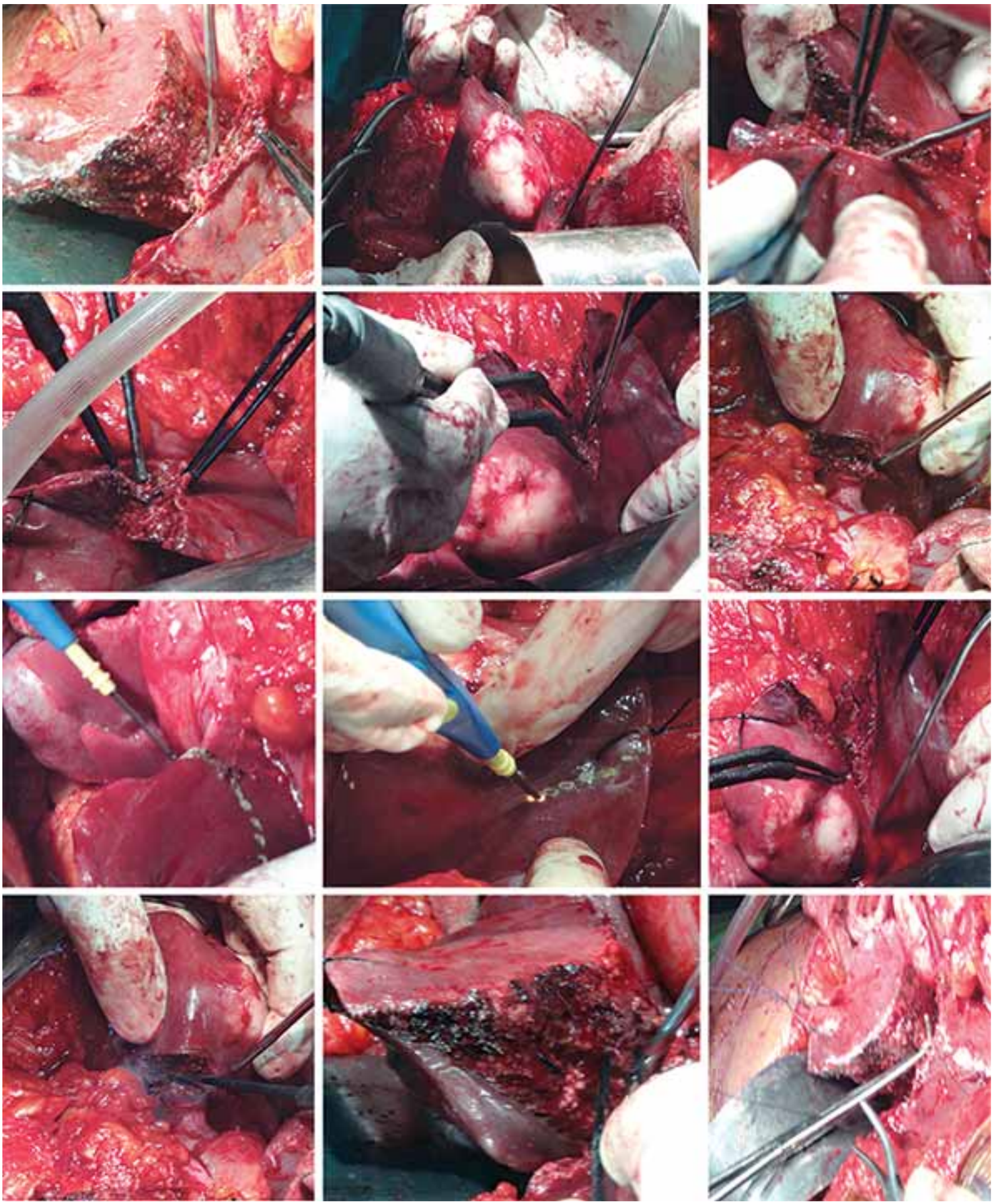


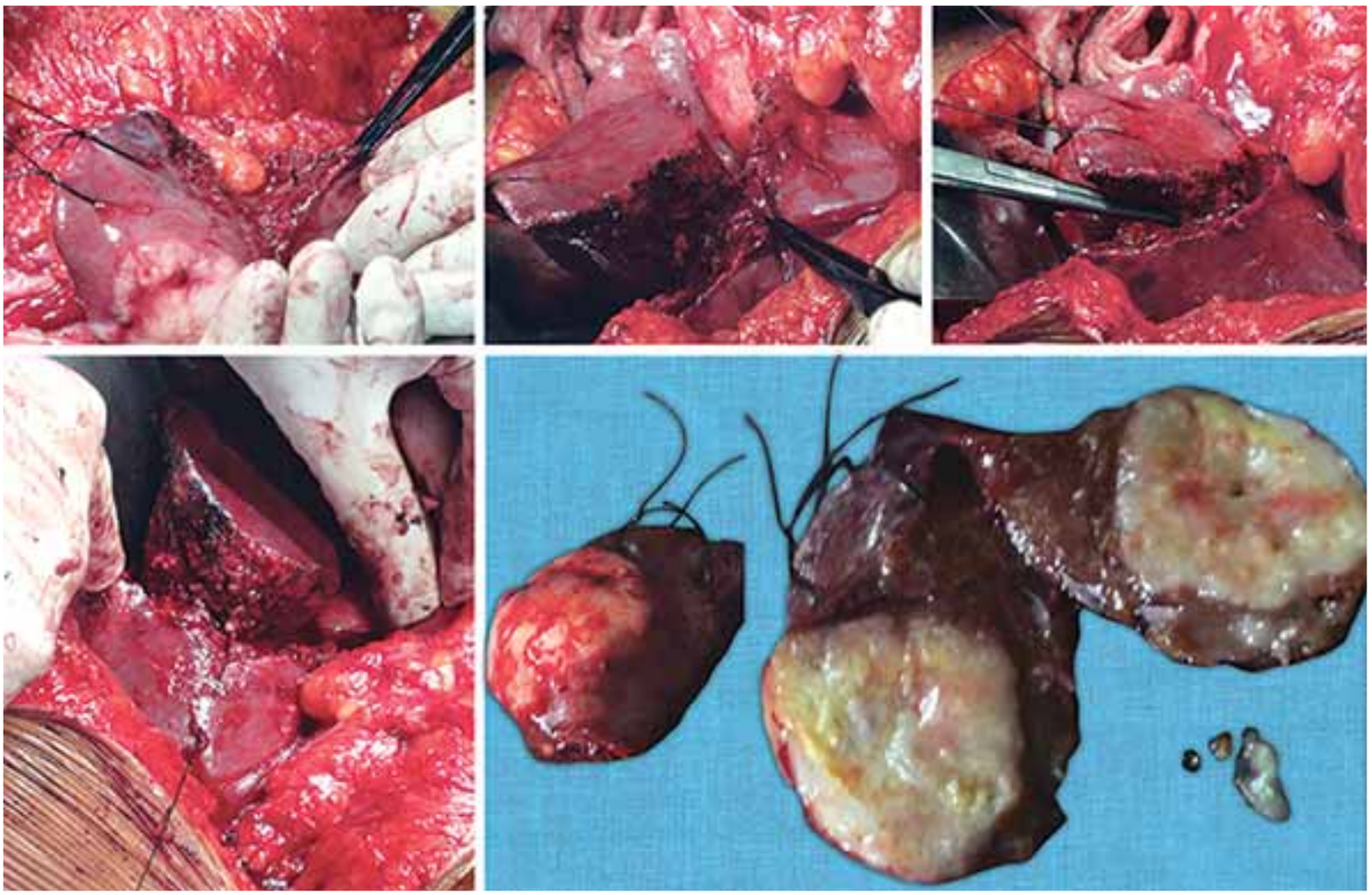
Fig. 22-18: Different types of hepatic resections.



Figs 22-19(1)



Figs 22-19(2)



Figs 22-19(3)

Figs 22-19(1 to 3): Segmental liver resection—for secondaries (single) in liver from carcinoma of colon.

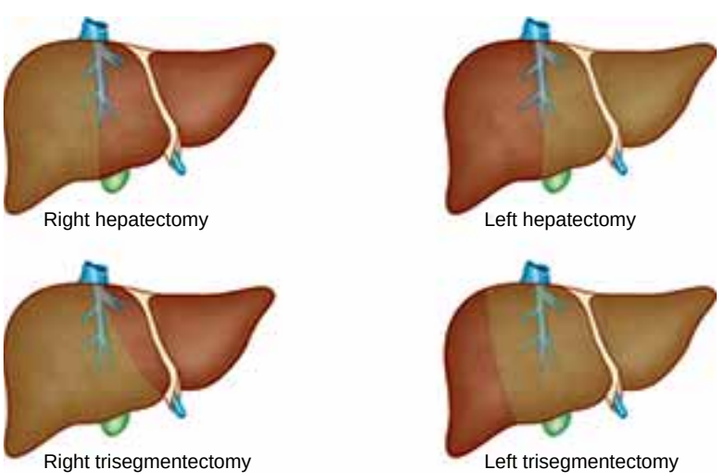


Fig. 22-20: Major hepatic resections.

Types of hepatectomy techniques

- Preliminary vascular section (Lortat-Jacob)
- Primary parenchymal transection (Ton That Tung in 1965)
- Selective clamping
- Total vascular exclusion
- Pedicular clamping (Pringles)
- Suprahilar clamping (Glissonian approach)
- Intrahepatic portal control

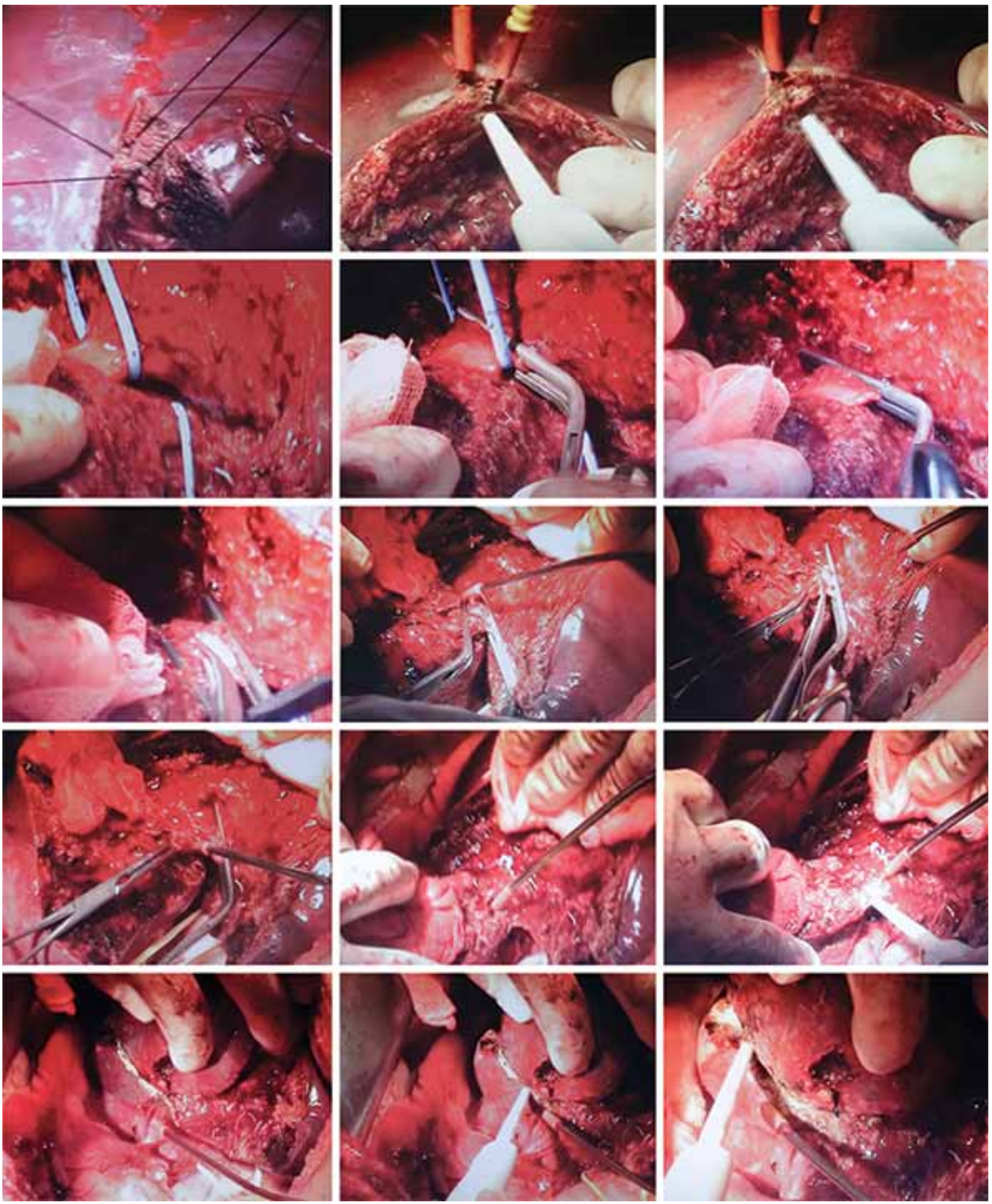
Technical principles

Inflow (portal vein, hepatic artery) control; outflow (hepatic veins) control; parenchymal transection; preservation of adequate sized liver remnant with intact inflow, biliary drainage and venous outflow; mobilisation of left and right triangular ligament; ligation of branches of portal vein and hepatic artery and resection of hepatic duct branch of the side; ligation of hepatic vein at a later period; proper haemostasis and ligation of individual biliary ductules. Retrohepatic caval dissection includes—dissection of right adrenal vein, inferior hepatic veins and IVC ligament. Preservation of the bile duct to the remnant liver is also equally important.

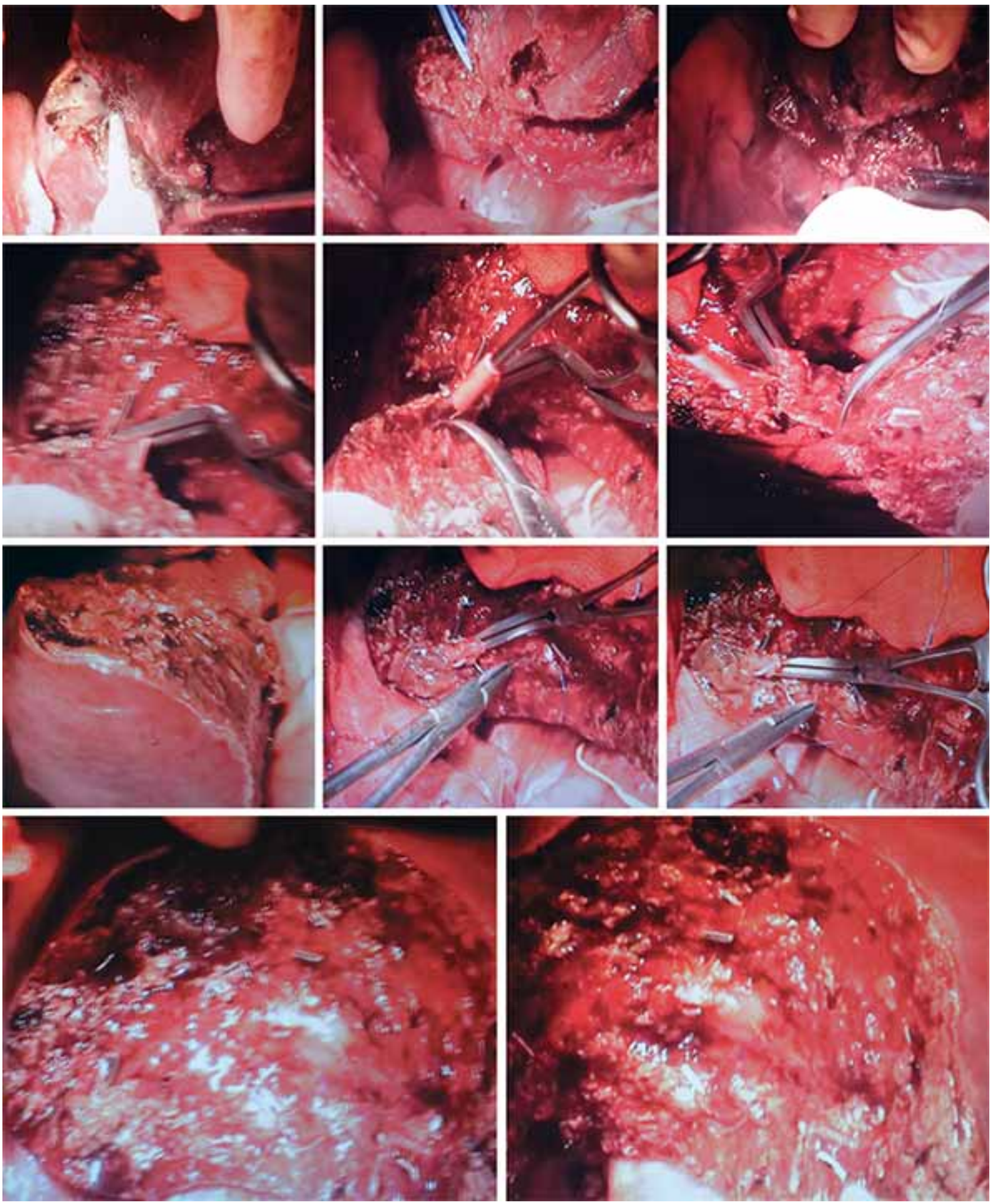
Vascular control
↓
Parenchymal dissection
↓
Precise anatomical identification
↓
Division of biliary tree (ducts/branches) with preservation of bile drainage of remnant liver

Resection along the main portal fissure (Cantlie's line) and removal on right side is *right hemihepatectomy* and removal on left side is *left hemihepatectomy*. Resection on right of the ligamentum teres is called as *right trisegmentectomy* (older—right lobectomy); and left of the ligamentum teres is called as *left lateral segmentectomy* segment II and III (older left lobectomy). Removal of single segment is called as *unisegmentectomy. Plurisegmentectomy* is removal of two or more segments. Segments IV and V are removed in carcinoma of gallbladder. Removal of small portion of liver either within the segment or traversing segments is called as *wedge resection* of the liver.

Figs 22-21(1)



Figs 22-21(2)



Figs 22-21(3)

Figs 22-21(1 to 3): Technique of liver resection—note the usage of waterjet for parenchymal transection (By Dr Ravishankar Mch Gastro, Bengaluru).

Techniques of parenchyma dissection • Kelly clamp and bipolar forceps • Water jet dissection • Ultrasonic dissection • Ultrasound cutting • Dissecting sealer **How much to cut** • Remnant liver— ≥30% of the original liver volume with complete venous drainage is safe	**Intraoperative ultrasound** • Identifying tumour • Recognizing the anatomy • Unexpected contralateral tumour • Intrahepatic selective vascular control using a balloon catheter • Guided biopsy
After completion of resection • Check for bile leak by injecting dye through cystic duct • Check for absolute haemostasis • Cholangiogram to confirm contra lateral biliary patency • Fix the left lobe through falciform ligament	**Complications** Bleeding, infection, septicaemia Subphrenic abscess formation Bile leak, haemobilia Liver failure Pleural effusion, empyema

Right Hepatectomy

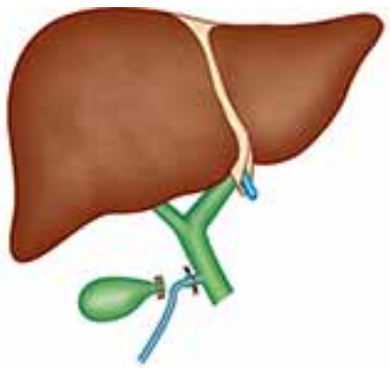
The patient is positioned supine with a slight (15 degree) head up tilt. The abdomen is opened using a Mercedes Benz incision or Makuuchi J shaped incision. A Thompson type table mounted retractor is used for adequate and fixed retraction. The abdominal cavity is explored for any signs of extrahepatic spread. The falciform ligament is divided between ligatures. It is then taken down from the diaphragm till its posterior extent of suprahepatic vena cava. The hepatic veins are defined in this region by dividing the peritoneal reflection under vision. Applying downward traction on the liver opens up this space so as to carry out dissection under vision. The right triangular ligament is then divided which allows us to rotate the liver towards the left to expose the posterolateral side of the right liver. The right hepatic vein can be seen entering the IVC at the apex. The right subphrenic vein enters the IVC just above the insertion of the right hepatic vein. This needs to be divided between ligatures which allow safe encircling of the right hepatic vein. If the subphrenic vein is not divided, avulsion injury to it can cause troublesome bleeding.

The main portal pedicle is now encircled with a tape (*Pringle's manoeuvre*) but without clamping the same. Clamping can be done any time during the surgery if required. Cholecystectomy is performed and the cystic duct is cannulated with an infant feeding tube and secured. The portal plate is now lowered and the right hepatic artery and common hepatic duct are identified. Right hepatic artery is found between common hepatic duct and portal vein; it is confirmed by feeling the pulsation. Right hepatic artery is dissected close to the hilum of right liver to avoid injury to hepatic arterial branch to segment 4 which often may arise from right hepatic artery. Variations can occur which should be kept in mind while dissecting it. Right branch of portal vein is situated behind these structures and is also identified and looped. Arterial supply of hepatic duct is preserved while dissecting by staying away from it. A temporary vascular occlusion of right hepatic artery confirms the vascular anatomy in the patient. Initially bulldog clamp is applied to right hepatic artery; left hepatic artery pulsation should be checked now to confirm that inadvertent clamping of proper hepatic artery has not occurred. On table, Doppler study may be helpful for this purpose. The line of demarcation will appear along the Cantlie's line on arterial occlusion.

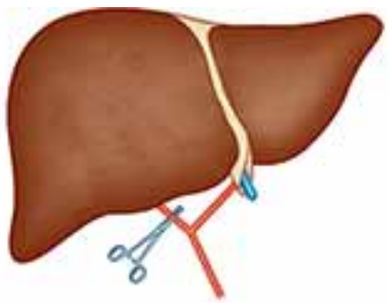
The right liver is now rotated to the left by the assistant so as to expose the retrohepatic IVC. The right hepatic artery is then divided between ligatures; two ligatures on either side should be placed before dividing. The right portal vein is now exposed. Atraumatic retractor is gently used to retract common hepatic duct while dissecting portal vein and its divisions. Small branches towards caudate lobe from right portal veins should be divided. Right portal vein is divided between vascular clamps and the edge over sewn with 6-0 polypropylene sutures. Alternately it can be divided with vascular stapler; or two ligatures are placed with more than 1 cm gap and two transfixation sutures are placed between two ligatures and divided in between. The right hepatic duct is not divided extrahepatically (at this juncture). It is divided during parenchymal division away from the hilar plate **(Fig. 22-22)**.

The attention is now given to separate the right lobe of the liver off the IVC. The right lobe is rotated towards midline by the assistant and short veins draining from the liver to the IVC are carefully isolated and divided between fine silk ligatures. The separation is continued cranially till the right hepatic vein is identified entering the IVC. Process and paracaval portion of the caudate lobe is divided from front and right side of the IVC. Inferior hepatic vein may be present if so should be carefully divided. Right adrenal gland will be visible and may interfere with the proper dissection; careful dissection is done between liver adrenal gland to expose the IVC; in a difficult situation, right adrenal gland may be removed. Right side of IVC ligament is carefully dissected and divided between clamps and sutured as it often contains a vein which may trouble with bleeding. The right hepatic vein is divided between curved vascular clamps. The cut edge on the hepatic vein is over sewn using 4-0 prolene running sutures. A vascular stapler fire across the right hepatic vein also achieves the same result. Thinner blade should be on the liver side as gap here is less but caution should be taken not to interpose liver tissue. Either method is acceptable although stapler is a more expensive choice over suture ligation.

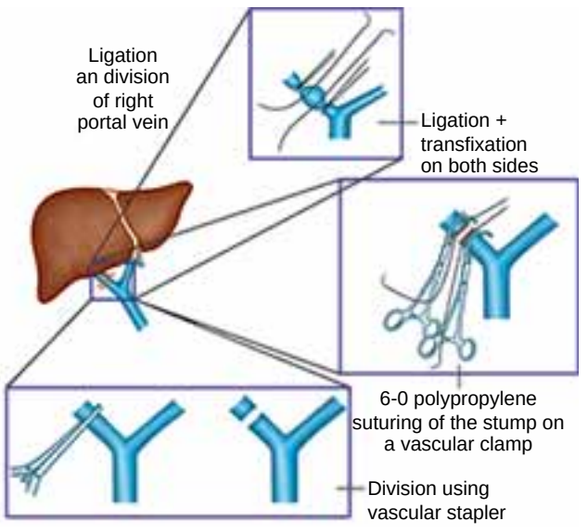
Right liver is rotated within the abdominal wound; should not bring out of the wound to prevent ischaemia of left liver. After devascularising the right lobe, clear line of demarcation is seen on the liver surface which is scored using electrocautery. If demarcation is not there then right anterior hepatic artery or portal vein may be present. The parenchymal dissection is now carried out under low CVP (<5 mm Hg). Dissection is done along the middle hepatic vein plane rather than towards left. Transection plane is not vertical in relation to IVC but oblique in right hepatectomy. The choice of method for liver transection depends on the surgeon preference and the available gadgets at his disposal. In fibrotic cirrhotic liver, dissection along the middle hepatic vein is difficult and troublesome. The small biliary radicles and vascular branches are secured within liver parenchyma by bipolar coagulation or fine silk sutures if more than 3 mm in diameter. After parenchymal transection careful inspection of the cut surface is done to look for any bile leaks. It is usual to place a fresh piece of gauze on the cut surface and look for any biliary stains on the same after few minutes. Such points are then suture ligated using 4-0 vicryl sutures. At this point a saline leak test can be done using the already cannulated cystic duct stump. Saline is pushed from the cystic duct and any leak from the cut surface of the liver is looked for. Dilute methylene blue injection also can be used. Right hepatic duct is now dissected from the surrounding hilar plate and is divided with scissor and sutured with vicryl. It is usual to apply a pair of vascular clamps across the right hepatic duct and divide it; but care should be taken not to clamp part of the confluence; so after clamping, dye is injected into the cystic duct cannula to delineate the left hepatic duct properly under C arm image intensifier. Once again after inspecting the cut surface of the remnant

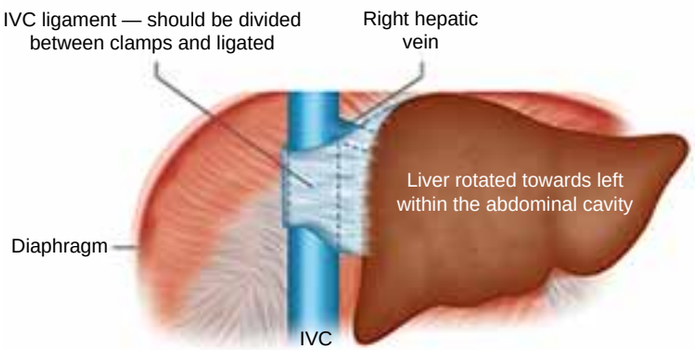


Cholecystectomy is done. Cystic duct is cannulated with fine tube for eventual cholangiogram to delineate biliary system

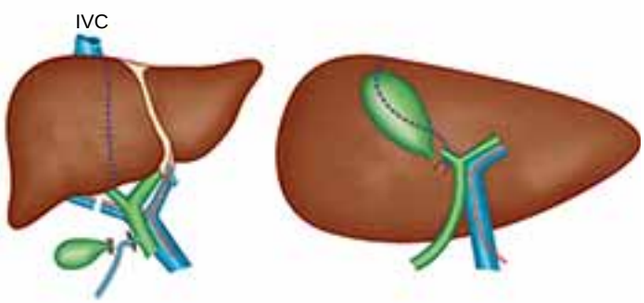


Right hepatic artery is dissected after retracting the right hepatic duct. Soft vascular clamp or bulldog clamp is applied to right hepatic artery Presence of left hepatic artery pulsation should be confirmed Doppler on table will help to identify this and anomalies and also segments — 2,3,4 hepatic arterial branch and flow

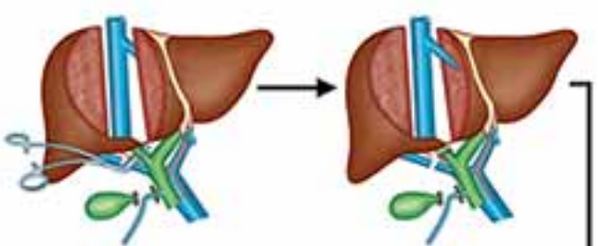

Ligation an division of right portal vein
Ligation + transfixation on both sides
6-0 polypropylene suturing of the stump on a vascular clamp
Division using vascular stapler


IVC ligament — should be divided between clamps and ligated
Right hepatic vein
Liver rotated towards left within the abdominal cavity
Diaphragm
IVC

Right hepatic vein should be transected ideally with stapler or using sutures When stapler is used, thinner blade should pass between liver and right hepatic vein

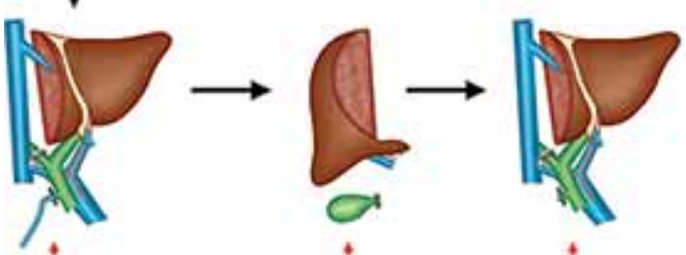


Scoring is done the superior and inferior surface along the Cantlie's line — while doing parenchymal dissection in this plane, middle hepatic vein terminal branches are identified and ligated, divided



After completion of parenchymal transection right hepatic duct is clamped carefully; cholangiogram through cystic duct cannula is done to confirm that left hepatic duct is patent

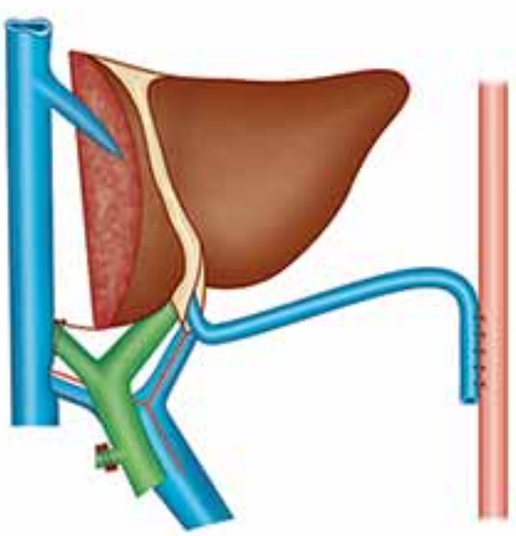
Right hepatic duct is divided and sutured with vicryl



Cystic duct cholangiogram is repeated or dilute methylene blue or saline is injected to identify possible bile leak from the surface of remnant liver; if present site is ligated with fine suture

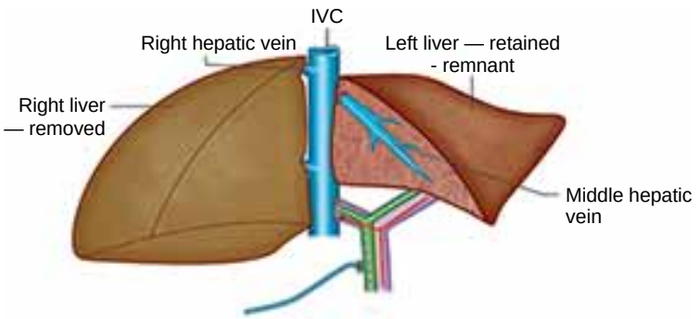
Removed right hepatectomy specimen with gallbladder

Cystic duct cannula is removed and ligated securely



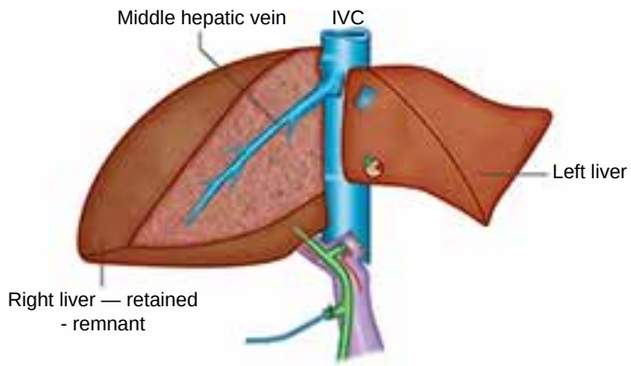
Falciform ligament should be fixed to the anterior abdominal wall to avoid falling of left lobe towards right and so torsion of remnant liver

Fig. 22-22: Technique of right hepatectomy.



Right hepatic artery, right hepatic duct and right portal vein are ligated (suture) and divided
Right hepatic vein is ligated and divided
Right sided segmental branches of middle hepatic vein are divided
Middle hepatic vein with its left branches are retained with left remnant liver

Fig. 22-23: Right hepatectomy—anterior approach.



Left hepatic duct, left hepatic artery and left portal vein are ligated;
Middle hepatic vein is retained towards right liver

Fig. 22-24: Left hepatectomy—anterior approach.

liver dye is injected through cystic duct across the left hepatic duct to rule out bile leak. Any significant bile leak is suture ligated using fine polypropylene or vicryl. Argon beam coagulation is used to control fine bleeders on the surface.

Cystic duct cannula is removed and stump is ligated securely. The falciform ligament is now sutured back to the underside of the diaphragm. This is an important step to make sure the remnant left liver does not rotate to the right thus causing torsion. The cut surface of liver is then covered by a single sheet of surgical. A drain is placed in the subhepatic space and the abdomen is closed.

Anterior Approach Hepatectomy (Right or Left)

It is done in large tumour of right liver where it may be adherent to diaphragm, adrenal or mobilisation becomes tougher.

Prior standard liver mobilisation is not done to begin with. First hilar dissection is done. Cholecystectomy is done by ligating cystic artery and cystic duct; cystic duct is cannulated temporarily till the end of the procedure to identify left hepatic duct and bile leaks after resection in the remnant liver. Right hepatic artery, right portal vein and right hepatic duct is ligated after proper dissection. Liver is transected from anterior surface towards the liver hilum; initially scoring on both superior and inferior surface is done. Caudate lobe may be retained or excised depending on the need. Parenchymal dissection is done with ligation of segment 8 hepatic vein on the right side of middle hepatic vein. IVC is exposed in front on its entire length. Hepatic veins of segment 6 (inferior right) and 7 (middle right) and right hepatic vein is exposed. All three veins are dissected carefully, ligated and divided from front. IVC ligament is identified, ligated and divided. Right triangular ligament and right adrenal gland is dissected from the liver.

Problem with anterior approach is bleeding during parenchymal transection **(Figs 22-23 and 22-24)**.

Belghiti et al. Liver Hanging Manoeuvre

Belghiti et al. liver hanging manoeuvre when done very carefully will have control on bleeding during parenchymal dissection. Curved forceps is passed gently between liver tissue and anterior surface of liver to allow passage of a tape between suprahepatic IVC and infrahepatic IVC. It creates compression, guides the transection of liver and safeguards the IVC to some extent. But initial passage of forceps may injure the veins on the anterior surface of the IVC causing torrential haemorrhage.

Left Hepatectomy

The abdomen is opened by either a Mercedes Benz incision or J (Makuuchi) incision and preliminary exploration is done to make sure the lesion is operable. Any evidence of peritoneal involvement precludes resection. A table mounted abdominal retractor system is essential to relieve the assistants hands from retraction in a long procedure and it gives better and sustained exposure of the operative field especially at the hiatus and the suprahepatic IVC area. The falciform ligament is ligated and divided up to the suprahepatic IVC. Care must be taken during the posterior dissection near IVC. Then the left lobe of the liver is mobilized by dividing the left triangular ligament using scissors or electrocautery. A mop placed behind the left lobe prevents inadvertent injury to the stomach or spleen. Attention is now given to taking down the hilar plate (dividing the peritoneum along the inferior surface of the liver at the hilum) which exposes the hilar structures.

The left pedicle is easy to identify and control as it runs a long and more horizontal extrahepatic course. The hepatic artery is temporarily clamped to confirm the anatomy and to look for any aberrant left hepatic artery (if present from the left gastric artery, the liver parenchyma will appear perfused despite clamping of the normal left hepatic artery) and after confirming anatomy divided between double ligature of 1-0 silk. The left hepatic vein is then identified behind the artery and isolated. Tributaries draining the caudate lobe may drain close to the bifurcation and they can be preserved or divided between fine ligatures. The left portal vein is taken down around 5 mm distal to the bifurcation to avoid any stenosis of the right portal branch. The vein can be suture ligated with 1-0 silk or divided with vascular staplers or closed with running 5-0 prolene suture **(Fig. 22-25)**.

Cholecystectomy is performed and cystic duct can be cannulated and kept for performing a leak test at the end of the parenchymal transection. The biliary duct is often taken down higher up in the liver parenchyma during dissection to avoid any damage to the right bile duct. Bile duct is extremely prone to ischaemic injury and every precaution is taken to avoid it. Hence the ducts are always taken inside liver be it right or left hepatectomy. The left hepatic vein also runs a horizontal course and joins the middle hepatic vein within the liver on most of the occasions. The vein is usually divided at the end

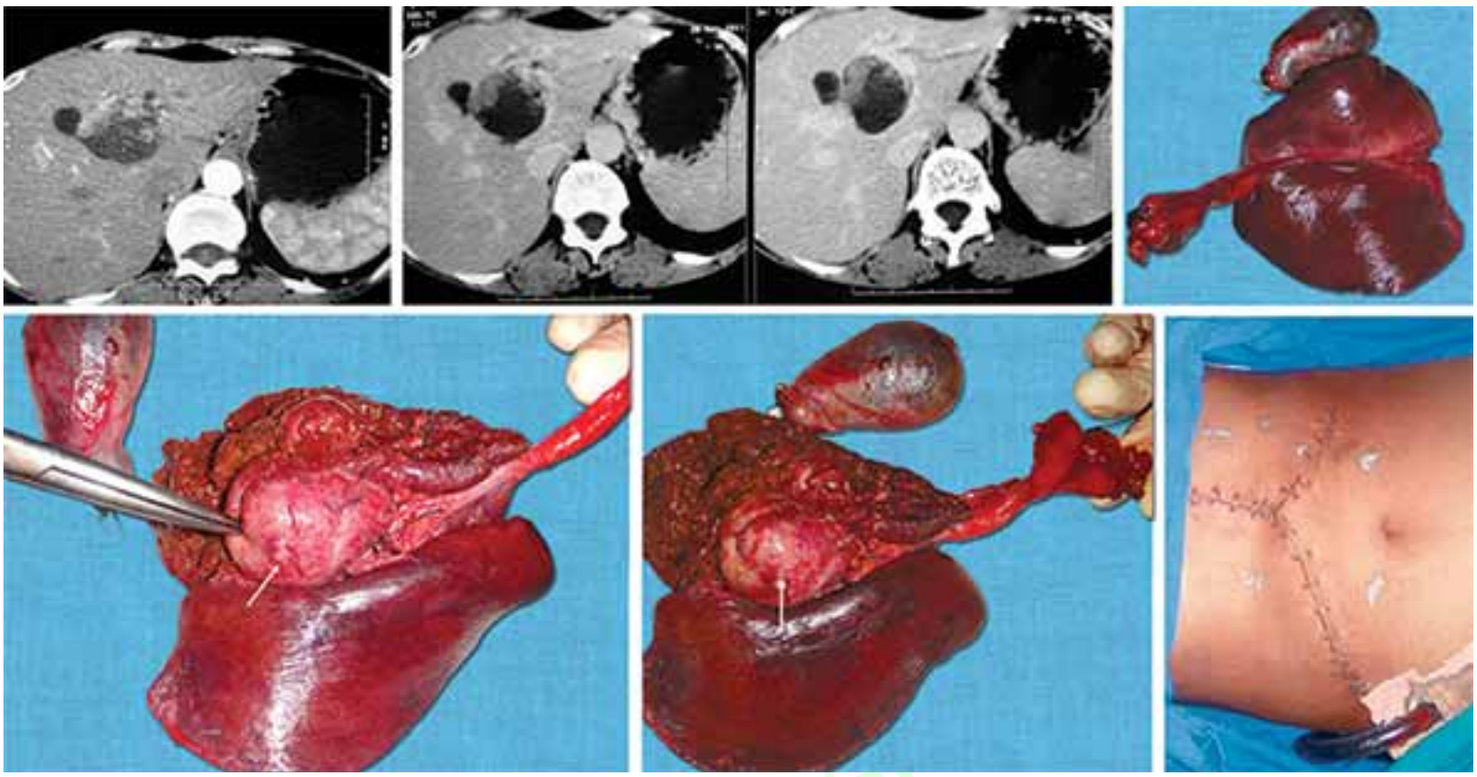


Fig. 22-25: CT scan picture of left lobe HCC with resected left hepatectomy specimen and sutured incision.

of parenchymal transection. Once the left hepatic artery is divided, the plane of parenchymal transection is obvious on the surface of the liver. This is a good time for requesting a low central venous pressure from your anaesthetist colleague. CVP lower than 5 mm Hg decreases blood loss during parenchymal transection. The line of transection is scored using monopolar cautery. Stay sutures are taken on either side of line of demarcation which helps in applying traction during parenchymal dissection. The liver capsule is the toughest structure during transection and it needs to be divided using electrocautery. Further parenchymal transection is carried out in one of the methods as described above. Our preferred method of transection still remains Kelly clamp method as it is economical and fast. In cirrhotic patients, however, CUSA or water jet dissection is preferred. As the parenchymal transection is towards completion, Satinsky vascular clamp is applied to include the left hepatic vein. The left hepatic vein is then closed with running sutures using 5-0 prolene. Alternately, the left hepatic vein can be divided using a vascular stapler load. Meticulous haemostasis is achieved with bipolar coagulation. In some situations, a figure of eight suture using 4-0 prolene may be required to achieve haemostasis **(Fig. 22-26)**.

The cut surface of liver is observed carefully for any biliary leaks. A fresh piece of gauze is placed over the cut surface. Any yellowish discoloration should be looked into very carefully and identified biliary radicles should be ligated. A simple saline leak test can be performed at this stage as well. Saline is injected via the cannulated cystic duct and cut surface of liver is observed for any leaks. Various methods of managing the cut surface of liver have been described such as using argon beam coagulation, use of surface cauterisation using ball cautery and use of tissue glue on cut surface but none have been proved superior to one another. We cover the raw surface with single sheet of surgicel (oxidized cellulose). A single drain is placed in the subhepatic space and brought out via a separate stab incision in the right subcostal region. Abdomen is closed routinely after haemostasis. Patient is extubated as early as possible as this decreases the overall ICU stay of the patients and helps in early recovery of the patient. The patient is shifted out of high dependency unit by post-operative day 2 when his drain output has decreased and bowel sounds return. The drain is removed by post-operative day 5 or when the drain output is less than 50 mL over 24 hours. Patients liver function test, prothrombin time and INR are monitored and fresh frozen plasma is given for correcting any abnormality. Albumin infusion is given only if the plasma albumin falls below 3g/dL **(Fig. 22-27)**.

Postoperative Complications

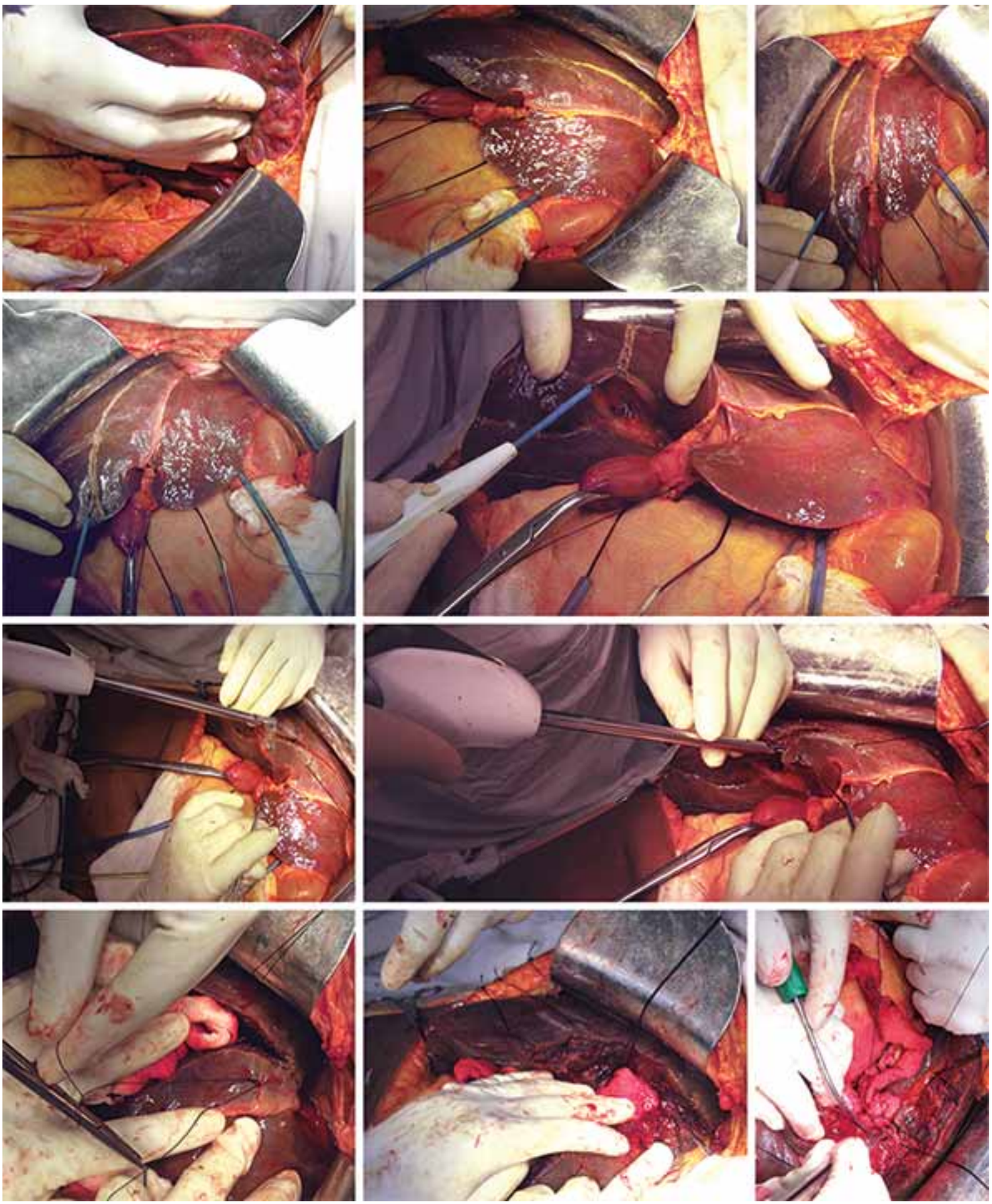
Biliary leaks: Incidence of bile leak and biliary duct injury is more in left hepatectomy as confluence is towards left side; and right anterior and posterior hepatic duct may join left hepatic duct.

Liver failure: It is the failure of remnant liver may be due to less volume or sepsis or ischaemia. Renal failure develops as a after effect of the liver failure or sepsis.

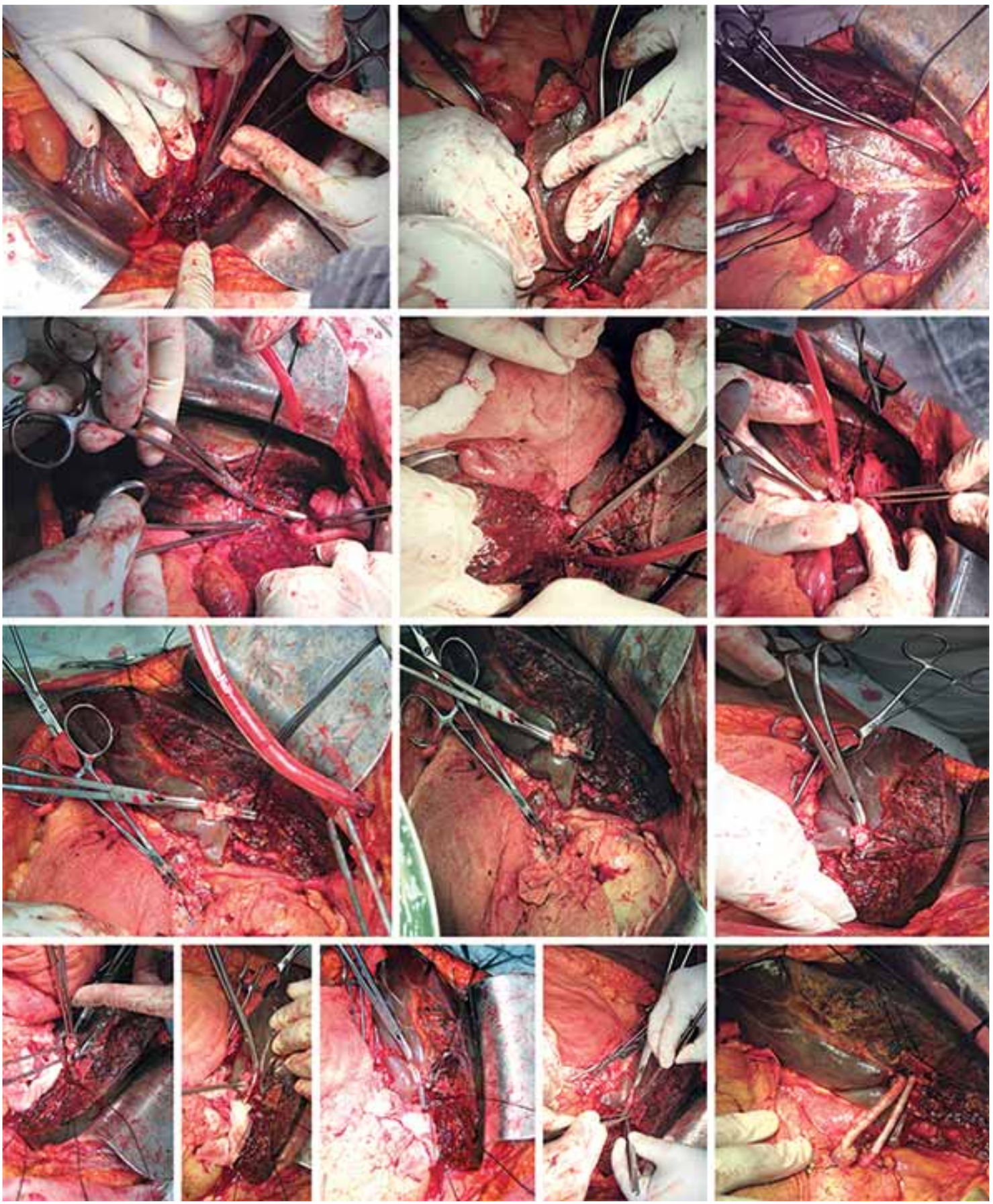
Intra abdominal bleeding: Usual bleeding is 500 mL to 800 mL in hepatectomies;' but torrential bleeding can occur at any stage of the surgical dissection.

Delayed gastric emptying and intolerance to oral feeding is common after liver resection.

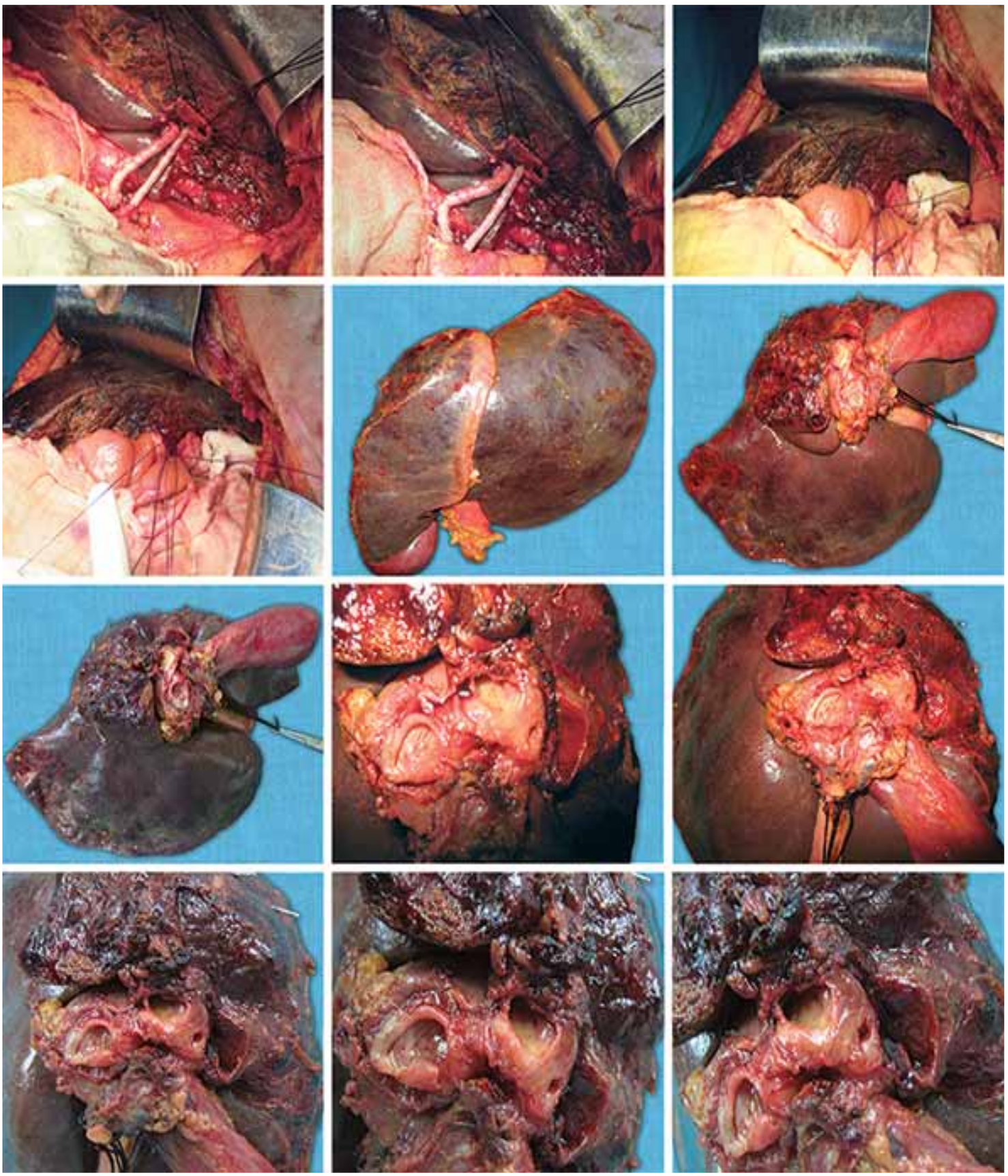
Ascites; portal vein thrombosis; other pulmonary complications; bliliary strictures; biliomas are other complications which are addressed and evaluated accordingly.



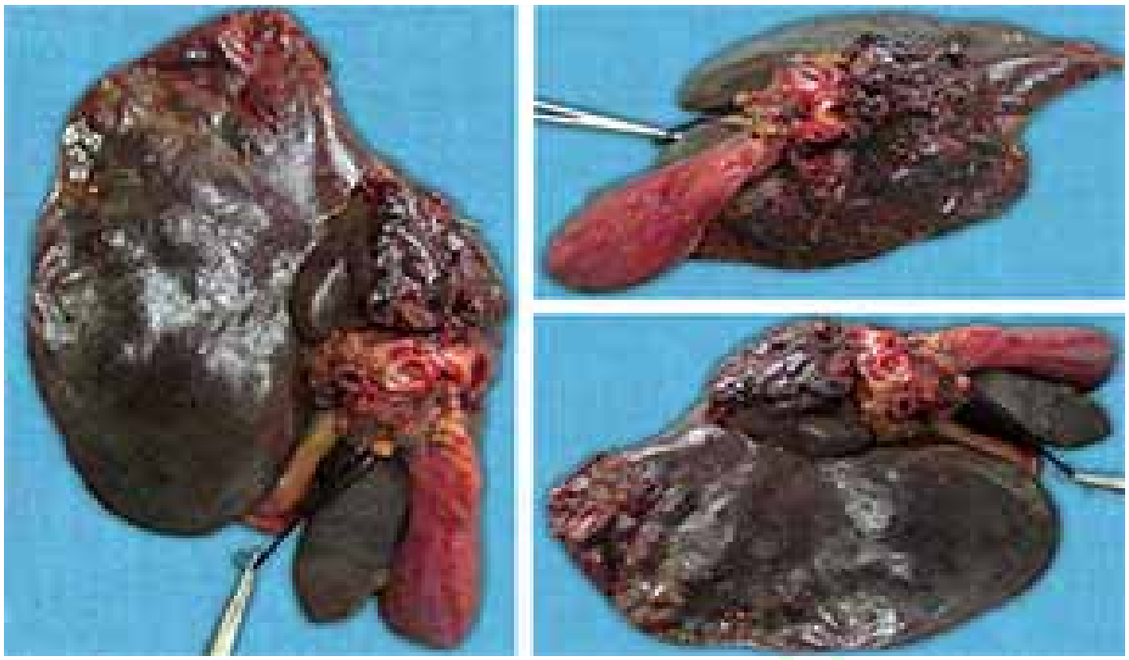
Figs 22-26(1)



Figs 22-26(2)

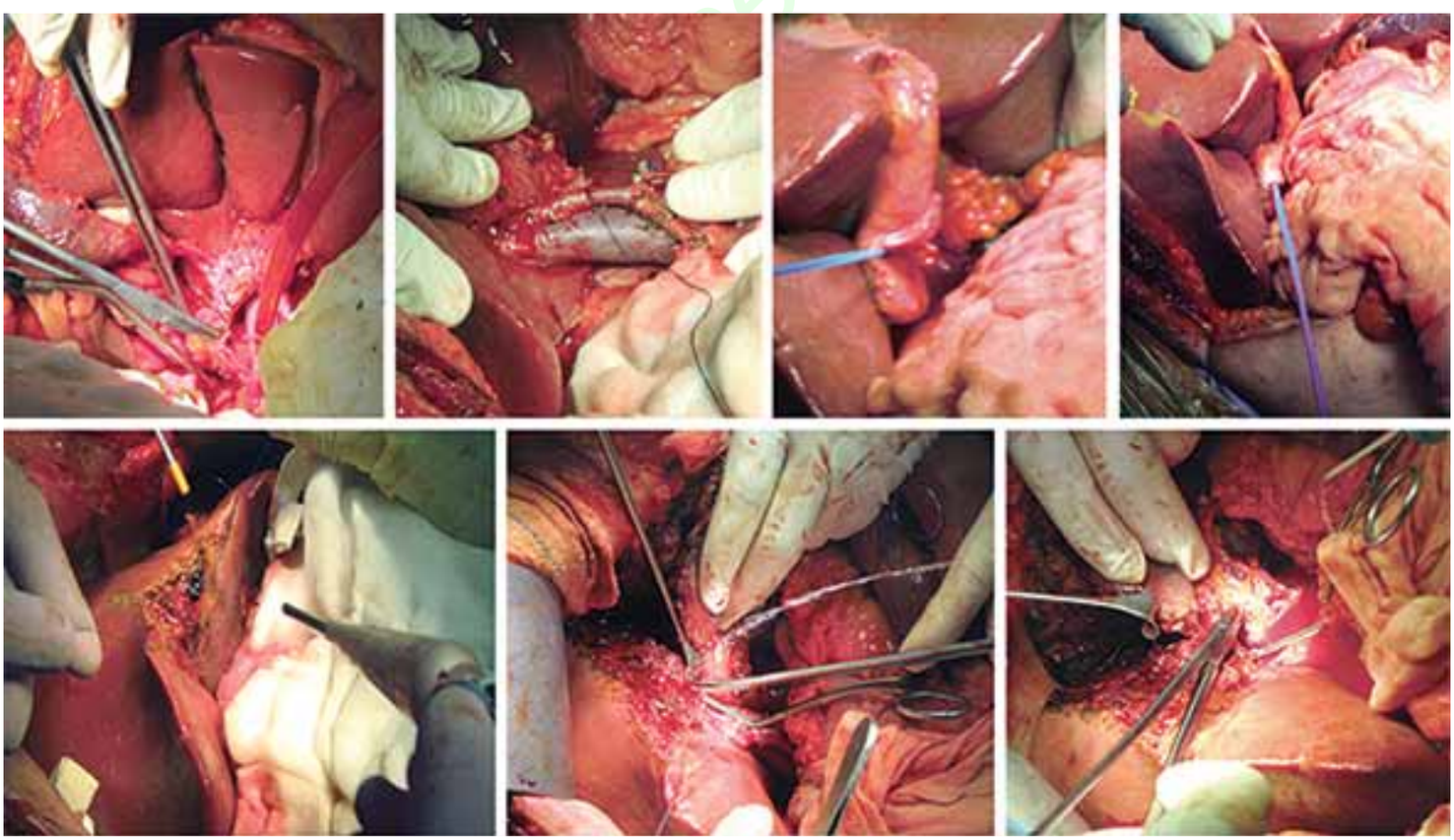


Figs 22-26(3)

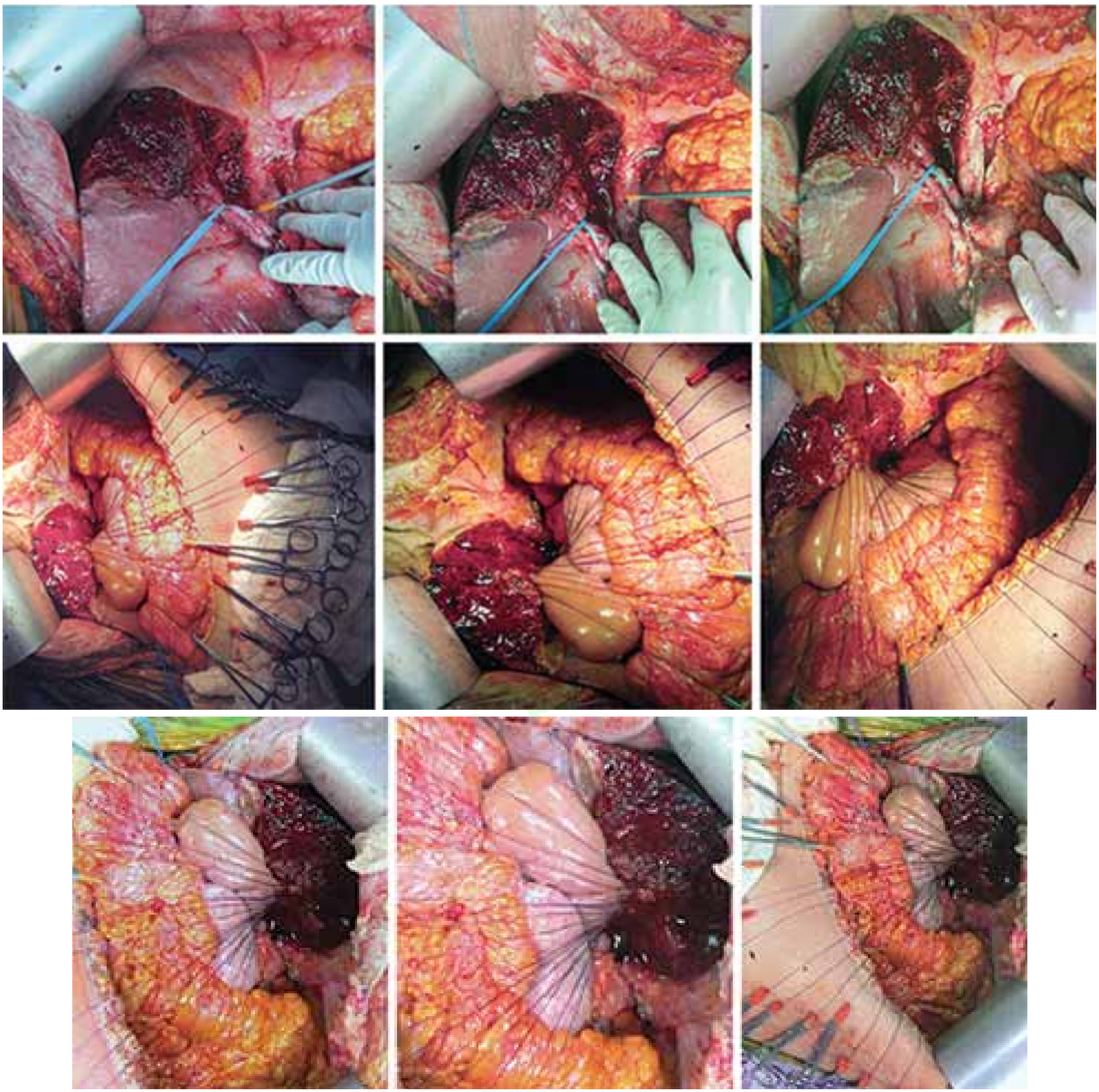


Figs 22-26(4)

Figs 22-26(1 to 4): Klatskin tumour—underwent left hepatectomy with resection of hepatic artery and portal vein with saphenous vein grafts to both (*Source:* Dr Arunkumar Mch Gastro, Kochin).



Figs 22-27(1)



Figs 22-27(2)

Figs 22-27(1 and 2): Hilar cholangiocarcinoma—left hepatectomy (By Dr Arunkumar MCh Gastro, Kochin).

Infection and intra abdominal abscess formation: Sepsis is due to liver failure or sepsis may precipitate liver failure. Bronchopneumonia is also common other than intra-abdominal sepsis.

Postoperative Care

Post-operatively patient is kept in critical care unit for 48 hours with monitoring urine output, liver function, hydration, blood pressure, body temperature, etc. High ammonia level, metabolic acidosis, respiratory distress, hypoglycaemia are indicators of inadequate remnant liver cell function. Dopamine or noradrenaline should be used to maintain blood pressure. Meantime fluid overload is also should be avoided. Parenteral nutrition with branched chain amino acids, phosphate and medium chained triglyceride emulsions and vitamin infusion is better. Phosphate is essential for liver regeneration and energy release. Intravenous potassium phosphate or oral sodium

phosphate is given. Early enteral feeding promotes liver regeneration but tolerance for food especially medium chained triglycerides which is essential in post-operative period otherwise parenteral nutrition to be continued.

Extended Hemihepatectomy

Extended Right Hepatectomy

The extended right hepatectomy or right trisectionectomy includes liver segments 4 to 8 (segment 4 with right liver). It is usually done for resection of hilar cholangiocarcinomas or resection with carcinoma of gallbladder. Any extended hemihepatectomy is carried out after confirming that the remnant liver will be able to withstand the demand. In the classical approach, the segment 4b pedicle is secured before the parenchymal transection. The right pedicles are isolated and divided as for right hepatectomy (described earlier). The right hepatic vein is also taken down after mobilising the liver from the IVC posteriorly. For isolating the segment 4 pedicle, after lowering the hilar plate dissection is carried out to the right of portal pedicle going cranially. The pedicle is identified in the liver substance, isolated and divided between ligatures. The plane of parenchymal dissection is to the right of falciform ligament and is now identified by the ischaemic line. Parenchymal dissection is done in the usual fashion. As the right hepatic vein is already divided, the middle hepatic vein is the one major vessel to be encountered. It joins the left hepatic vein most of the times within the liver substance and hence, taking it needs careful attention. Care should be taken not to damage the left hepatic vein which joins it just within the liver. The falciform ligament is now sutured back to the underside of the liver. Drain is placed in the cavity. Rest of the procedure and post-operative care is the same as in major hepatic resection.

Extended Left Hepatectomy

This involves removal of liver segments 2, 3, 4, 5 and 8 (segment 5 and 8 with left liver). The residual liver 6 and 7 segment volume must be adequate to warrant a safe resection. In this case, the right hepatic vein needs to be preserved to provide drainage to the remnant segments. Portal vein embolisation with delayed hepatectomy (about 4 weeks) should be considered prior to resection, if the remnant liver is judged too small. The left portal pedicle is identified and tackled similar to left hepatectomy. The right anterior segmental pedicle is identified as it runs a horizontal course to the right after bifurcating from the posterior sectoral duct which runs deep into the liver cranially. After ligation of the pedicle, the transection line is demarcated on the liver surface and the parenchymal dissection is carried out in the usual fashion. The location of the right hepatic vein should be known at all the times and dissection should be to the left of the vein. At the end of parenchymal transection, the middle and the left hepatic vein are divided using a vascular stapler or suture ligated with continuous 4-0 prolene suture. Attention should be given to identify and points of biliary leaks from the cut surface of the liver. The abdominal cavity is drained and the post-operative monitoring done in routine fashion.

Right Anterior Sectionectomy

This is the resection of segments V and VIII which is supplied by anterior segment of the right portal pedicle. After performing cholecystectomy, the right main portal pedicle is identified and isolated. The anterior segmental pedicle is identified as going to the right and horizontally compared to the posterior pedicle which enters liver parenchyma cranially and posteriorly. The pedicle is isolated and clamped to produce the line of ischaemia which is seen on the liver surface. The parenchymal dissection is started and the anterior pedicle is ligated. The branches draining to the right hepatic vein are ligated intraparenchymally and at the end of parenchymal transection, the middle and the right hepatic vein are seen exposed in the field.

Left Lateral Sectionectomy

This procedure includes the removal of segments II and III of the left lobe of liver. These segments are situated to the left of the falciform ligament. The procedure is started with the mobilisation of the left liver by releasing the left triangular ligament and dividing the falciparum ligament. By pulling up the left liver via the round ligament, hepatic parenchymal transection is done along the left edge of the falciform ligament. The portal pedicle of the segment 3 is situated within 2 cms of liver transection and it is taken down intraparenchymally. The segment 2 pedicle is reached during more cranial dissection and it is usually thicker than the segment 3 pedicle. After dividing it, the left hepatic vein is reached. It is divided by using a vascular stapler or with help of a Satinsky clamp and cut edge is over sewn using 4-0 prolene.

Non-anatomical Wedge Resection

This is usually indicated in patients who have peripherally situated tumours which are easy to access on the surface. In patients who are not candidates for anatomical resections and in cirrhotic patients as well, these wedge resections are helpful. A resection margin of 1 cm is adequate in such situations. The line of resection is marked around the tumour and the depth is confirmed by an on table ultrasound. Parenchymal transection is begun without any vascular clamping whenever the lesion is large or significant bleeding is anticipated, the portal inflow can be taped (not clamped) and prepared should any inflow occlusion be needed. The biliary radicles and vessels are secured and divided as and when they cross the operative field **(Fig. 22-28)**.

Laparoscopic Liver Resection

There are three types of laparoscopic liver resections – pure laparoscopic (75%); hand-assisted laparoscopic resections; hybrid method.

Usually done procedures are—segmentectomy, left lateral sectionectomy, right and left hepatectomies, metastasectomy in colorectal malignancies.

It should have similar ***indications***, technical principles are same as of open procedure. Safety and outcome should be considered. Patient selection, size of tumour (<5 cm), location (in segments 2, 4, 5, 6), number of lesions, status of the liver, condition of patient, facilities available and skilled expertise are important.

Contraindications: Central tumours; right posterior lobe tumours; tumours at hilum/close to major vessels; not fit for laparoscopic procedures.

Technique: Right side of the patient is elevated with surgeon standing on the left side and first assistant on the right side. Surgeon can also stand between legs of the patient.

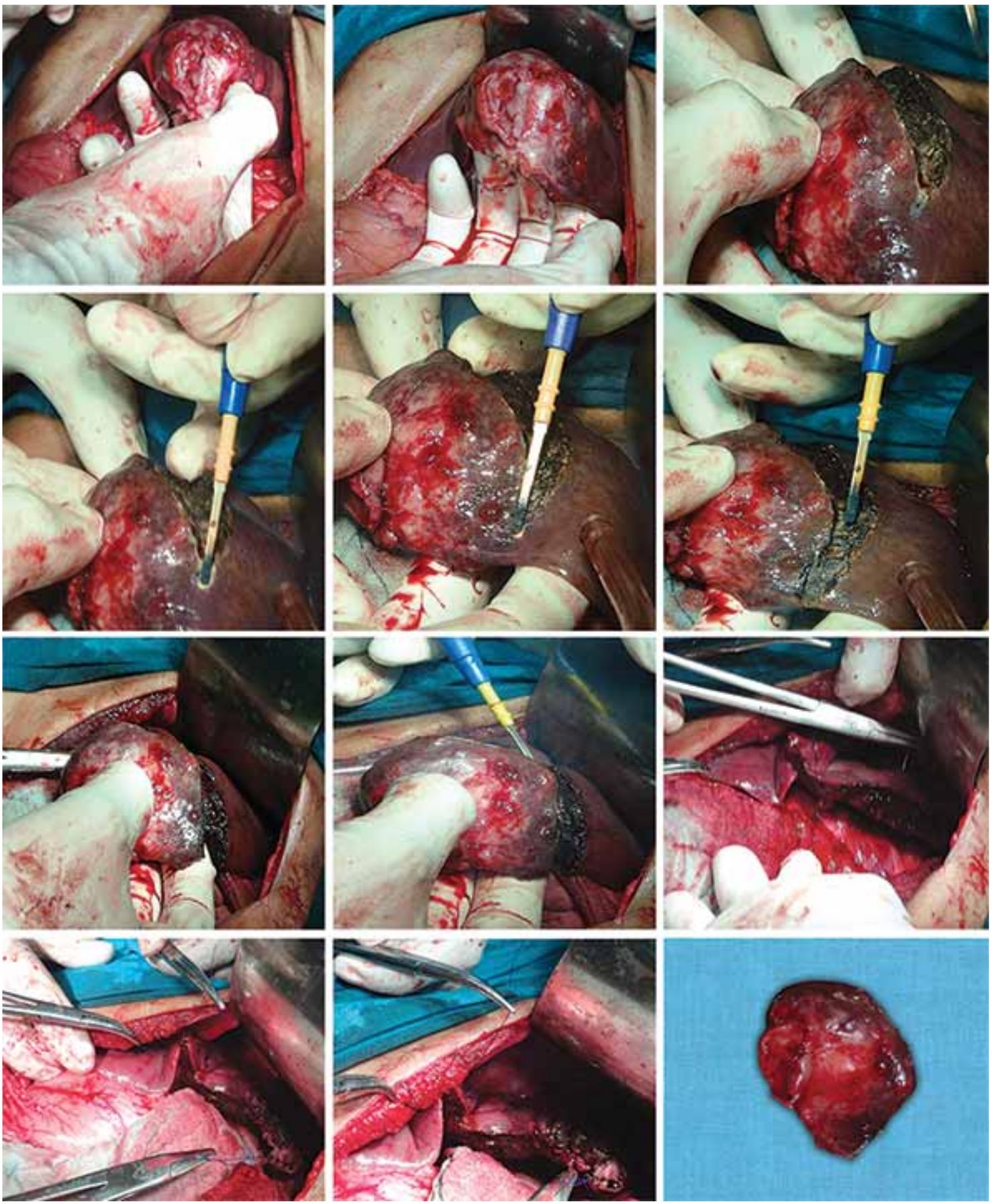


Fig. 22-28: Non-anatomical resection for secondaries in liver; primary is in colon.

A 12 mm port is introduced just above the umbilicus by open method. After laparoscopic exploration, additional 12 mm ports are placed in the right subcostal region. Laparoscopic ultrasound is essential. 5 mm ports are not used usually; but it is individual surgeon's choice. Parenchymal transection is done using ligaseal, harmonic or ultrasonic dissector or endovascular stapler. Cholecystectomy is done with fundus first method to reach Calot's. Blood vessels and bile duct branches are managed with endoclips or endostaplers. Raised pneumoperitoneum controls the oozing from the parenchymal surface. Portal inflow occlusion is usually not necessary. Hepatic veins are divided with cutting endovascular stapler. Intraoperative cholangiogram is done to identify biliary leak. Liver surface of the remnant liver may be covered with fibrin glue. Specimen is removed using a retrieval bag which is removed through a lengthened port incision. Drain is placed through the laparoscopic port. All other technical steps and principles are same as open procedure but through laparoscopy. Here tissue feel is not present; only magnified vision is present.

Conversion when needed—undue bleeding; difficulty in proceeding with dissection should be done without hesitation.

Complications are—pulmonary embolism; bleeding; biliary injuries; respiratory infections; bowel, diaphragm, pericardium, pleural injuries; air embolism and CO_2 embolism can occur. Air embolism is more risky.

Post-operative care—ICU management; electrolyte management; sepsis control; monitoring liver and renal functions; nutrition support; analgesia, prevention of DVT; daily biochemical assessment; when needed imaging evaluation.

LIVER TRANSPLANTATION

Introduction

Liver transplantation is the choice for end stage liver disease. Liver transplant is an accepted and effective treatment. Many tumours can be treated by transplantation. Cirrhosis, hepatitis, sclerosing cholangitis, biliary atresia, tumours are indications. In Budd-Chiari syndrome, if portacaval shunt has failed with progressive liver damage liver transplantation is indicated.

CTP (Child-Turcotte-Pugh) scoring system (ascites, encephalopathy, bilirubin, albumin, PT- INR), model for end stage liver disease (MELD score) consists of total bilirubin, INR, creatinine, paediatric end stage liver disease scoring (PELD) are different scorings used to assess the patients.

MELD Score = $0.957 \times \text{Log}_e(\text{creatinine mg/dL}) + 0.378 \times \text{Log}_e(\text{bilirubin mg/dL}) + 1.120 \times \text{Log}_e(\text{INR}) + 0.643$

Transplantation of the liver is among the most technically demanding surgical procedures. TE Starzl performed the first human liver transplantation in 1963. Since then continuous improvements in surgical techniques, immunosuppressant's, prolongation of ischaemic tolerance and experience with indications/timing, liver transplantation has become a standard modality of treatment for chronic and acute end stage liver disease. The majority of liver transplantation is performed orthotopically. The shortage of organs has led to development of reduced size, split liver and living related (donor) liver transplantation techniques. Given the overall broad nature of the topic, the focus will be on deceased donor liver transplantation procedure along with a brief description of other techniques. For further reading, readers should refer to references at the end of the chapter.

Contraindications for Liver Transplantation

Active sepsis, SBP and HIV; extrahepatic malignancy; large hepatocellular carcinoma and cholangiocarcinoma; unfit for surgery—Severely advanced cardiopulmonary disease, active alcohol or substance abuse, inability to comply with immunosuppression protocols because of psychosocial situations—are the contraindications.

Donor Criteria

They are related to donor liver function, hepatitis screening, history of consumption of alcohol and toxic substances. Marginal donor and expanded donor criteria are in use in places due to very high demand for donor for transplantation. ABO compatibility is important. HLA matching is not necessary unlike in renal transplantation.

Deceased donor liver transplantation donor (DDLT)	*Living donor liver transplantation donor (LDLT)*
• 50 years or younger • No hepatobiliary disease • Haemodynamic and respiratory stability (systolic blood pressure >100 mm Hg, and central venous pressure >5 cm/H_2O); an acceptable PaO_2 and haemoglobin level • No severe abdominal trauma, systemic infection, or cancer • Normal kidneys—diuresis greater than 50 mL/h and normal creatinine; and finally, a dopamine requirement less than 10 µg/kg/min • Simple technically • Recipient complication is low (of bile duct) • Graft quality is average • Donor's complication—nil	• Young • Non-obese, tall • No infection and malignancy • No fatty liver • Enough liver to donate • Enough residual liver • Suitable anatomy • Technically complex procedure • Recipient complication is higher • Graft quality is good • Donor's complication—25% morbidity; 0.4% mortality

Back—Table Preparation of Liver Graft—Donor Operation

It is by a midline incision from suprasternal notch to pubic symphysis. Initially, dissection is done with a beating heart; but later with a cold preservation into aorta and portal vein and local ice application. UW solution extends cold ischaemic time for 24 hours but usually within 10 hours transplantation is done. IVC segment is removed with hepatic veins. Portal vein is transected. Celiac artery with branches along through hepatic artery is dissected and transected at celiac artery origin. Bile duct is transected.

Note: Remnant liver—≥30% of the original liver volume with complete venous drainage is safe for donor survival.

The donor liver is prepared on the back table for implantation. Bench preparation includes resection of the donor diaphragm and adrenal gland off of the bare area of the liver and vena cava. Meticulous ligation of tributaries from the vena cava (adrenal vein, phrenic vein, and lumbar branches) is performed. The artery is dissected free from the Carrel patch of the aorta up to the gastroduodenal artery. Dissection near the right or left hepatic arteries is avoided to prevent unnecessary injury. The portal vein is circumferentially dissected free.

The gallbladder may be removed at this stage or following reperfusion. Tissues surrounding the common bile duct are left intact to avoid injury of the blood supply.

Recipient Operation

Bowel preparation, prophylactic antibiotics, administrative immunosuppressive agents are needed before surgery. Bilateral subcostal incision is used with midline upward extension. Falciform ligament, left lateral ligaments, hepatogastric and hepatoduodenal ligaments are divided. Right and left branches of hepatic arteries are ligated. CBD and cystic ducts are divided with ligatures. Portal vein is dissected. Infra and suprahepatic vena cava are exposed. Portal vein and suprahepatic vena cava are clamped. Venovenous bypass between portal and femoral veins and internal jugular vein is created with a flow of blood through it more than 2.5 mL/minute. Warming circuits and ultrafiltration is needed. Suprahepatic vena caval cuff is created at the opening of the right, middle and left hepatic veins. Donor IVC is sutured to recipient IVC first above and then below as end to end. Recipient IVC can be preserved entirely and donor IVC is sutured to recipient IVC as end to side. Preservation solution is passed. Portal vein is sutured. Reperfusion injury can occur at this stage with hyperkalaemia and acidosis. Arterial reconstruction is done between donor celiac artery to recipient gastroduodenal artery. Bile ducts are sutured as end to end with or without T tube. Often choledochojejunostomy is also done.

Graft should be:

- 40% of the estimated standard liver volume.
- 0.8% to 1% of the body weight of the recipient is necessary for the recipient recovery.

Details of the Technique

The recipient's abdomen and bilateral groins are prepped and draped in a standard fashion. The most commonly used incisions are bilateral subcostal incision with a midline extension to the xiphoid process and reverse 'L'. The ligamentum teres is carefully divided between clamps and ligated because a large recannulised umbilical vein is often present in patients with severe portal hypertension. After dividing the falciform ligament with cautery, a mechanical retractor (Thompson) is used to retract the bilateral costal margins anteriorly and superiorly for excellent exposure of the upper abdomen. The abdominal cavity and liver are then inspected for any abnormalities including unsuspected malignancy. Following this, liver transplantation occurs in three stages:

a. Recipient hepatectomy
b. Anhepatic phase and implantation of donor liver
c. Post-revascularisation phase.

Recipient Hepatectomy

The liver is mobilised from its ligamentous attachments and the portahepatis is skeletonised. The peritoneum overlying the portal triad is divided with electrocautery near the liver edge. The right and left hepatic arteries are dissected free, ligated, and divided, leaving adequate length to form a branch patch for the arterial anastomosis. The proper hepatic artery is also dissected free to the level of the gastroduodenal artery allowing enough length for clamping during the anastomosis. A replaced or accessory right hepatic artery, which arises as a branch off the superior mesenteric artery travels in a posterior position to the common bile duct and lateral to the portal vein, can usually be palpated if present and can be ligated and divided. When the replaced right hepatic artery is relatively large and the proper hepatic artery is diminutive in size, the replaced right hepatic artery can be left long and used for arterial inflow for the donor liver.

The common bile duct and common hepatic duct should be dissected free with as much length as possible and without injuring the blood supply to the bile duct. Leaving the recipient bile duct as long as possible allows the length of the donor bile duct, which may have a tenuous blood supply, to be shorter and still avoids tension at the time of anastomosis. This is accomplished by first ligating and dividing the cystic duct. The common bile duct and common hepatic duct are then circumferentially dissected free, leaving the surrounding tissue to preserve the bile duct blood supply. The common hepatic duct is then ligated as close to the native liver as possible.

Once the bile duct and the hepatic artery are freed from surrounding tissues, the portal vein can be easily approached from its anterior, medial, and lateral aspects. In general, the portal vein is freed circumferentially from the edge of the duodenum up to its bifurcation of the right and left portal veins. Small branches may arise near the pancreas and excessive bleeding may arise if these are inadvertently injured. In situations where there is small bowel oedema, the portal vein should be left in continuity for as long as possible, particularly when the use of venovenous bypass is not intended.

The ligamentous attachments of the liver are then divided using electrocautery. Care must be taken to avoid injury to the phrenic or hepatic veins when freeing the suprahepatic inferior vena cava where it traverses the diaphragm. The liver is then dissected off of the anterior aspect of the inferior vena cava. Small venous branches from the inferior vena cava to the caudate lobe are ligated and divided. Division of the portal vein facilitates exposure for this dissection but is not required. The liver may be gradually retracted and dissected from either the right or left aspects until the right, middle, and left hepatic veins are reached. If a venacaval resection technique will be used, the vena cava can be circumferentially mobilised near the diaphragm above the hepatic veins as well as in an infrahepatic position. However, if a piggyback or cavocavostomy (side-to-side caval anastomosis) technique is intended, the dissection of the posterior aspect of the vena cava should be avoided to prevent bleeding from collaterals or lumbar vessels.

Anhepatic Phase and Implantation of the Donor Liver

At this point, the liver has been completely mobilised except for its attachments of the hepatic veins to the inferior vena cava and, in some cases, the portal vein. The decision should now be made whether to use venovenous bypass. Most patients will tolerate clamping of both the portal vein and the inferior vena cava without difficulty. At this point, communication with the anaesthesiologist is essential and the vena cava should be test clamped before division to make sure that adequate cardiac filling and blood pressure can be maintained. If the patient becomes hypotensive during test clamping, the clamp should be removed and additional volume or pressor support can be administered. Occasionally, patients will require venovenous bypass, but its use is no longer routine at most centres.

If necessary, venovenous bypass can be accomplished from both the portal vein and inferior vena cava simultaneously, or a single cannula in either the portal vein or the inferior vena cava may be used.

Inferior vena caval and mesenteric blood is delivered to the superior vena cava by a centrifugal pump. Flow rates of 1 to 2 L/min are usual.

Once venovenous bypass has been established or the decision to forego bypass has been made, the recipient hepatectomy is completed. If still intact, the portal vein is divided as high in the hilum as possible. Three methods are commonly used for orthotopic liver transplantation: (1) the segmental IVC resection (bicaval) technique, (2) the piggyback technique, and (3) cavocavostomy (side-to-side caval anastamosis) technique.

1. For the segmental IVC resection technique, the recipient liver is excised en bloc with the retrohepatic inferior vena cava after caval clamps have been placed in a suprahepatic and infrahepatic position. The hepatic veins are divided within the substance of the liver to allow the creation of a large suprahepatic cuff compromising the left, middle, and right hepatic veins. This technique has the disadvantages of (a) totally obstructing inferior vena cava flow, resulting in renal ischaemia and decreased cardiac filling with associated hypotension, possibly leading to the requirement of venovenous bypass; (b) requiring two vena caval anastomoses, prolonging the warm ischaemic time; and (c) requiring dissection posterior to the vena cava, possibly leading to bleeding. However, complete dissection of the caudate lobe off of the vena cava is not necessary, making the recipient hepatectomy phase somewhat easier and faster.
2. For the piggyback technique, a clamp is placed transversely, partially occluding the vena cava at the level of the hepatic veins. The vena cava is left in continuity and the hepatic veins are divided within the substance of the liver, allowing the creation of a common patch of the right, middle, and left hepatic veins for a wide anastomosis. This technique does have the advantage of only requiring a single vena caval anastomosis, helping to limit warm ischaemic time.
3. For the cavocavostomy technique, clamps can be placed on the right hepatic vein as well as the junction of the left and middle hepatic veins. The liver is excised and these venous branches are oversewn and the clamps are removed. Alternatively, the hepatic veins can be divided using an Endo GIA stapler. Advantages of the cavocavostomy anastomosis include (a) minimalisation of the time that the vena cava is clamped; (b) the vena caval clamp is placed longitudinally, only occluding the anterior third of the vena cava, leading to minimal or no changes in the recipient's hemodynamics; (c) a cavoplasty with long anastomosis over 6 cm is performed, limiting the likelihood of caval stenosis and minimising the risk for hepatic vein outflow complications; and (e) exposure during suturing of the anastomosis is considerably improved compared to the piggyback or bicaval technique.

After removal of the recipient liver, the right upper quadrant is carefully inspected and haemostasis is obtained. Complete haemostasis in the bare area is essential at this time because this region is easily visualised when the liver is absent but may be relatively inaccessible once the donor liver is implanted, especially if the donor liver is relatively large or the recipient is obese.

The donor liver is then brought onto the operative field. The vascular anastomoses are performed using a running monofilament polypropylene suture. If an IVC resection technique is planned, two caval anastomoses are required. For the piggyback technique, the donor infrahepatic vena cava is either oversewn or stapled and donor suprahepatic vena cava is then sewn in to the recipient hepatic vein cuff. For the side-to-side caval technique, a clamp is placed longitudinally on the anterior third of the recipient vena cava. A longitudinal venotomy is made on the anterior surface of the recipient vena cava. The donor suprahepatic and infrahepatic vena cava are either oversewn or stapled closed. A longitudinal posterior venotomy is then made matching the length of the recipient venotomy. The liver is then placed in the right upper quadrant and the left lateral segment is elevated. The two vena cava are then sutured in a side-to-side fashion.

During the caval anastomosis, the donor liver may be perfused with cold fluid via a cannula placed within the donor portal vein to wash out the preservation solution and helps to maintain the cold temperature of the liver. This step is not required but may be considered if the liver was preserved with a solution containing a high concentration of potassium or if a prolonged warm ischaemic time is anticipated.

Once the caval anastomosis or anastomoses are completed, the portal anastomosis, arterial anastomosis, or both can be performed prior to reperfusion. In theory, reperfusion with arterial blood would limit the extent of warm ischaemia to the biliary tree, which, unlike the remainder of the liver, receives its blood supply exclusively from the arterial blood and not along with portal venous blood. However, neither sequence has been clearly shown to be an advantage over the other, so the choice is made based on the surgeon's preference and the patient's anatomy. Most commonly, the portal venous anastomosis is completed and the liver is reperfused. The portal anastomosis is usually performed in an end-to-end fashion using a running technique. To avoid narrowing, an air knot (growth factor) is used when the suture is tied. For those patients with portal vein thrombosis, portal venous flow can be restored in most cases. Often, the thrombus can be evacuated with the use of forceps or by placing a Yankauer suction tip within the lumen of the portal vein. If the thrombus is more mature, an eversion endovenectomy may be necessary. If these manoeuvres are unsuccessful, the junction of the splenic vein and superior mesenteric vein may be patent. Dissection of the portal vein behind the pancreas to this junction can then be performed to allow for future anastomosis. In rare cases, all of these manoeuvres may be unsuccessful and a venous bypass graft using donor iliac vein from the superior mesenteric vein may be necessary. If the superior mesenteric vein is also occluded, either inferior vena cava (cavoportal hemitransposition) or left renal vein can be used for portal inflow.

At the time of revascularisation, flow is restored to the liver through the portal vein and/or the hepatic artery. Alternatively, the caval clamp can be "flashed" and the anastomosis inspected for bleeding and repaired if present. Portal blood should be restored gradually to minimise cardiac irritability, bradycardia, and hypotension. Close coordination between the surgeon and anaesthesiologist is necessary during this phase as hypotension and bradycardia are routinely encountered and cardiac arrest may rarely occur. If venovenous bypass has been used during the anhepatic phase, it can now be discontinued.

Once haemostasis is obtained and the patient has stabilised, attention can now be turned toward the arterial anastomosis if it has not already been performed. Hepatic artery (HA) anstamoses can be performed in variety of different ways due to variations in recipient and donor vascular anatomy, the need to optimise arterial inflow and surgeon's preference. At the end of HA reconstruction, one needs to avoid excessive looping, redundancy or twisting, especially so after release of retractors. For a donor HA with a standard anatomy either celiac axis with or without aortic carrel patch or shortened celiac artery near splenic artery origin with subsequent joining of celiac and splenic arterial orifice to form a patch, can be used. On recipient side, a patch created between the orifice of right and left hepatic arteries or between that of common hepatic and gastroduodenal arteries is used. Anastomosis is usually performed using a fine, non-absorbable,

monofilament, running suture. Variations in donor arterial anatomy require back-table reconstruction. If the recipient arterial inflow is inadequate, an aortic conduit may be constructed. This is often performed using a graft consisting of the donor common and external (or internal) iliac artery. A partially occluding aortic clamp can either be placed in a supraceliac or infrarenal position and the common iliac artery is sutured in an end-to-side fashion to the recipient aorta. The donor Carrel patch can then be sutured in an end-to-end fashion to the external iliac artery of the conduit.

Post-revascularisation Phase

Following revascularisation, the liver should assume a normal colour and consistency within several minutes. Bile production should be seen while in the operating room and is among the first evidence for liver function. Inspection for surgical bleeding should be performed. If bleeding continues after all surgical bleeding has been resolved, attention should be directed toward correction of coagulopathy as described earlier.

Because of the relatively high complication rate associated with biliary reconstruction, it has been referred to as the "Achilles heel" of liver transplantation. There are several options for biliary reconstruction. The simplest and most common technique is currently an end-to-end choledochocholedochostomy from the donor to the recipient bile duct. If a size discrepancy exists, the narrower duct can be spatulated. Absorbable monofilament suture is most commonly used to avoid a nidus for future stone formation within the bile duct. While T-tubes were commonly used in the past to stent the anastomosis, evidence now suggests that more leaks or strictures develop as a result of the T-tube than are prevented. Alternative biliary reconstruction methods may be necessary for those with a bile duct of inadequate quality or size or in those whose primary disease is biliary pathology such as primary sclerosing cholangitis or biliary atresia. The most common option employed in these situations includes a standard Roux-en-Y choledochojejunostomy. Placement of drains is optional. Abdominal wall and skin closure is then performed in the standard fashion.

Reduced Size and Split Liver Transplantation

In the 1980s, the waiting list mortality for small, paediatric liver candidates was relatively high because the number of suitably sized small liver donors was inadequate. As a result, techniques to reduce the size of an adult liver, based on Couinaud's segmental anatomy were developed so that the left lobe, left lateral segment could be used for a recipient smaller by weight than the donor. During the early experience, the donor hepatectomy was performed in a standard fashion and the liver was brought back to the recipient hospital. The needed segments of the liver were cut down on the back table with the organ on ice, the vessels were left intact to the future transplant graft, and the remainder of the liver was discarded. Techniques have now developed so that both sides of the liver can be transplanted into two recipients, either a child and an adult or two adults. In addition, the liver may be split in situ at the donor hospital, allowing coagulation of the cut edge of the liver so that bleeding is minimised following reperfusion. Perfusion to both sides of the liver can be inspected prior to flushing, ensuring that blood flow to all segments of each future graft has been preserved. Split liver transplantation has been associated with a decreased survival rate and the potential for increased risk of complications, including primary non-function, hepatic artery thrombosis, and biliary complications. Because of this split, liver transplantation only accounts for a small proportion of transplants performed. In addition, only grafts from "ideal donors" are thought to be suitable for this form of transplantation. Current criteria for splitting include that the donor should be less than 40 years of age, to be on a single pressor or no pressors, have transaminases no greater than three times normal, and have a body mass index of 28 or less.

Segmental/Lobar/Split/Living Donor Liver Transplantation

Experience with deceased donor split liver transplantation as well as the success with living donor kidney transplantation led to the adoption of the techniques for split liver transplantation to living donor liver transplantation. The first living donor liver transplantation allowed an adult volunteer to donate the left lateral segment of the liver to a child. Based on the success of living donation in the paediatric population as well as the increased waiting list mortality rate for adults, these techniques have also been applied to adult recipients receiving either the right or left lobe from an adult volunteer. Living donor liver transplantation now accounts for approximately 5% of all liver transplants performed in the United States. In south East Asian countries including India, where deceased donor transplantation has developed more slowly because of cultural difficulties living donor transplant is the rule rather than the exception.

It is newer beginning but becoming preferred one. It is based on segmental anatomy and liver regeneration capacity. Minimum liver mass required is more than 1% of graft to body weight ratio. Right lobe is better. It is basically used in children; but useful in adults also. MELD score in donor should be less than 20 for living donor transplantation. Regeneration occurs very significantly in recipients in first 2 weeks reaching standard in 1 month. Regeneration is slow in living donor liver in 1 year. Graft to standard liver ratio should be more than 40%. Function of liver in living donor should be optimum. Proper imaging of the donor for entire anatomy including vasculature is important. Individual branches of portal vein, hepatic artery and bile duct are dissected and isolated. Liver is carefully separated from IVC; small branches of hepatic vein are ligated. Main hepatic vein is isolated; liver parenchyma is dissected with finger/Kelly fracture technique. After completion of parenchymal division, vessels are transected; dissected liver is perfused with cold preservation. Diseased liver of the recipient is removed completely. Graft is anastomosed in usual manner hepatic vein, portal vein, hepatic artery, bile duct. Living donor transplantation has got higher chances of morbidity, complications compared to cadaveric transplantation.

In many respects, transplantation of a graft from a living donor is similar to transplantation of a whole liver from a deceased donor. However, an IVC segmental resection technique is not possible given that the donor vena cava is not available for replacement of the recipient's retrohepatic inferior vena cava. Therefore, the recipient vena cava must be left intact. A direct hepatic vein to vena caval anastomosis is used. Establishing adequate outflow of hepatic venous blood is necessary to prevent oedema of inadequately drained segments of the liver possibly leading to small-for-size syndrome. Therefore, any accessory veins greater than 5 mm in diameter should be reconstructed either by direct anastomosis to the vena cava or by using an interposition graft. In addition, the lengths of the portal vein, hepatic artery, and bile duct on the donor graft are considerably shorter than those available from a deceased donor. Therefore, during the recipient hepatectomy, considerable care should be given to

preserving the length of the recipient bile duct as well as the right and/or left hepatic artery and portal vein that are intended for future anastomosis.

Auxiliary/Heterotopic/Ectopic Liver Transplantation

Under selected circumstances, there is a good rationale for placing the donor allograft in heterotopic rather than orthotopic position, leaving the native liver in place. This procedure is known as auxiliary liver transplantation. Auxiliary liver transplantation has occasionally been used for cases in which liver transplantation is indicated for enzymatic deficiency but the native liver is otherwise normal in all other respects. It has also been used in cases of fulminant hepatic failure where the liver candidate is expected to die in the near future without transplant but if adequate time was allowed, the native liver may recover and return to normal. In this situation, immunosuppression can slowly be weaned, the transplanted liver will atrophy, and the recipient can be taken off of all immunosuppression. Another option, auxiliary partial orthotopic liver transplantation (APOLT), has been developed. For this technique, part of the native liver is resected, often the right trisegment, leaving only the left lateral segment intact. The donor liver is then transplanted in an orthotopic position. If the native left lateral segment recovers, immunosuppression can be weaned, leading to hypertrophy of the left lateral segment and involution of the allograft.

Post-operative Management

Antirejection drugs are given. Liver shows low immunogenicity and high regeneration capacity causing long-term outcome. Initially cyclosporine or tacrolimus with MMF or azathioprine with prednisolone is given. ICU care is needed.

Electrolyte and fluid management, sepsis management, prevention of encephalopathy, observation for complications are important.

Complications and Problems of Liver Transplantation

- Bleeding on table and post-operatively can occur especially when recipient liver is cirrhotic. FFP, platelet and blood are needed. Re-exploration is needed if bleeding persists post-operatively.
- Hepatic artery thrombosis is the common vascular complication leading into graft failure, CBD necrosis and anastomotic dehiscence.
- Immediate graft failure as primary non-functional graft can occur (5% liver grafts).
- Bile leak due to CBD ischaemia which can be identified by HIDA scan, ERCP, revision anastomosis is needed.
- Infection is common especially enterococci, staphylococci, Gram negative organisms, *Candida*, *Aspergillus,* etc. Antibiotic and antifungal therapy is needed.
- Acute rejection (30%) of T cell-mediated is seen within 10 days commonly but can occur up to 6 months. Liver biopsy confirms the rejection. Higher steroid therapy, polyclonal anti T cell antibodies are used.
- Chronic rejection is seen after 6 months; appears gradually with liver cell dysfunction and hyperbilirubinaemia. Liver biopsy shows less numbered biliary radicles—vanishing bile duct syndrome. It is due to humoral immunity. It is difficult to control; eventually needs retransplantation.
- Recurrent of the earlier disease to the transplanted liver like hepatitis, biliary sclerosis, sclerosing cholangitis. Hepatitis can be controlled by lamivudine (antiviral DNA polymerase for HBV), interferon α, ribavirin for HCV.
- Complications of immunosuppressive drugs like hypertension, hyperglycaemia, hyperlipidaemia, osteoporosis, malignancy, infection, bone marrow suppression, are often difficult to manage.

Survival

5 year survival is 70% in adults and 80% in children. It depends on age, general condition, earlier disease, associated problems, MELD scoring. The risk of rejection is highest (40%) during the first 3-6 months after transplantation and decreases significantly thereafter.

SURGICAL TREATMENT FOR PORTAL HYPERTENSION

Liver Transplant (Orthotopic)

Liver transplant is becoming popular for cirrhosis with varices. It is ideal, final and best. But donor availability and cost is the problem. If patient is for orthotopic liver transplantation (OLT), open shunt surgeries should not be done as liver hilum should be kept virgin for effective transplantation. TIPSS can be done as a bridge in such patients.

Shunt Surgery

Prophylactic shunt surgery should not be done. Shunt surgeries should not be done if the varices have not bled before.

Indications

Child's Grades A and B status with portal hypertension which has bled earlier at least once. Budd-Chiari syndrome with ascites is an indication. Familial heterozygous hypercholesterolaemia and glycogen storage disorders in olden days were indications for portacaval shunting. (Child's grading is used for selecting patients for surgery and predicting prognosis).

Surgery is contraindicated in Child C.

Non-selective Shunt Surgeries

Porta-caval shunt (end-side, side-to-side); Mesentericocaval shunt with or without graft; Mesenterico-renal shunt.

Proximal splenorenal shunt—Linton's shunt.

Non-selective shunts control and prevent further bleeding as well as reduce the ascites. But since it diverts the blood from liver, *there is high incidence of encephalopathy.*

Note: End-to-side porta caval shunt is called as ECK fistula (Eck, 1877).

Non-selective shunt surgeries are done in supine position with right side slightly elevated. Right subcostal incision extending on to left side is commonly used. Thoracoabdominal incision is used in patient with significant hepatomegaly or in obese patients. Liver is retracted upwards; duodenum is mobilized by Kocherisation; hepatoduodenal ligament is dissected.

Common bile duct is dissected and isolated. Kocherisation should be done. Posterior part of the portal vein is dissected first as front aspect is having mainly collateral which may cause torrential haemorrhage (it is often found that collaterals are so tortuous and friable and creates difficulty on dissecting the portal vein); these collaterals are more on the anterior aspect. Once portal vein is dissected all around an umbilical tape is passed around it. Adequate posterior dissection is essential to prevent angulation during anastomosis with IVC. Portal pressure should be measured through an omental vein.

Retroperitoneum is incised; IVC in front, lateral and medial aspect is dissected from a point where right renal vein joins the IVC to a point where IVC becomes retrohepatic. Vascular clamps are applied to portal vein proximally just above the pancreas and distally prior to bifurcation. ***In end-to-side portacaval shunt*** distally portal vein is divided and distal end is sutured using continuous 5-0 polypropylene suture. Two stay sutures are placed to proximal cut end of portal vein. Satinsky vascular clamp is applied to the anterior aspect of the IVC. IVC is incised. Often an ellipse of the wall in front of IVC may be excised. Incision in IVC should be at least 1½ *times the size of the portal vein. Posterior part of the portal vein is sutured to the medial part of the IVC using 5-0 continuous polypropylene sutures.* It is easier if many sutures are taken and then tightened to slide the portal vein into IVC. Anterior suturing is done between anterior aspect of the portal vein to lateral part of the IVC incision. This should be done always from upper part towards lower part. Continuous or interrupted sutures are used. End-to-side will decompress the splanchnic pressure but keeps sinusoids under high pressure; it will control the variceal bleeding; but will not relieve ascites. End-to-side is not done now. It is a total shunt. Hypertrophied caudate lobe creates problem in side-to-side anastomosis. Future liver transplantation may become difficult **(Fig. 22-29)**.

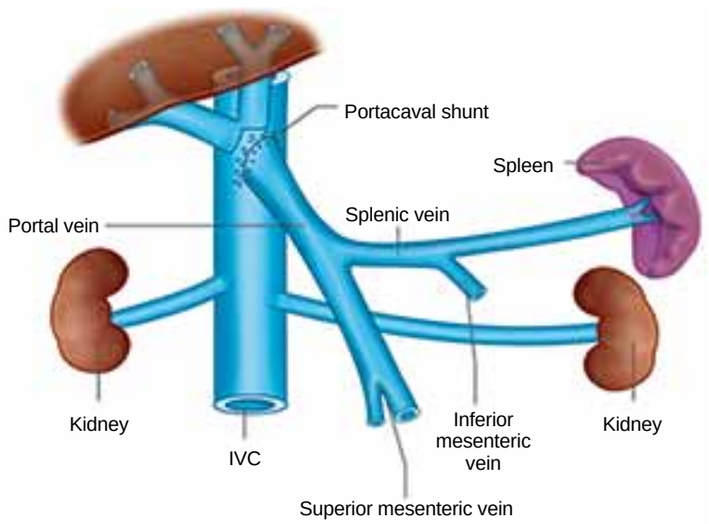


Fig. 22-29: End-to-side portacaval shunt.

Side-to-side shunt is also done similarly without transecting the portal vein. Longitudinal incisions in both portal vein and IVC are done. IVC incision should be 1½ times more than that of portal vein. Posterior continuous and anterior continuous or interrupted sutures are placed from above downwards. Shunt size should be minimum 10 mm. This shunt reduces the obstruction of sinusoids and so relieves ascites also along with control of variceal bleeding. It is a total shunt. *Total shunt* should have a shunt diameter not less than 10 mm.

Side-to-side shunt with an interposition graft (PTFE 8 mm size graft, 3 cm long) diverts blood causing reduction in portal pressure. Since its size of shunt is less than 10 mm, it controls the variceal bleeding well and also maintains the portal perfusion significantly reducing the incidence of the hepatic encephalopathy. It is a partial shunt. *Partial shunt* should have a shunt diameter not more than 8 mm; usually 8 mm **(Fig. 22-30)**.

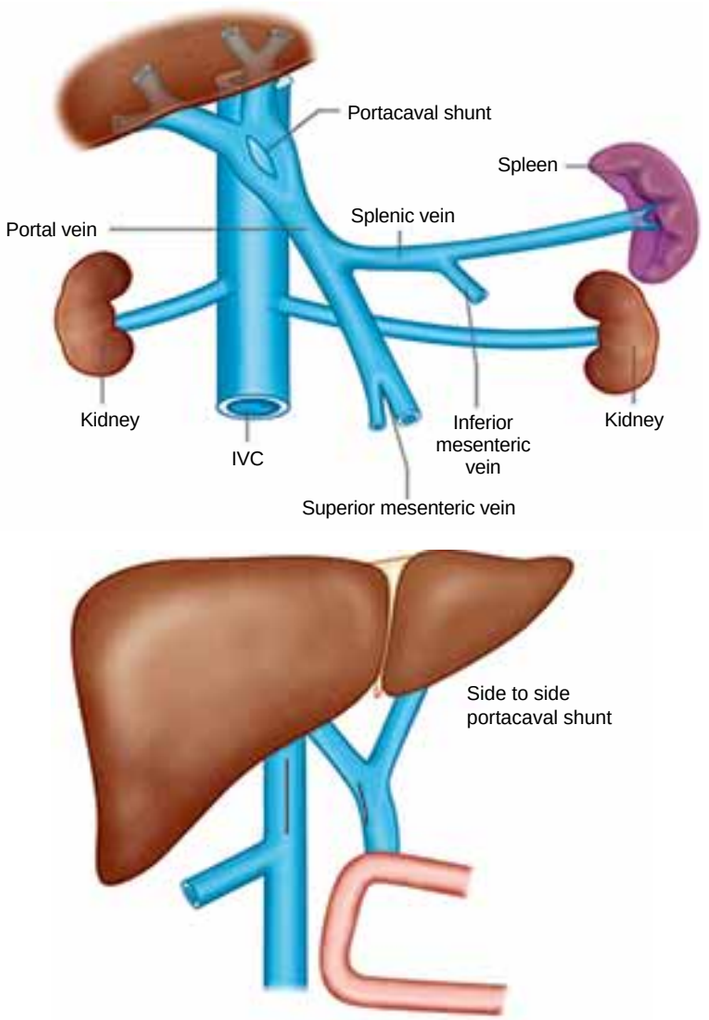

Portacaval shunt
Spleen
Portal vein
Splenic vein
Kidney
IVC
Inferior mesenteric vein
Kidney
Superior mesenteric vein
Side to side portacaval shunt
Incision in IVC should be 11/2 times more than incision in portal vein; posterior continuous and anterior continuous or interrupted 5 zero polypropylene suture is used. suturing starts from above downwards.

Fig. 22-30: Side-to-side portacaval shunt surgery.

Mesocaval shunt can be side-to-end or side-to-side with a graft. In portal cavernoma in children side-to-side mesentericocaval shunt is used. In adult side to side with a graft is used. Midline laparotomy incision is used. When transverse colon is held and stretched upwards superior mesenteric vein can be seen; it is dissected and isolated. Ligament of Treitz is divided to mobilise small bowel forward and right **(Fig. 22-31)**.

Duodenum should be mobilised by Kocherisation. A 2 cm long SMV unobstructed segment is needed; large tributary vein on the left side of SMV should not be present; artery should not cross or override the SMV. Peritoneum in the right paracolic gutter is incised; entire ascending colon and proximal transverse colon is mobilised medially to identify IVC. IVC is dissected from iliac vein confluence to right renal vein level. Vascular clamps are applied across the IVC one

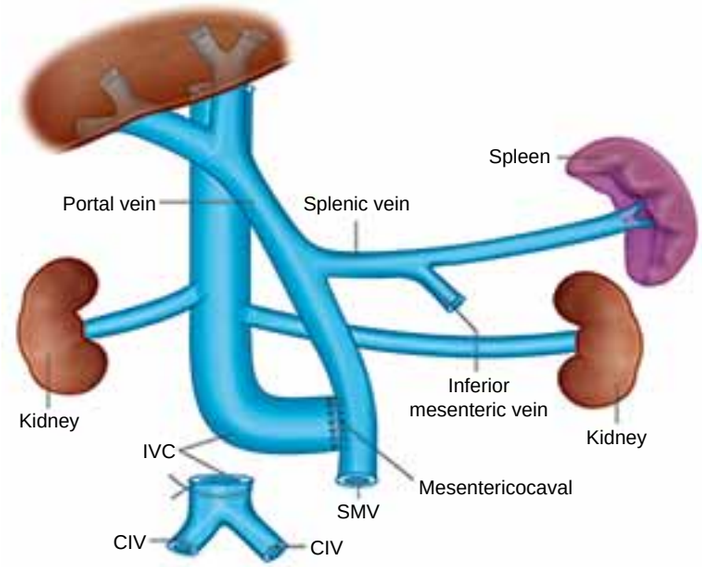


Fig. 22-31: Side-to-end mesentericocaval shunt.

at close to its iliac confluence, another just below the renal vein level. IVC is transected just above the lower clamp; it is passed through the small mesentery through a created window between distal ileal vessel and ileocolic vessel. SMV is incised after applying a vascular clamp; incision is made on posterolateral part of it longitudinally proximal to right colic vein level. Anastomosis is done using 5 zero polypropylene continuous sutures.

Mesentericoocaval shunt with an *interposition graft* is side to side. Graft used is woven Dacron or PTFE. IVC is similarly dissected; side of IVC is incised after applying Satinsky clamp; IVC is anastomosed to graft as side to end with continuous 5-0 polypropylene suture. Other end of the graft is passed through the mesentery and is anastomosed to the side of mobilised SMV. Mesocaval shunt is preferred for isolated hepatic vein obstruction; technically easier; hilar dissection is not present **(Fig. 22-32)**.

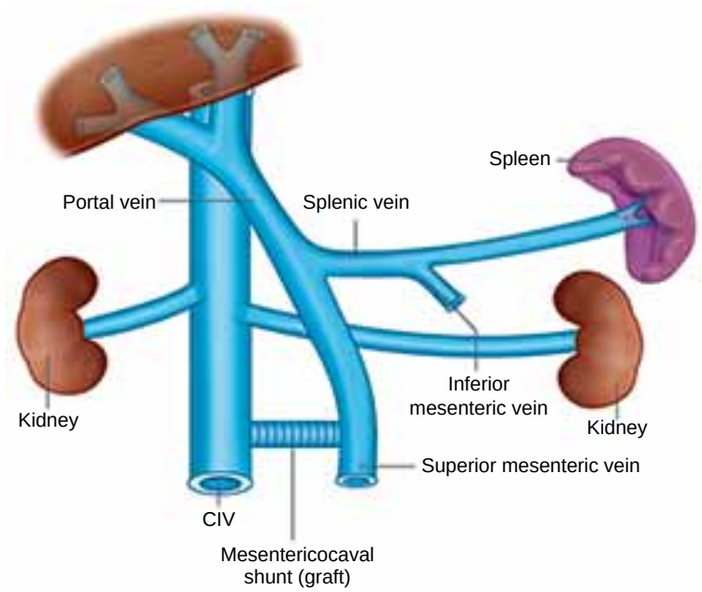


Fig. 22-32: Side-to-side mesenteric caval interposition graft to create a shunt.

Proximal (central) splenorenal shunt: Here blood flows high pressure portal system towards the low pressure systemic venous system through renal vein. It is presumed it allows part of blood to course through the liver to reduce the encephalopathy effects. Patient under general anaesthesia with left side up or oblique; left lengthy subcostal or left thoracoabdominal incision is made. Splenic flexure and transverse colon is mobilised to retract them downwards. Short gastric vessels are ligated and divided; splenophrenic and splenorenal ligaments are divided to reach the splenic hilum to identify splenic vessels. Splenic artery is ligated. Splenic vein is dissected proximally by ligating and dividing all branches entering into it so has to free it until it joins the superior mesenteric vein. Inferior mesenteric vein entering the splenic vein can be ligated and divided safely if needed. Vascular clamp is applied to the splenic vein; spleen is removed **(Fig. 22-33)**.

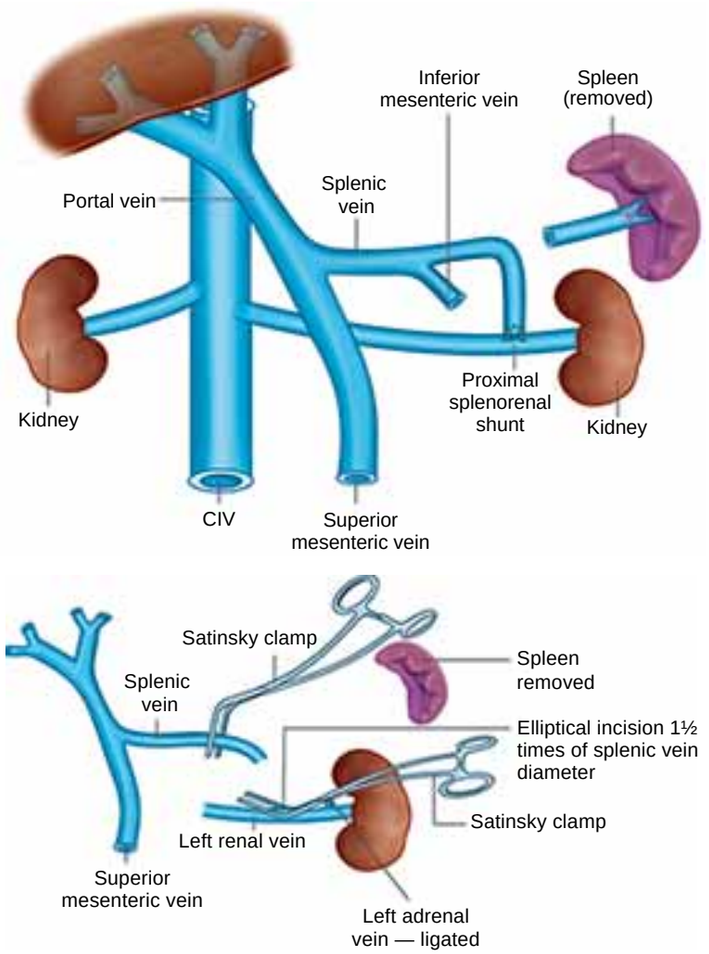


Fig. 22-33: Proximal splenorenal shunt surgery. It is a non-selective shunt (Linton's).

The retroperitoneum is incised to identify the left renal vein just at lower margin of the pancreas. Left renal artery and renal vein is isolated with vascular tapes. Left adrenal vein needs often ligation and division for proper mobilisation of the left renal vein. Left renal vein is mobilised adequately. Left renal artery is often occluded with vascular bulldog clamp to reduce renal vein flow temporarily. A Satinsky clamp is placed obliquely across the renal vein; incision is made on the anterosuperior aspect of the left renal vein often to remove elliptical piece of it; incision should be 1½ times the diameter of the splenic vein end. End of splenic vein is anastomosed to the left renal vein using continuous 5-0 polypropylene sutures posteriorly

and interrupted sutures anteriorly to complete the proximal/central splenorenal shunt. Tapes and clamps are removed from the left renal artery, renal vein and splenic vein.

Portacaval Shunt with Arterialisation

This is done in end-to-side portacaval shunt as there is abrupt stop of hepatic blood flow. So hepatic blood flow is maintained by interposition of the saphenous vein graft or synthetic PTFE graft between infrarenal aorta and hepatic stump of portal vein in end side shunt. Arterialisation is also can be achieved by turning splenic artery end to the portal vein to create as end-to-end anastomosis. As end-to-side portacaval shunt is not done now, arterialisation procedure has also no role at present **(Fig. 22-34)**.

Selective Shunts

Distal splenorenal shunt (DSRS)—Warren's shunt *(Warren, 1967)*. Size of the splenic vein should be 10 mm or more to do distal splenorenal shunt; if less, then shunt may develop thrombosis and shunt failure can occur. End of splenic vein is shunted to the side of the left renal vein. Splenic vein should be more than 10 mm in size (diameter). It selectively decompresses the portal bed near oesophagogastric area (so that it prevents bleeding). Liver is also perfused adequately and so possibility of encephalopathy is less. But it may augment incidence of ascites. Left subcostal or chevron incision is used with left side up position. Incision extends from left anterior axillary line extending across the right rectus up to the right margin of the right rectus muscle. Through gastrocolic ligament lesser sac is entered. Gastroepiploic arcade is divided to prevent later formation of collaterals (arcade is divided towards gastric side). Short gastric vessels should be retained (should never be interrupted; it is through this variceal bed is decompressed into splenic vein). Plane is created between 3rd part of the duodenum and pancreas by dividing peritoneum over it. When gland is reflected upwards, splenic vein is identified which is dissected carefully by ligating all branching vessels individually carefully and divided. A venous catheter is passed into the splenic vein to measure the splenic vein pressure. Inferior mesenteric vein is identified and, dissected, doubly ligated and divided. Splenic vein is mobilised up to its entry into the superior mesenteric vein. Vascular clamp is applied to the splenic vein. Splenic vein is divided at its junction with SMV. Small pancreatic branches entering the splenic vein are ligated and divided **(Fig. 22-35)**.

Left renal vein is dissected similarly; left adrenal vein is ligated but left gonadal vein is retained. Average length of the renal vein is 8 cm; 5 cm of it should be mobilised for proper shunt anastomosis. Portal side of the cut end is sutured with continuous polypropylene sutures. Left gastric (coronary) vein at its junction where it enters the portal or splenic vein is ligated and divided; all veins along the retroperitoneum above the pancreas, along splenocolic ligament, along greater and lesser omentum are interrupted effectively; right gastroepiploic vein is already ligated but should be confirmed. Efficacy in control of bleeding is 94%; with 90% preserved portal blood flow. Encephalopathy incidence is 15% or less.

Inokuchi shunt is a selective shunt between IVC and left gastric vein (using a graft).

Unconventional shunts

Modified Rex Shunt: It is done between left portal vein and SMV using autologous IJV graft.

Alternative splanchnic drainage is done route using inferior mesenteric or gastroepiploic veins; coronary vein to left portal vein.

Alternative systemic route: Mesogonadal or lienoadrenal shunts.

Unconventional shunts cause partial non-selective decompression; yield effective shunting; does not preclude liver transplantation. But need is good quality adequate length and caliber (>5 mm) vein.

Splenectomy

Left sided portal hypertension also called as s*egmental portal hypertension* (sinistral portal hypertension) is due to splenic vein thrombosis (If partial channels are present within it, it is called as *splenic vein cavernoma*). Here liver is normal and *splenectomy* alone will correct the condition. Banti in 1894 originally suggested splenectomy for portal hypertension.

Transjugular Intrahepatic Portosystemic Stenting/Shunt (TIPSS)

Size of stent must be 10 mm. It is a non-surgical, interventional radiological method, wherein, a stent is placed in the liver between hepatic venule and portal through a guidewire following dilatation. It

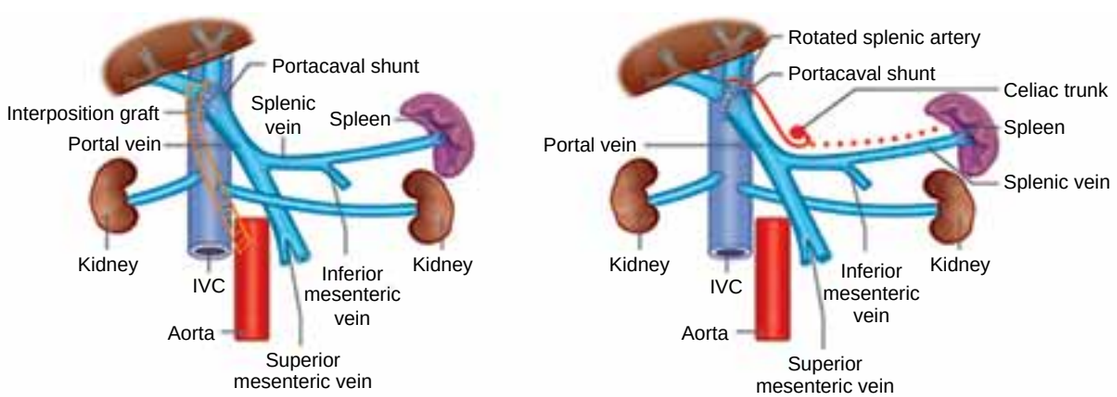


Fig. 22-34: Portacaval shunt with arterialisation being done.

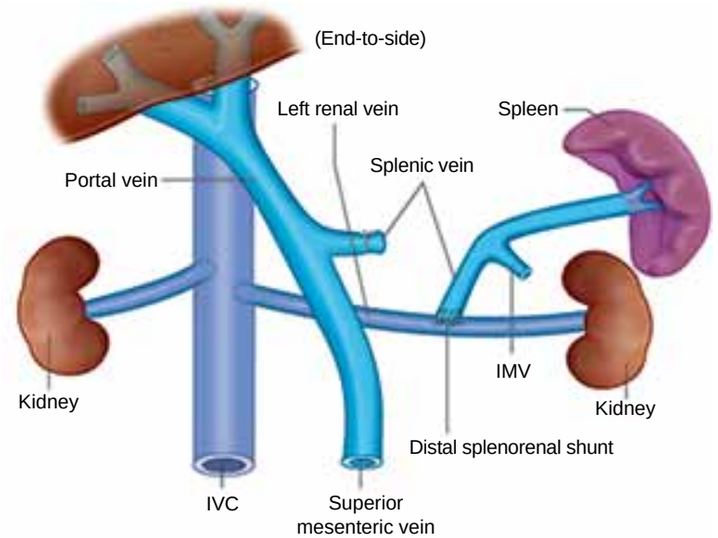


Fig. 22-35: Distal splenorenal shunt (DSRS)—Warren's shunt.

is a simple and easier method to reduce portal pressure. It can cause hepatic encephalopathy, bleeding, bile leak and infection.

It is contraindicated in encephalopathy, tumours and liver cysts. It is quite useful as a temporary measure to reduce portal bed pressure, before doing orthotopic liver transplantation in cirrhotic patients.

Problems with TIPSS

Post-stent encephalopathy—40%; stenosis (50%) and recurrent varices; bleeding; bile leak; sepsis **(Fig. 22-36)**.

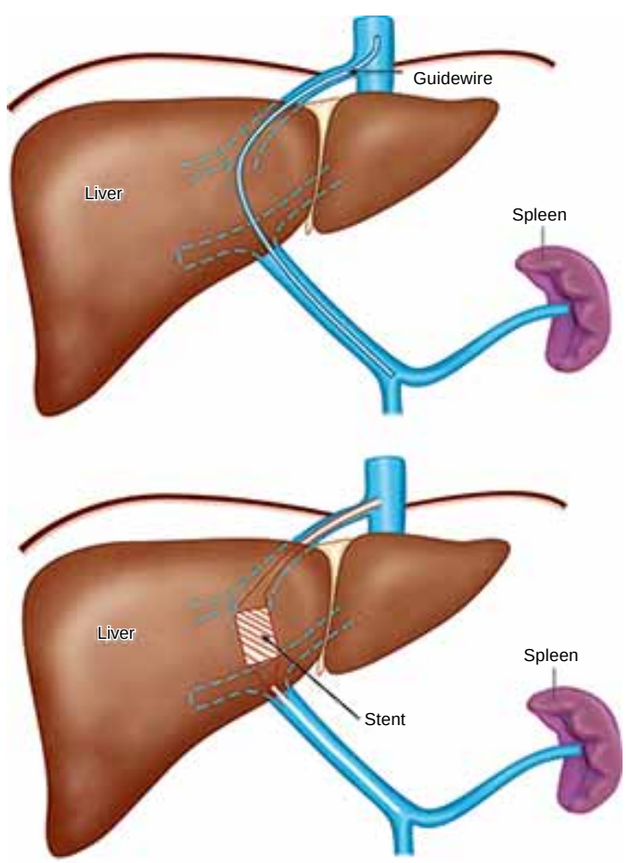


Fig. 22-36: Transjugular Intrahepatic Portosystemic Stenting/Shunt (TIPSS).

Mesoatrial Shunt

When hepatic vein and IVC block are present, mesoatrial shunt or caval stenting and portacaval shunt or cavoatrial shunt with portacaval shunt is needed. Mesocaval shunt is indicated when there is IVC block that is not amenable for stenting; prerequisite is a pressure gradient of 15 mm Hg or more between IVC and right atrium. Shunt placement in low pressure system may precipitate shunt thrombosis.

Table 22-1: Child's grading of severity of liver disease

Clinical and biochemical measurement	*Points scored*		
	1	2	3
Serum bilirubin (mg/dL)	<2.0	2.0 to 3.0	>3.0
Serum albumin (gm/dL)	>3.5	3.0 to 3.5	<3.0
Ascites	None	Controlled	Uncontrolled
Mental status	Normal	Disoriented	Coma
Nutrition	Very good	Good	Poor
Total score	<6 Child's A	7-9 Child's B	10-19 Child's C
Pugh's modification			
Prothrombin time prolonged in secs	Increased up to 3	Between 3-6	> 6

Surgeries for portal hypertension
- Orthotopic liver transplant (OLT)
- Devascularisation surgeries
- Decompression surgeries

Surgeries for oesophageal varices and portal hypertension

Decompression procedures
- Non-selective shunts
  - End-to-side portacaval shunt (Eck fistula)
  - Side-to-side portacaval shunt
  - Mesentericocaval shunt
  - Mesentericocaval shunt with graft
  - Proximal splenorenal shunt—Linton's shunt
  - TIPSS

Selective shunts
- Distal splenorenal shunt—Warren's shunt
- Inokuchi shunt between left gastric vein and IVC through a graft

Devascularisation procedures
- Oesophageal stapler transection; Boerema Crile operation; Tanner's oesophageal gastric transection; Milnes Walker transection; Sugiura Futagawa/Hassab/Orozco and colleagues operations

Porta-azygos Disconnection/ Devascularising Procedures

They are inflow control that act effectively by devascularising the portal bed. It is useful in extensive portal and splenic vein thrombosis. Incidence of encephalopathy is very low here.

***Oesophageal stapler transection of Johnston*:** Through an anterior gastrotomy incision end-to-end stapler is passed across the oesophagogastric (OG) junction into the oesophagus and stapler is fired to transect, interrupt all varices, disconnect azygos and portal connection at oesophageal level and reanastomose automatically through the stapler. It is simple to do **(Fig. 22-37)**.

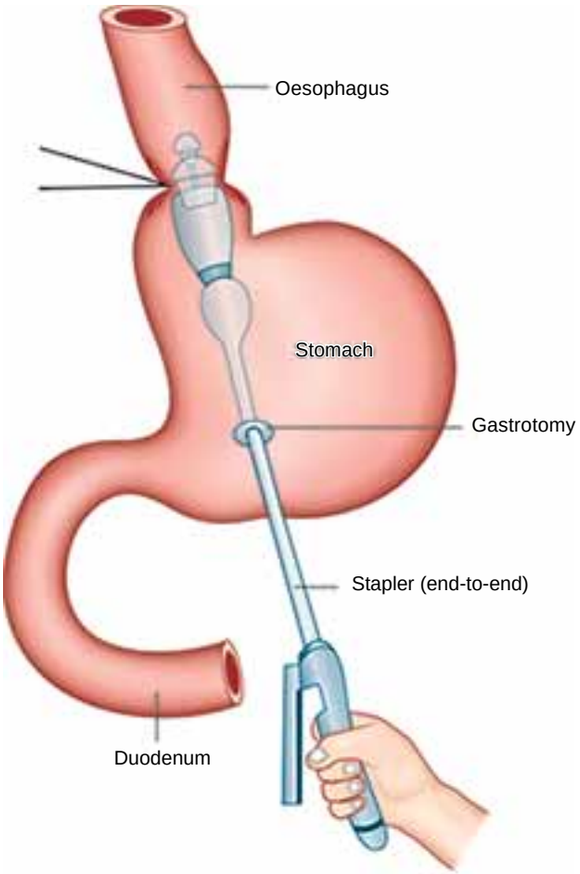


Fig. 22-37: Stapler transection—devascularisation procedure.

Boerema-Crile operation: It is a thoracic approach. Patient with right lateral position, thoracotomy is done through 8th rib; oesophagus is dissected and isolated; clamp is applied at cardia; oesophagus is opened longitudinally to hold edges with stay sutures. Varices columns are underrun using continuous vicryl sutures. Oesophageal incised muscle layer is resutured again. Usually hiatus is not opened across the diaphragm to abdominal cavity as if ascites is present, it may communicate into the pleural cavity.

Milnes-Walker thoracic oesophageal transection: It is done through left sided thoracic approach; vagi are safeguarded. Oesophageal muscle is incised longitudinally; mucosa and submucosa are dissected and isolated as like longitudinal tube which is resected to interrupt the mucosal and submucosal varices. This tubular structure is resutured and muscle incised is sutured back again. Below this, transected is done at the level of hiatus and resutured again.

Tanner's abdominal oesophagogastric transection: It is done through abdominal approach. All communications between the portal system and azygos systemic veins are interrupted after transecting the stomach 5 cm below the OG junction. After proper interruption reanastomosis is done between the cut ends of stomach.

***Sugiura-Futagawa operation* (1977, Japan):** Vagotomy, pyloroplasty, devascularisation, splenectomy. Laparotomy is done; can also use thoracoabdominal incision. Spleen is removed; devascularisation begins at lesser curvature of stomach; left gastric artery and vein (coronary vein) are ligated; greater curvature, posterior part of the stomach are devascularised. Paraoesophageal devascularisation is done by disconnecting all vessels passing between hemiazygos and azygos veins up to inferior pulmonary vein (in original Sugiura method, devascularisation was done up to arch of aorta) for at least 7 cm of lower oesophagus. Highly selective vagotomy is done (in original Sugiura truncal vagotomy and pyloroplasty is done). Oesophagus is transected using EEA stapler; anastomosis is covered with Nissen's fundoplication. Hassab from Egypt did similar devacularising procedure. Orozco and colleague from Mexico did similar devascularisation procedure without splenectomy with good results.

Fig. 22-38: Hydatid cyst CT scan—large cyst in liver.

SURGERIES FOR HYDATID CYST

Hydatid cyst is managed by chemotherapy; minimally invasive techniques (PAIR); open surgeries; laparoscopic procedures **(Figs 22-38 to 22-42)**.

Classifications

Hassen Gharbi's ultrasound-based classification of liver hydatid cysts (1981)
Type 1 – Pure fluid collection
Type 2 – Fluid collection with split wall
Type 3 – Fluid collection with septa
Type 4 – Heterogeneous appearance
Type 5 – Reflecting thick walls

WHO classification of liver hydatid cyst
Type – CL – Active; unilocular; no cyst wall; early stage; not fertile
Type – CE 1 – Active; cyst wall present; hydatid sand present; fertile
Type – CE 2 – Active; multivesicular rosette-like cyst wall; fertile
Type – CE 3 – Transitional; detaching laminated membrane; *water-lily* sign; beginning of degeneration
Type – CE 4 – Inactive; degenerative contents; no daughter cysts; not fertile
Type – CE 5 – Inactive; thick calcified wall; not fertile

Cyst is common in right lobe (65%); left lobe is (18%); both (16%). Segment 8 is commonly involved (30%); then segment 5 (22%).

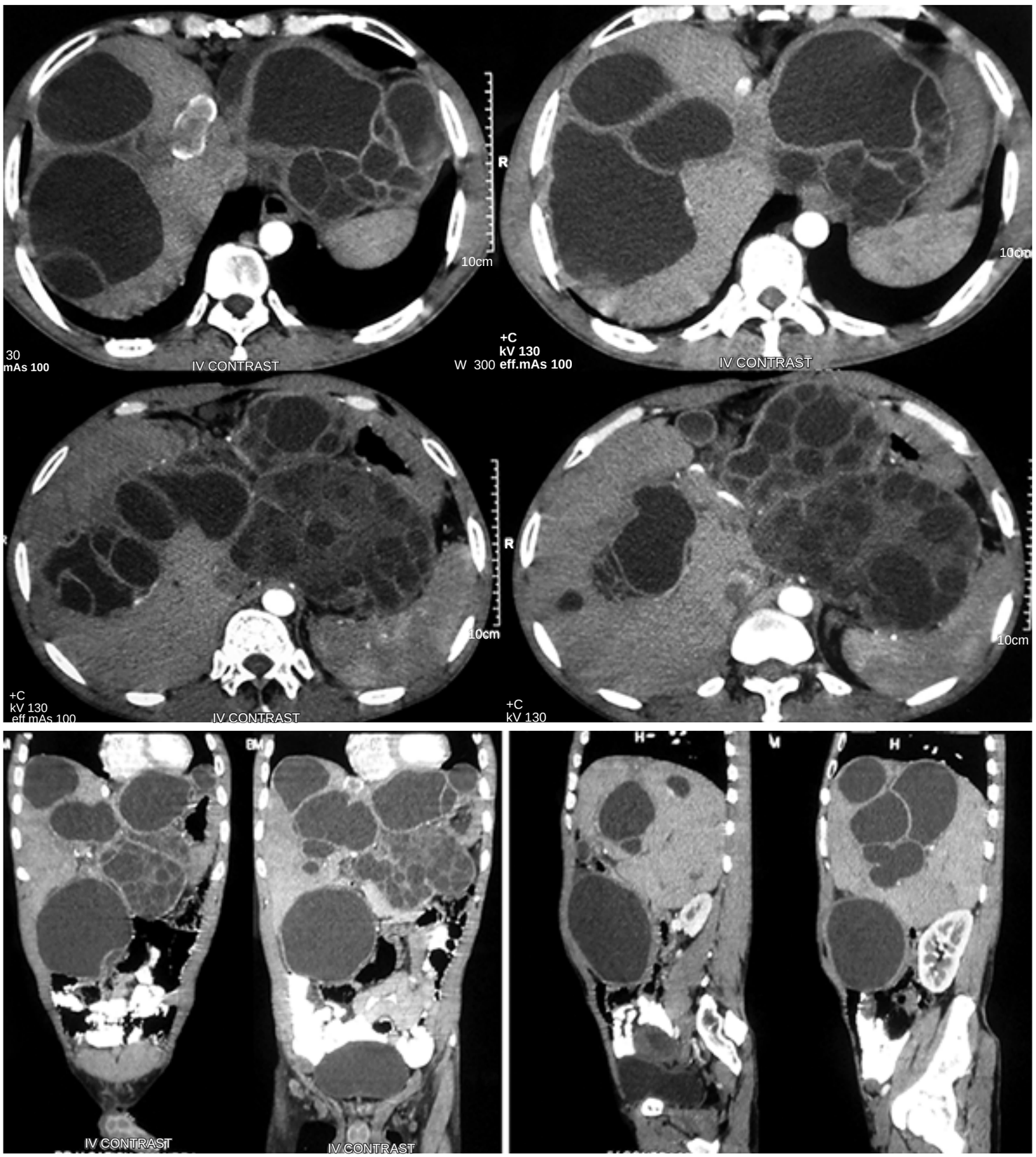


Fig. 22-39: Hydatid cyst—multiple in liver and extrahepatic region.

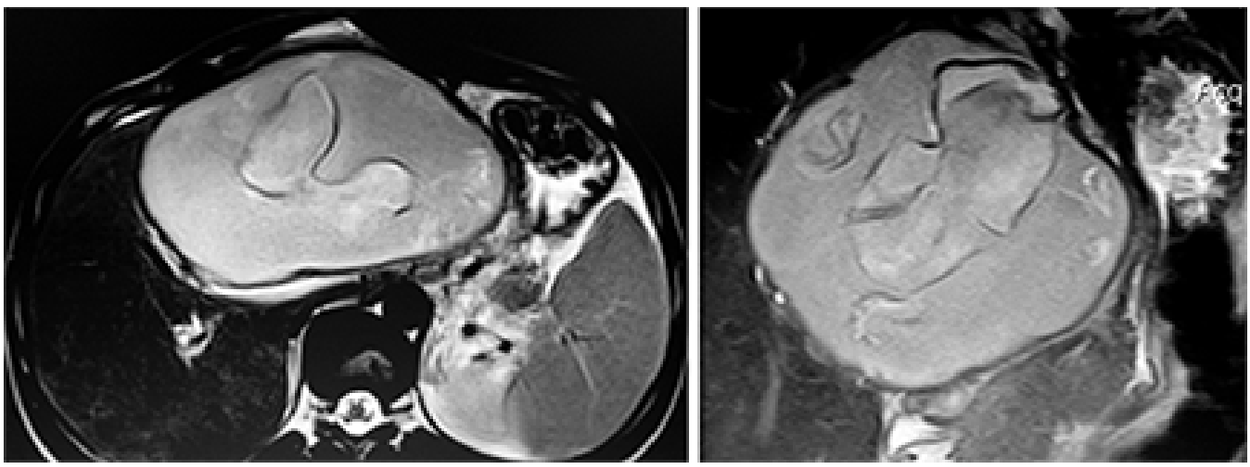


Fig. 22-40: Hydatid cyst—MRI is ideal and better than CT scan.

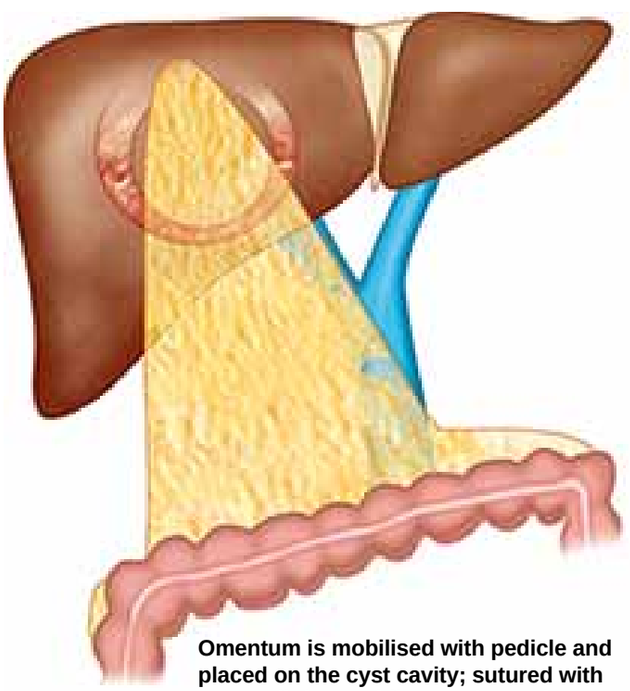


Fig. 22-41: Hydatid cyst—cavity obliteration by omentoplasty.

Drugs

Indications for drug therapy: 4 days prior to intervention and continue it for 1 month (albendazole) to 3 months (mebendazole) after the intervention; inoperable cysts; multiple or multiorgan cysts; recurrent hydatids; surgically unfit patients; cysts in lungs, bone, brain and eyes.

Contraindications: Large cysts; Honeycomb cysts (with septae); infected or calcified cysts; pregnancy.

Drugs used are: Albendazole 4 weeks cycles with 2 weeks drug free interval. It is ovicidal/larvicidal/vermicidal. Commonly used; praziquantel—60 mg/kg along with albendazole for 2 weeks; mebendazole—600 mg daily for 4 weeks.

Puncture–Aspiration–Injection–Reaspiration (PAIR)–Percutaneously Done (1980)

Aspiration of the cyst should not be done due to risk of anaphylaxis but presently Puncture–Aspiration–Injection–Reaspiration (PAIR) is done effectively.

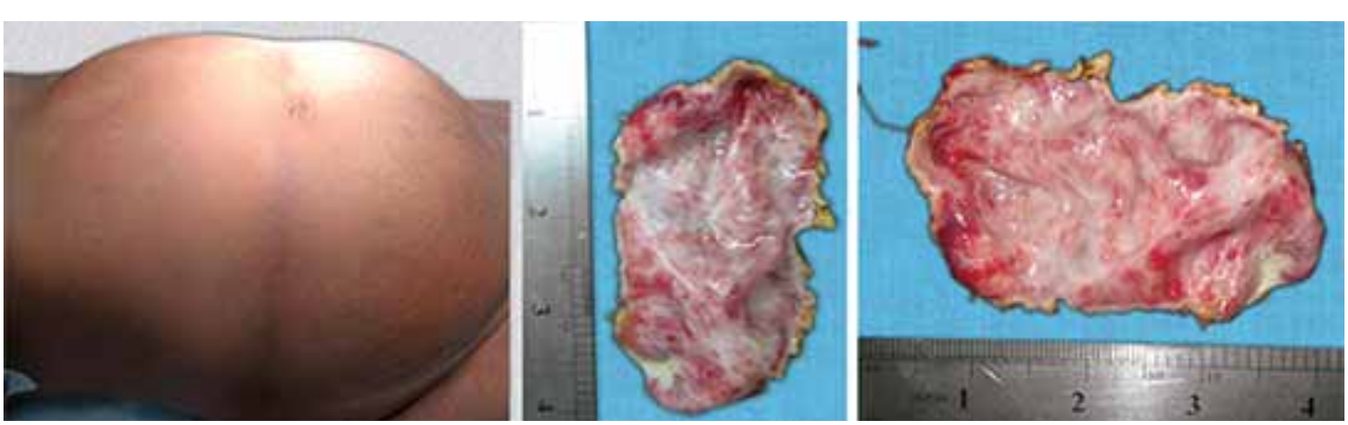


Fig. 22-42: Simple cyst of liver; it is removed through laparoscopy easily. It is a differential diagnosis for hydatid cyst of liver.

Indications for PAIR

- Inoperable patients
- Patients who refuse surgery
- CL, CE 1, CE 2 and CE 3 types/ Gharbi type 1 and 2
- Relapse cysts
- Infected cysts
- In pregnant women; children less than 3 years
- Cysts more than 5 cm in different liver segments

Results and problems of PAIR

- Complication rate—10-40 %
- Mortality rate—0.9-2.5%
- Fever—35%, disappears in 72 hours
- Anaphylaxis—0.1-0.2%, Same as open surgery, but drugs should be kept ready for
- Anaphylaxis
- Infection—10% well-controlled by antibiotics
- Local recurrences—4%, repeat PAIR can be done

Contraindications for PAIR

- Inaccessible cysts
- Cysts with multiple septae—honeycomb cysts
- Hyperechogenic cysts
- Communicating cysts to bile duct
- Calcified cysts
- Cysts in the lung

Technique of PAIR

It is done under US/CT guidance; under local anaesthesia, cyst is punctured using a cholangiography 22-gauge needle through thickest route/part of cyst wall; Cyst is entered through non-dependent wall and 50 % of fluid is aspirated. All multiple/daughter cysts are aspirated. Radiopaque dye is injected to see if any communications are present. Scolicidal agents— 15-20% hypertonic saline is injected into the cyst. After 20 minutes reaspiration is done. A sclerosant—alcohol is injected. If cyst is 6 cm or more, a drainage catheter is placed for 24 hours for complete drainage and later alcohol sclerosant is injected. Double – puncture aspiration and injection (D-PAI) or modified PAIR/PEVAC (Percutaneous EVAcuation of Cyst) are other procedures done. PAIR has gained wide acceptance as it is safe, less invasive, and easier to do, with low morbidity and mortality. Complications and results are same as open surgery.

SURGERY

Surgery is the best treatment for hydatid disease as it removes the parasite, cystobiliary communications are addressed, less morbidity and mortality and low recurrence rate.

Procedures are Conservative and Radical.

- Surgery is still the choice and gold standard therapy for hydatid disease. The abdomen is opened, and the peritoneal cavity is packed with mops (black or colored mops are used to identify white scolices clearly so as to pick up all and prevent any spillage). Fluid from the cyst is aspirated and scolicidal agents (cetrimide, chlorohexidine, alcohol, hypertonic saline (15-20%), 10% povidone iodine or H_2O_2) are injected into the cyst cavity (formalin should not be used). Hypertonic saline should be left within the cavity for 15-20 minutes to have effective scolicidal effect.
- Detection of cystobiliary communications is very crucial as it may cause caustic sclerosing cholangitis when scolicidal agent like formalin is used. Communicating openings may be single or multiple. Cyst more than 10 cm is likely to have cystobiliary communications. Often clinically features of communications may not be present. Preoperatively there may be recurrent cholangitis; dilated bile duct. Factors important are—its size, number, site, involvement of hepatic/bile ducts and liver dysfunction.

Contd...

Contd...

Bile stained cyst on table during aspiration is highly suggestive of communication. White mops soaked with hypertonic saline are kept in the cyst cavity and gallbladder is gently squeezed to see for the bile staining of the mop in the cavity which confirms communication.

- Pericystectomy is ideal, but technically demanding.
- Laparoscopic pericystectomy is becoming more popular. Contraindications are deeply situated cyst, densely adherent cyst, and inaccessible cysts; more than 3 cysts; calcified cysts and cysts in other organs. Main problems with laparoscopic pericystectomy is spillage and difficulty in preventing it.
- Liver resection—only occasionally segmental or hemihepatectomy is done.

Scolicidal agents

- Cetrimide—can cause acidosis
- Alcohol 80%—can cause cholangitis
- Hypertonic saline—hypernatraemia
- Sodium hypochlorite—hypernatraemia
- Hydrogen peroxide

In cases with biliary communication, only hypertonic saline (15-20%) is used (not other agents)

Features of formed abscess are

Procedures used to correct the cystobiliary communications and to obliterate the cavity are:

- Suturing of the communication – simple suture using vicryl/PDS suture with T tube drain of bile duct.
- Pericystectomy (Pericystectomy is done by peeling off the cyst wall and abdomen is closed with or without a drain), marsupialization.
- Tube drainage of the cavity; capitonnage–spiral suturing of the bottom of the cavity upward from base of cavity to the edge of the cyst wall; introflexion–inverting the rim of the cyst edge without apposition; omentoplasty.
- Internal drainage procedures like choledochojejunostomy; transduodenal sphincteroplasty; Roux-en-Y cysto/intracystic hepatico jejunostomy; Roux-en-Y hepaticojejunostomy.
- In cystobiliary communication (fistula), cystobiliary disconnection is achieved anatomically between cyst and fistula and a multiperforated transparenchymal drain is placed into the fistula through the cyst and another multiperforated drain is placed into the cyst cavity. A T tube drain is placed into the bile duct (perdomo procedure) to achieve complete external drainage with facilitation of closure of the communication.
- Bipolar drainage: A drain is placed to cyst cavity and a T tube is placed into common bile duct. .
- Reconstructive procedure like pericystojejunostomy; bile duct repair.
- ERCP sphincterotomy.

Conservative Surgical Approach

It is technically easier; hepatic specialized surgeons are not necessary; safer; liver parenchyma is not entered; multiple bilateral cysts can be approached; cost-effective; tissue sparing; acceptable in relation to recurrence, morbidity and mortality.

Cyst should be exposed completely; cyst should be sterilised properly (scolicidal); should be evacuated completely; cystobiliary communications and cyst cavities are to be managed effectively.

Right subcostal with often extension towards left side is needed for adequate exposure. Liver should be released of all adhesions and made mobile.

Entire field surrounding the liver should be packed with hypertonic saline (20%) black/blue/green drapes/mops (to identify white scolices. Cyst wall is punctured carefully; often specialised cones are used for this purpose (Saidi Nazarian cryogenic cone (1971); Aaron's cone by Aaron's and Kune, Australia). Aaron's suction cone is better, safer and

effective. But it is not necessary to use these devices. Stay sutures are placed on the cyst wall; cyst wall incised for 5 cm. Large sump suction is used to suck all fluid in the cavity. All laminated membranes are removed using forceps or hand or spoon.

Cyst roof which is redundant is excised. Cut edge of the cyst should be underrun with sutures (oversewing) to block small vessels and ducts in the cyst wall. Inside cyst cavity wall is gently scraped using hypertonic saline soaked gauze. All daughter cysts should be removed by this method with care, gentleness and patience. Cavity is washed with hypertonic saline repeatedly. Saline soaked packs are kept in the cavity for 10 minutes.

Different scolicidal agents are used. Different types have got different efficacy and exposure time. Hypertonic saline is safer with 30% solution having 10 minutes exposure time; lesser concentration needs more exposure time. Cetavlon has got shortest exposure time—5 minutes. Other scolicidal agents are—povidone-iodine, hydrogen peroxide, formalin (not used) with different exposure timings. Scolicidal agents can cause severe sclerosing cholangitis, methhaelmoglobinaemia, acute toxicity, hypernatraemia, air embolism, anaphylaxis, metabolic acidosis, may cause death rarely. Hypertonic saline is ideal. Partial pericystectomy is done usually in many situations; subtotal pericystecomy is also done occasionally. Pericyst adherent to biliary and vascular structures are left behind.

Cystobiliary communications (CBC) should be identified and managed properly. It may be single or multiple. Its management depends on the number, type, depth, site, size (minute or wider orifice), duct involved, and status of liver. On table bile-stained cyst suggests communication. In such situation, carefully with repeated saline wash staining site of bile can be identified. It is better to pass a needle into the CBD and inject saline or saline and air or dilute methylene blue to the bile duct to identify the site. Intraoperative cystic duct cholangiography is also done through cystic duct which needs cholecystectomy. It demonstrates the CBD scolices, site of leak. But it is not mandatory, often may not be sufficient. ERCP or intraoperative ultrasound (IOUS) is very useful in identifying the CBD scolices. Scolices in gallbladder are very rare.

Commonly such cystobiliary communications are of peripheral duct branches and small; just secure suturing of the minute orifice the using 4-0 vicryl or PDS is sufficient. In biliary tree, bile enters into scolices existing there and parasite dies and so CBD scolices are rare **(Fig. 22-43)**.

If cholangiogram or on table IOUS shows hydatid debris, then choledochotomy is done debris is removed; choledochoscope is done; T tube is placed while closing the CBD. T tube is also often placed when there are communications (which are sutured accordingly) to have assured decompression of the biliary tree so that sutures will not disrupt. Once T tube is placed per operative T tube, cholangiogram is done.

In case if suturing of the leaking orifice is impossible, then combined external drainage of the pericyst by placing a drain on pericyst and drainage of extrahepatic biliary apparatus is done (either external or internal). This method of draining both pericyst and biliary apparatus is called as bipolar drainage. External biliary apparatus drainage is achieved by placing a T tube into CBD. Often a multiperforated drain is passed through the orifice to drain fistula across the parenchyma; another such drain is placed into the cyst cavity; T tube is placed the CBD—*Perdomo procedure*.

Internal drainage of biliary tree can be achieved by *ERCP sphincterotomy* or transduodenal sphincteroplasty or bilioenteric anastomosis (Roux-en-Y choledochojejunostomy or duodenostomy). Bilioenteric drainage is done when there are many daughter cysts in CBD or dilated CBD or when there is cholangitis.

Cystobiliary communication into a major biliary ductal system if sutured may obliterate ductal drainage partially which is dangerous. Here Roux en Y cystojejunostomy or intracystic hepaticojejunostomy or intracystic bile duct repair is done. These procedures are often technically difficult and liver resection may be final answer in these patients.

Residual cavity of the cyst often needs obliteration by different methods. This cavity may be superficial or anterior or posterior or superior or inferior; it can have large opening with large capacity or small opening with large capacity. Residual cavity can be managed by—(1) Leaving cyst open; (2) With rim oversewn on the entire edge—marsupialization; (3) Small cyst can have simple closure; (4) Placing drainage tube into the cyst cavity as external drainage; (5) Introflexion by infolding edge of the cyst inward with taking bites from overlying liver tissue; (6) Capitonage—redundant pericyst is infolded from depth to outwards by consecutive interrupted layer of sutures or by continuous spiral suture bites taken from pericyst wall at alternative sides; This is difficult in large or calcified cysts; deep bites may injure liver parenchyma or hepatic veins underneath or stiff cyst wall may get avulsed off from the liver tissue causing severe haemorrhage; (7) Omentoplasty – Viable omental pedicle is placed into the cavity and fixed with absorbable sutures; drain is placed adjacent to the omental flap; omentum obliterates the cavity but will not prevent bile leak; omentoplasty can be combined with partly capitonage; (8) Roux-en-Y cystojejunostomy not commonly used; (9) Rectus abdominis and diaphragm myoplasty **(Figs 22-44 to 22-47)**.

Radical Surgical Procedures for Hydatid Liver Disease

It is done if conservative surgery is impossible; already done conservative surgery has failed; lobe involved is irreversibly damaged; adequate biliary drainage if cannot be achieved. Every patient with hydatid disease is not an indication for radical procedure. Closed pericystectomy; open pericystecomy; near total cystectomy; subadventitial cystectomy; non-anatomical liver resection and anatomical liver resections are different procedures done. In closed pericystectomy, cyst is not opened, instead entire pericyst is removed carefully and gently. In open pericystectomy also after opening, the cyst is entirely removed by similar methods. Near total pericystectomy is done when pericyst is adherent to IVC and major hepatic veins past of pericyst are left behind after sterilization with hypertonic saline but remaining part of the pericyst and scolices are completely removed. Pericyst is the outer most layer which is adherent to the liver tissue including vasculobiliary structures which may get damaged in during even careful dissection as adhesions are very strong often. Inner avascular granulomatous exocyst layer is separated from pericyst along the subadvential plane. If dissection is done little away from pericyst, it becomes non-anatomic liver resection. Hepatectomy is done only if entire right or left liver is involved.

Pericystectomy for Hydatid Liver Cyst

There is controversy regarding optimal treatment for this parasitic disease. Options of deroofing and content evacuation is considered suboptimal and pericystectomy may be too radicle a procedure for some cases. The main principle of the surgery is to eradicate the parasite and prevent intraoperative spillage of cyst contents avoiding peritoneal spread. Preoperatively 10-14 mg/kg/day of albendazole is administered orally for a period of 4 weeks. Deep seated cysts and

Enlarged palpable liver due to hydatid with positive hydatid thrill
Right subcostal incision
Liver is mobilised adequately
Coloured mop/towel should be kept around to identify white scolices (black)

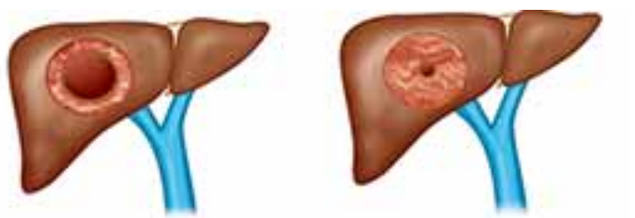
Figs 22-43(1)

Black towels
should be used
Hypertonic saline 20-30%
soaked and kept for 10 minutes
Any cytobiliary communications
are sutured using 4-0 vicryl
One drains the cyst cavity other in the
peritoneal cavity is placed
Hypertrophied left lobe

Figs 22-43(2)

Figs 22-43(3)

Figs 22-43(1 to 3): Hydatid cyst – conservative decompression—drainage procedure; it is commonly advocated, reasonably safe, simple and easier than radical surgeries for hydatid cyst of liver.



Hydatid cyst after conservative surgical drainage may have a large opening with large volume cavity

Hydatid cyst after conservative surgical drainage may have a small opening with large volume cavity

Fig. 22-44: Large and small opening of large volume/cavity hydatid cyst.

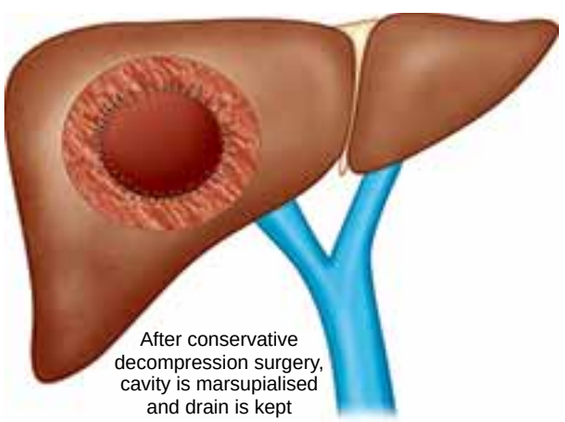
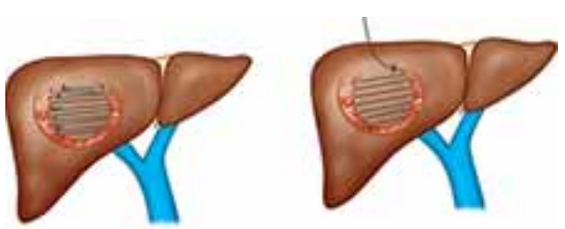


Fig. 22-45: Hydatid cyst—marsupialisation of the cyst wall and cavity.



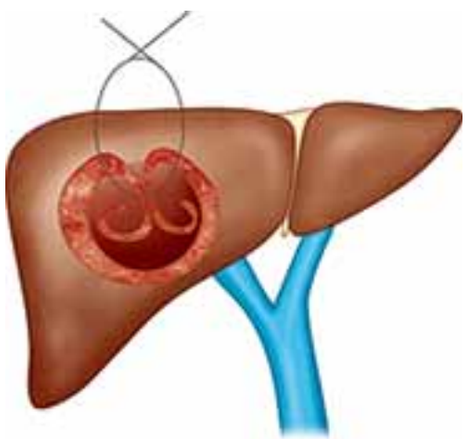
Interrupted sutures to infold cyst wall

Spiral sutures to infold the cyst wall

Capitonage is infolding of the cyst wall from depth by suturing the cyst wall with interrupted or continuous spiral sutures from deeper plane towards outside. It obliterates the cyst cavity

Fig. 22-46: Hydatid cyst—cavity obliteration by capitonage.

those close to major veins may not be candidates for pericystectomy and formal hemihepatectomy may be indicated. Access to the abdomen is gained like for any major liver surgery. Abdomen is



Ectocyst is infolded and sutured to liver capsule so as to obliterate the cavity

Fig. 22-47: Hydatid cyst—obliteration of cavity by introflexion.

carefully explored for presence of any extrahepatic disease. Povidine-iodine soaked mops need to be kept ready in case of spillage of the cyst contents. Intraoperative ultrasound is helpful to determine the relation of the cyst to the hepatic veins and vena cava. The cyst on the surface are separated from the under surface of the diaphragm. The central venous pressure is kept under 5 mm Hg to decrease the intra operative blood loss. The portal inflow is taped and kept ready in case there is need for inflow occlusion due to bleeding. Stay sutures are placed in the liver parenchyma around the emerging part of the cyst to enable traction and better exposure during resection. The liver capsule is incised using diathermy. The identification of the right plane around the cyst capsule is important to decrease intraoperative blood loss. The parenchyma around the cyst is dissected out using Kelly clamp method or any available energy source. Attention must be paid to identify any biliary radicles communicating with the cyst. In case of difficulty, the procedure can be abandoned in favour of deroofing of the cyst and evacuation of the contents. After giving good wash inside a careful inspection is done to identify biliary communications if any and they are underrun. Omentum can be used to plug the cyst cavity.

Complications of Surgery

Biliary leak is the most important complication in large hydatid disease surgeries. Causes are—persistent cystobiliary communications; biliary tree injury; retained debris in CBD; calcified cyst. Conservative treatment with or without ERCP and sphincterotomy is usually sufficient.

Infection is one of the most common complications after hydatid cyst surgery; often patient develops septicaemia. Subphrenic abscess, liver abscess formation are not uncommon which should be addressed accordingly by antibiotics and guided external drainage using a tube.

Liver failure is the most dreaded complication especially very large cyst. Often patient succumbs to liver failure.

Respiratory problems like bronchopneumonia and ARDS can occur which should be addressed accordingly with ICU care.

Recurrences during long-term follow-up can also occur due to retained scolices or part of the germinative membrane. Progression of disease at different sites as secondary hydatids can occur which should be addressed depends on the site of the cyst. Recurrence rate is 1-30% in different studies. Initial surgical precision plays a major role in recurrence incidences.

B. GALLBLADDER WITH EXTRAHEPATIC BILIARY TREE

SURGICAL ANATOMY

Gallbladder

It is a pear-shaped (size is 5-12 cm) reservoir, located in a fossa on the inferior surface of the liver. Four parts of gallbladder are fundus, body, infundibulum and neck. *Hartmann's pouch* is pathological one located in the infundibular region created by gallstones. The hepatic surface is attached to liver by connective tissue of liver capsule; non-hepatic surface and fundus is covered by peritoneum. Body of the gallbladder is covered by peritoneum on the non-hepatic surface and is related to transverse colon, and 1st and 2nd portions of the duodenum. In 4% of individuals body has got its own mesentery. Such gallbladder is called as *floating/roving gallbladder* and is prone for torsion and gangrene. Body of the gallbladder is related to transverse colon and 1st and 2nd part of the duodenum.

Gallbladder drains through cystic duct into common hepatic duct to form common bile duct. It is supplied by cystic artery, a branch of right hepatic artery. *Calot's triangle* is (Calot, 1891; cholecystohepatic triangle) formed by common hepatic duct to the left, cystic duct and gallbladder below, and inferior surface of liver above. Cystic artery originating from right hepatic artery passes behind the common hepatic duct enters the Calot's triangle to reach the gallbladder. It contains lymph node of '*Lund' (Fred Bates Lund)*.Often cystic artery, hepatic artery, cystic duct have anomalous positions and anomalous origins. Both gallbladder neck and cystic duct contain mucosal fold called *valves of Heister.* Gallbladder is pear-shaped with 50 mL capacity. *Fundus* is in the summit like a dome and is covered fully by peritoneum; it projects beyond the liver margin. It contains smooth muscle. This part is anastomosed to small bowel while doing cholecystojejunostomy. *Body* contains mainly elastic tissue which is a storage part; it is in deeper plane is attached to liver and outer part is attached to peritoneal cavity. Body tapers into *neck* like a funnel lying on the free border of hepatoduodenal ligament; its distended convexity is called as *infundibulum*/Hartmann's pouch (pathological). *Lining* of the gallbladder is by columnar epithelium which contains cholesterol and fat globules. The *mucus* secreted into the gallbladder originates in the tubuloalveolar glands globular cells lining the mucosa of infundibulum and neck **(Fig. 22-48)**.

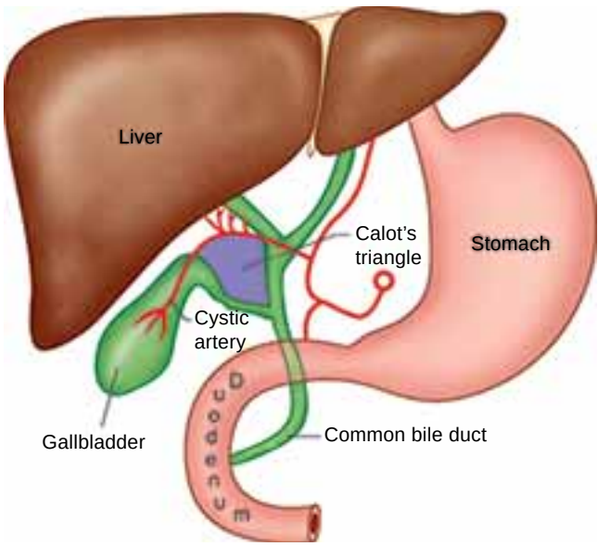


Fig. 22-48: Anatomy of gallbladder and Calot's triangle.

Extrahepatic Biliary Tree

The left hepatic duct is formed by the ducts draining II, III, IV segments of the liver. The right hepatic duct is formed by the ducts draining V, VI, VII, VIII segments of the liver. Both join to form the *common hepatic duct (CBD)*, which joins with the cystic duct to form the *common bile duct*. Junction of right and left hepatic ducts to form common hepatic duct is 0.25-2.5 cm from the surface of the liver. Left duct is longer about 1.7 cm than right hepatic duct which is 0.9 cm. occasionally this junction may be intrahepatic due to enlargement of the liver. Common hepatic duct is variable in length from 1.5 cm to 3.5 cm. When cystic duct joins the junction of the right and left hepatic ducts then common hepatic duct is considered as absent. Cystohepatic junction may be angular, parallel and spiral.

Cystic duct is 3 mm in diameter and 2-4 cm in length. Variations are common. During these variations should be remembered to avoid inadvertent injury to common bile duct.

Common bile duct is normally 5-12 cm in length and 6-8 mm in diameter. Length depends on the position where cystic duct joins. It has got 4 parts – (1) *Supraduodenal* with a length of 2 cm; (2*) Retroduodenal* part with a length of 1.5 cm; (3) *Pancreatic part* with a length of 3.0 cm; (4) *Intramural/intraduodenal* part with a length of 1.1 cm. Length of each part is variable. Supraduodenal portion lies in the two leaves of the hepatoduodenal ligament, in front of the portal vein to the right of the proper hepatic artery. Retroduodenal part runs from the superior margin of the 1st part of the duodenum to upper margin of the head of the pancreas. Gastroduodenal artery is left of the duct; posterior superior pancreaticoduodenal artery crosses the duct first in front of the duct later behind it just it joins the duodenum. Common bile duct may be covered partly by pancreas (44%) or fully (embedded in the pancreas—30%) or not covered by pancreas (16%) or covered by two leaves. It joins the major pancreatic duct in the wall of the 2nd part of duodenum to form the *ampulla of Vater*. Intraduodenal part of common bile duct (CBD) is surrounded by smooth muscle fibres called as *sphincter of Oddi.* CBD if more than 8 mm diameter is pathological. Pancreatic CBD is palpable from behind after Kocher's duodenal mobilisation. Intraduodenal part is oblique in the duodenal wall running for 1.5 cm. Here CBD diameter reduces from 5.5 to 3.5 mm. Pancreatic and bile duct initially separated by a septum with a common adventitia for 5-10 mm eventually forms a confluence of ducts **(Figs 22-49 and 22-50)**.

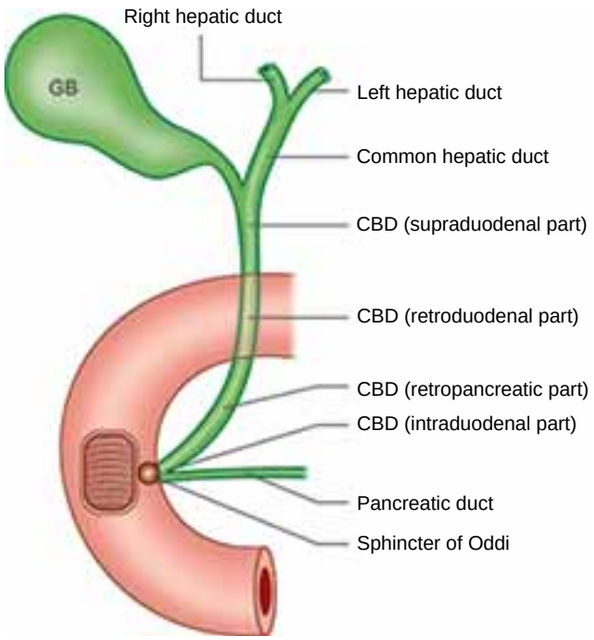


Fig. 22-49: Parts of common bile duct.

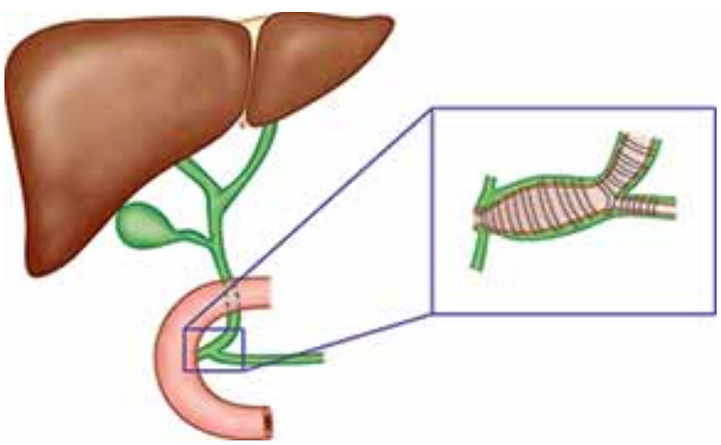


Fig. 22-50: Sphincter of Oddi—surgical anatomy.

Blood Supply

Arterial Supply

Gall bladder receives its blood supply from cystic artery which is a branch of right hepatic artery or aberrant hepatic artery. Right hepatic artery runs behind the common hepatic duct (87%), often it may be in front of common hepatic duct (13%). Incidence of aberrant right hepatic artery is 15 -20%; cystic artery arises from this (in 80% cases) when it is present.

Aberrant right hepatic artery may replace right hepatic artery (12-16%) or may be accessory to existing right hepatic artery (4-5%). Aberrant/accessory right hepatic artery arises from superior mesenteric artery.

Left hepatic artery anomaly is important. Left hepatic artery may originate from left gastric artery in 5% of cases. In such patients during gastrectomy, while dissecting and ligating this, *aberrant left hepatic artery* may get ligated causing devascularisation of the left lobe of the liver. Often normal left hepatic artery is present originating from common (proper) hepatic artery as usual; but additionally an *accessory left hepatic artery* arising from left gastric artery may also be present (5%).

Cystic artery after its origin, runs towards the neck of the gallbladder where it divides into superficial (anterior) and deep (posterior) branches. Cystic artery as *variation* may arise from left hepatic or proper hepatic or common hepatic or gastroduodenal arteries.

Bile and hepatic ducts are supplied by gastroduodenal, retroduodenal, right and left hepatic and posterosuperior pancreaticoduodenal arteries. One should not devascularise more than 3 cm of the surface of the common bile duct. Supraduodenal bile duct derives its blood supply from retroduodenal artery (60% from below and 38% from above) through right hepatic artery. Bile duct ischaemia should be avoided while doing choledochojejunostomy or choledochoduodenostomy. Two arteries run parallel in the common bile duct at 3 and 9 o'clock position. Interruption of these two arteries lead into bile duct stricture.

Afferent arteries supply the bile duct. Bile duct is not supplied by portal venous system unlike liver. Afferent arteries are gastroduodenal, retroduodenal, right and left hepatic and posterosuperior pancreaticoduodenal arteries. Afferent arteries empty into the marginal arteries which run at 3 and 9 o'clock positions longitudinally along the common bile duct and common hepatic duct. Hilar marginal artery is located at the upper angle of the confluence of right and left hepatic ducts. These marginal arteries form fine network of epicholedochal plexus on the surface of the bile duct, common, right and left hepatic ducts. At the right and left hepatic ducts confluence it forms hilar plexus. These plexus will not extend above beyond the fibrous sheath of the hilar plate. So dissection above hilar plate should be done with the sheath itself, not between sheath and hepatic ducts **(Fig. 22-51)**.

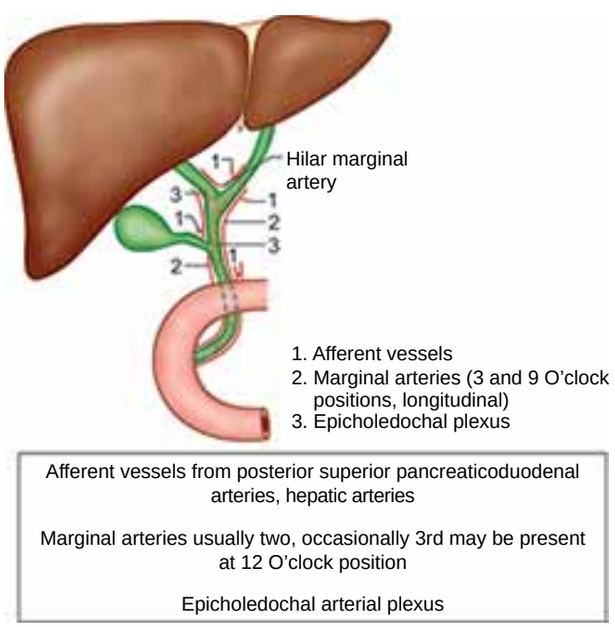

Hilar marginal artery
1. Afferent vessels
2. Marginal arteries (3 and 9 O'clock positions, longitudinal)
3. Epicholedochal plexus
Afferent vessels from posterior superior pancreaticoduodenal arteries, hepatic arteries
Marginal arteries usually two, occasionally 3rd may be present at 12 O'clock position
Epicholedochal arterial plexus

Fig. 22-51: Pattern of blood vessels in extrahepatic biliary apparatus.

Transection of the bile duct at superior most part makes lower cut edge ischaemic; transection at inferior part close to duodenum makes upper cut edge ischaemic. So in bile duct transection (traumatic/iatrogenic), primary anastomosis (choledochocholedochal) is not safer and is not practiced.

As extrahepatic biliary tree is supplied by hepatic arterial system (no portal venous supply) unlike dual supply of liver, blockage of hepatic artery may cause bile duct necrosis. Right hepatic artery may get

injured in laparoscopic cholecystectomy along with bile duct injury. It may cause ischaemia of bile duct also. During surgery bile duct should be divided sharply; it should not be dissected from surrounding tissue to main epicholedochal plexus.

Venous Drainage

Deep cholecystic veins in the gallbladder bed drains into the liver. Superficial cholecystic veins drain into upwards to liver and downwards to portal vein. Usually these veins are less prominent and will not cause significant bleeding after division. But in portal biliopathy gallbladder and choledochal varices will develop which may cause torrential bleeding on dissection **(Fig. 22-52)**.

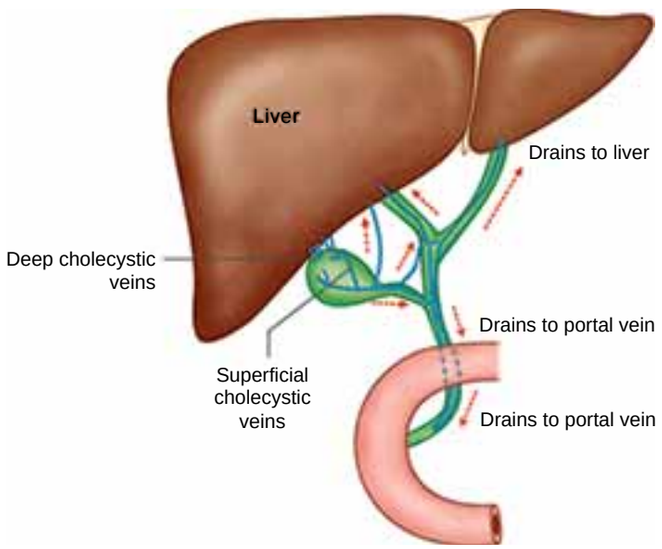


Fig. 22-52: Veins in biliary system—extrahepatic.

Lymphatic Drainage

Gall bladder drains into the cystic node at the junction of the cystic and common hepatic ducts (lymph node of *Lund*); from here to the '*node of the hiatus*' and posterior pancreaticoduodenal nodes. The *pericholedochal nodes* get their afferent lymphatics from extrahepatic bile duct and right lobe of the liver (**Fig. 22-53**).

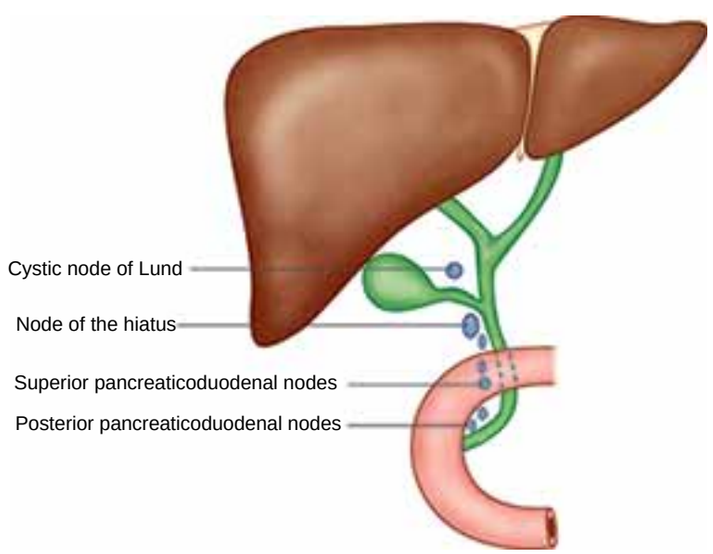


Fig. 22-53: Lymphatics of biliary system.

Bile

Daily up to 1000 mL of bile is secreted from the liver which contains water (98%), bile salts, bile pigments, fatty acids, lecithin, cholesterol, and electrolytes (sodium, potassium, chloride, bicarbonate, calcium, magnesium) with a pH more than 7.0. Main function of gallbladder is to concentrate and store the bile. Capacity of gallbladder is 40-50 mL. Bile salts form micelle which makes cholesterol soluble. Bile salts (i.e. salts of cholic and chenodeoxycholic acids) with formed deoxycholic acid (in the bowel) enter the enterohepatic circulation to get resecreted in the bile. Bilirubin conjugated in the liver is secreted into the bile, which in the bowel is converted into urobilinogen by bacteria. Urobilinogen gets absorbed in the bowel, enters the liver for resecretion again and part of it is excreted in the urine. Absence of urobilinogen in the urine signifies obstructive jaundice. In the absence of gallstones or any other disease, bile is sterile. Symptomatic gallstone disease shows positive culture for bacteria, commonest being *E. coli* and *Klebsiella*.

Congenital Anomalies of Gallbladder and Extrahepatic Biliary Tree

Anomalies of gallbladder may be in number; form; position.

Absence of gallbladder—rare.

Phrygian cap: A cap-like projection and bend over the fundus of the gallbladder (*Phrygia* is an ancient Asian country—Mongolia) (Liberte cap of French revolution). It is identified in cholecystogram. It is 6% common.

Double/triple gallbladder: Additional one may be intrahepatic. Cystic ducts may join to form a common cystic duct which joins the CBD, or cystic duct of each gallbladder may join separately into the CBD.

Mobile/floating/mesenteric gallbladder: Gallbladder has a long mesentery attached. It may cause torsion. It can cause recurrent abdominal pain. It is also called as gallbladder ptosis. Its incidence is 5%. There are three types of floating gallbladder. (1). Gallbladder is completely invested by peritoneum without mesentery and only attachment between liver and gallbladder is cystic duct and artery. (2). Gallbladder is having complete mesentery. (3). Cystic duct and neck of the gallbladder have mesentery with fundus and body are free hanging and ptosed. Such a ptosed gallbladder can position in iliac fossa, lumbar or pelvic region. Torsion is common in elderly, thin people. Its removal is easier through laparoscopic or open method **(Fig. 22-54)**.

Long cystic duct with low insertion of the cystic duct into CBD near the ampulla is possible. This is important in all pancreatic/biliary/laparoscopic biliary surgeries.

Absence of cystic duct with gallbladder directly entering the CBD through a wide opening near infundibulum.

Accessory cholecystohepatic duct (*duct of Luschka*) may be present (10%) which if not identified and ligated during cholecystectomy will cause biliary fistula/ peritonitis due to continuous leak.

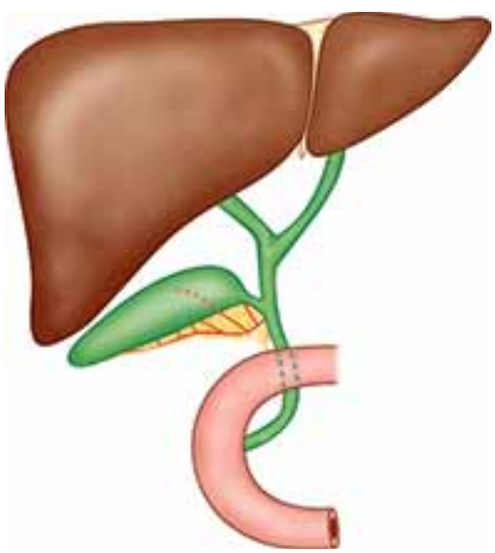
Cystic artery may originate anteriorly (15%) from right hepatic artery/from common hepatic artery.

Very tortuous hepatic artery in front of the origin of the cystic duct is called as *Moynihan's caterpillar hump*. It is important cause of bleeding in cholecystectomy.

There may be *double cystic duct* or cystic duct may insert high into the common hepatic duct or right hepatic duct.

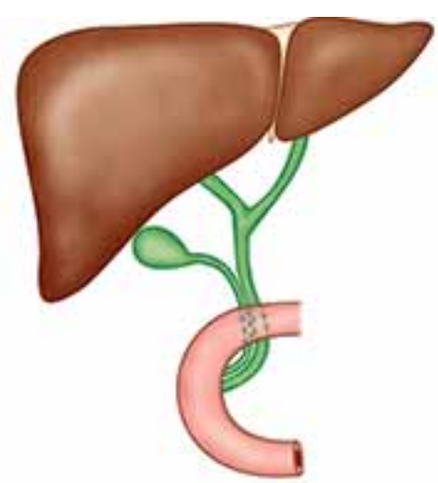
Aberrant hepatic duct is a normal segmental duct that joins the biliary tract just outside the liver instead of just within. It drains normal portion of the liver but travels hepatocystic triangle and may get injured during cholecystectomy **(Figs 22-55 to 22-78)**.

A



B

Figs 22-54A and B: (A) Laparoscopic view of gallbladder mesentery; (B) diagrammatic look.



Here cystic duct joins separately down into the duodenum directly without any communication to the CBD. This situation is called as 'absence CBD'.

Fig. 22-55: Absence common bile duct; here cystic duct joins duodenum separately.

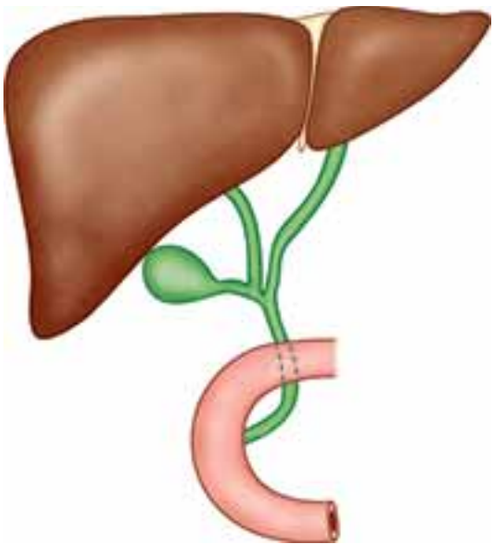


Fig. 22-56: Absence common hepatic duct; here right and hepatic ducts join at the confluence where cystic duct joins the bile duct.

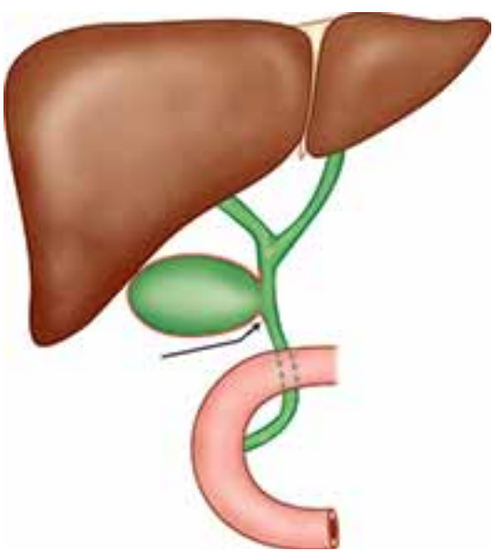
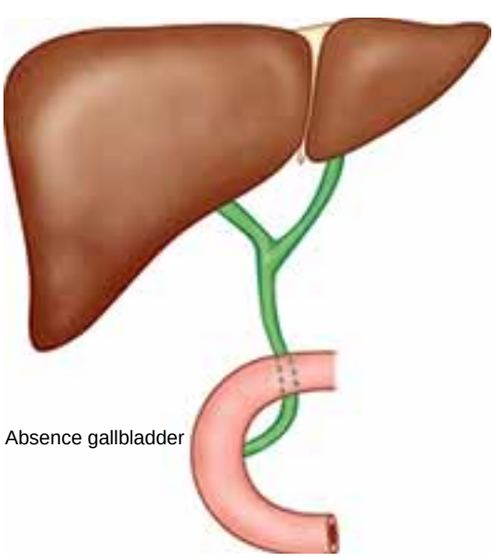


Fig. 22-57: Cystic duct is absent with wide communication into CBD. There is higher chance of CBD injury here.



Absence gallbladder

Fig. 22-58: Absent gallbladder.

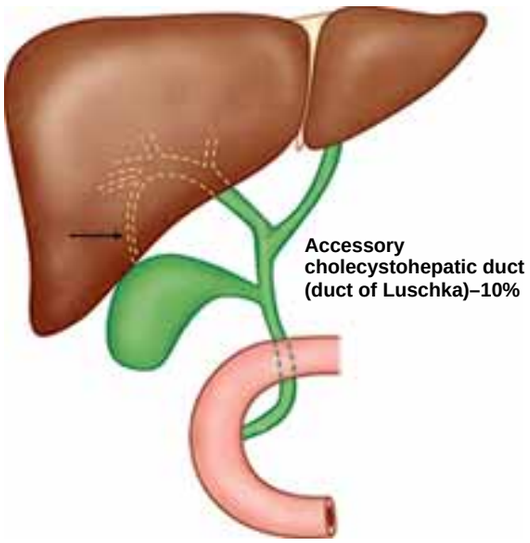


Fig. 22-59: Accessory cholecystohepatic duct (Duct of Luschka—10%). It may cause bile leak post-operatively if it is not ligated during cholecystectomy.

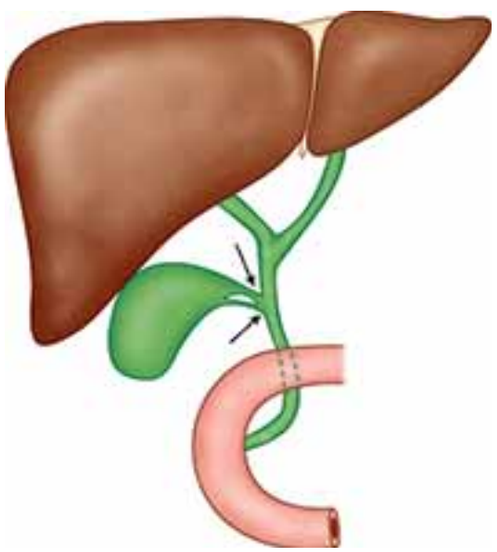


Fig. 22-60: Double cystic ducts from the gallbladder joining the CBD.

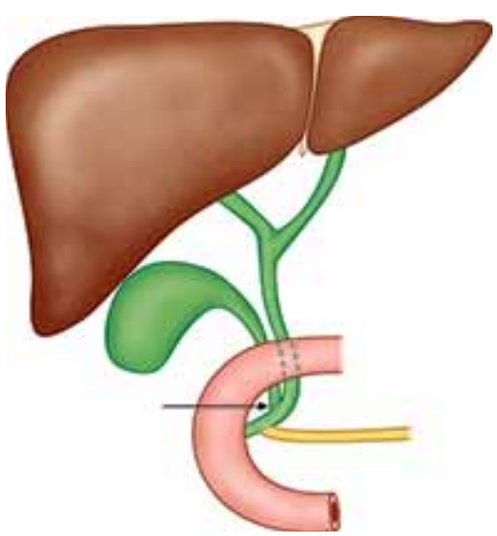


Fig. 22-61: Long cystic duct joining the CBD very low.

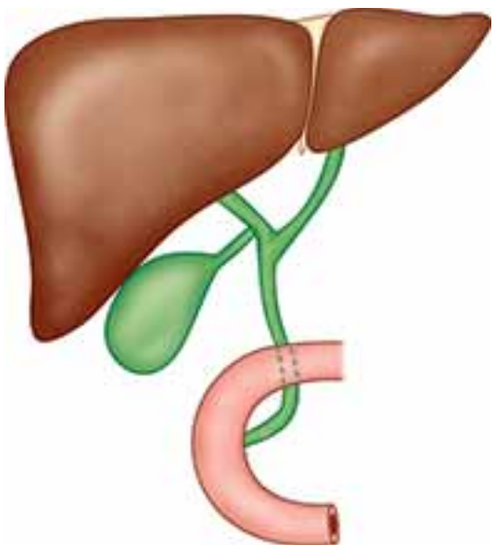


Fig. 22-62: Cystic duct joining the right hepatic duct—a variation.

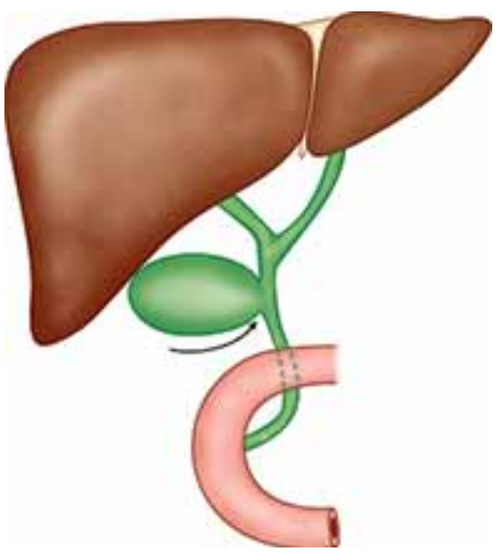


Fig. 22-63: Cystic duct with wide opening into CBD.

PREOPERATIVE PREPARATION AND ASSESSMENT

Outcome in hepatobiliary surgery depends on many factors. (1) *Hepatobiliary function*—Low pressure biliary system with obstruction to all functions of liver cells (synthetic, metabolic, secretory) will be affected. Secretion gets reduced due to increased pressure. If bilirubin is less than 1.5 mg%, mortality is less than 3%; if it becomes more than 20 mg% mortality raises up to or more than 30%. Metabolisms of many drugs are also affected. Bile acid serum level raises and inhibits cytochrome 450 enzymes reducing the oxidation. Albumin, coagulation factors and immunoglobulin synthesis is affected. (2) 50% of obstructive patients have *higher endotoxin level* in blood; it is due to reduced bile salts in intestinal lumen which normally prevents absorption of endotoxins from intestine and bile salts and also inhibit anaerobic bacterial growth. So reduced bile salt causes sepsis and endotoxaemia. That also causes acute tubular necrosis, and *renal failure*. Sludging of bile salts in the renal tubules reduces the tubular function by blockage and aggravates the

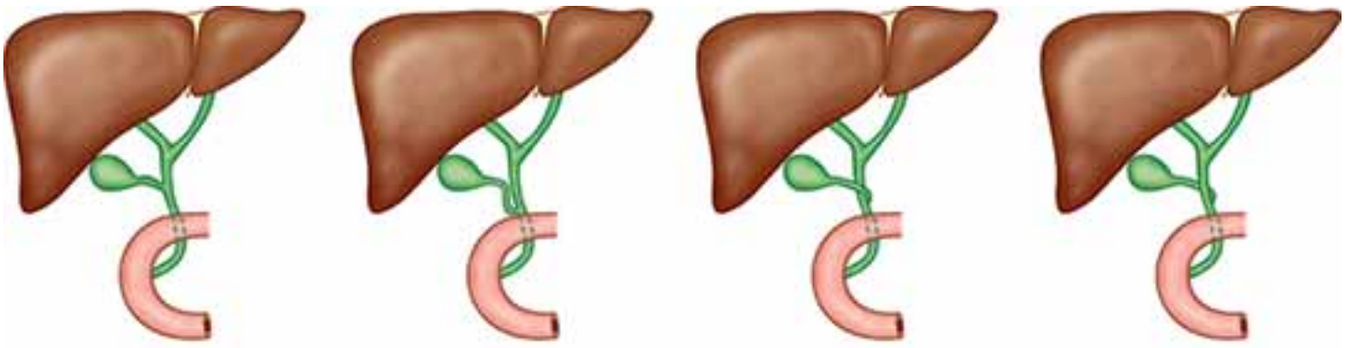


Fig. 22-64: Possible different types of cystohepatic junction.

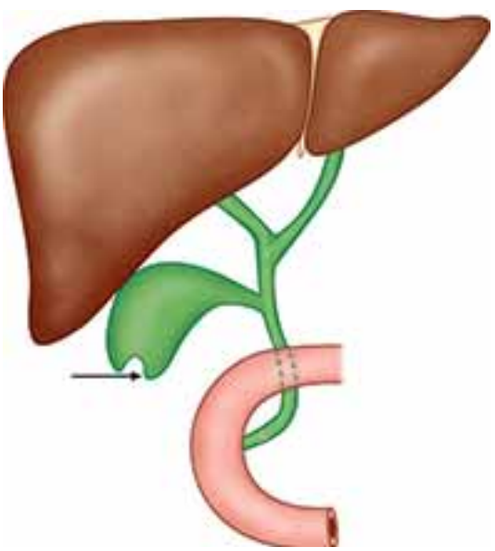


Fig. 22-65: Phrygian (cap) gallbladder.

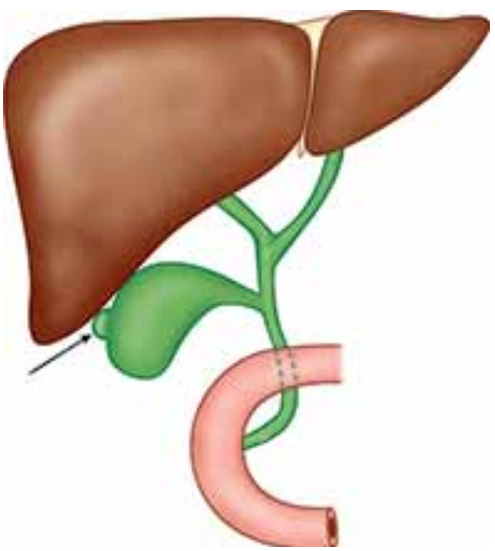


Fig. 22-66: Gallbladder diverticulum.

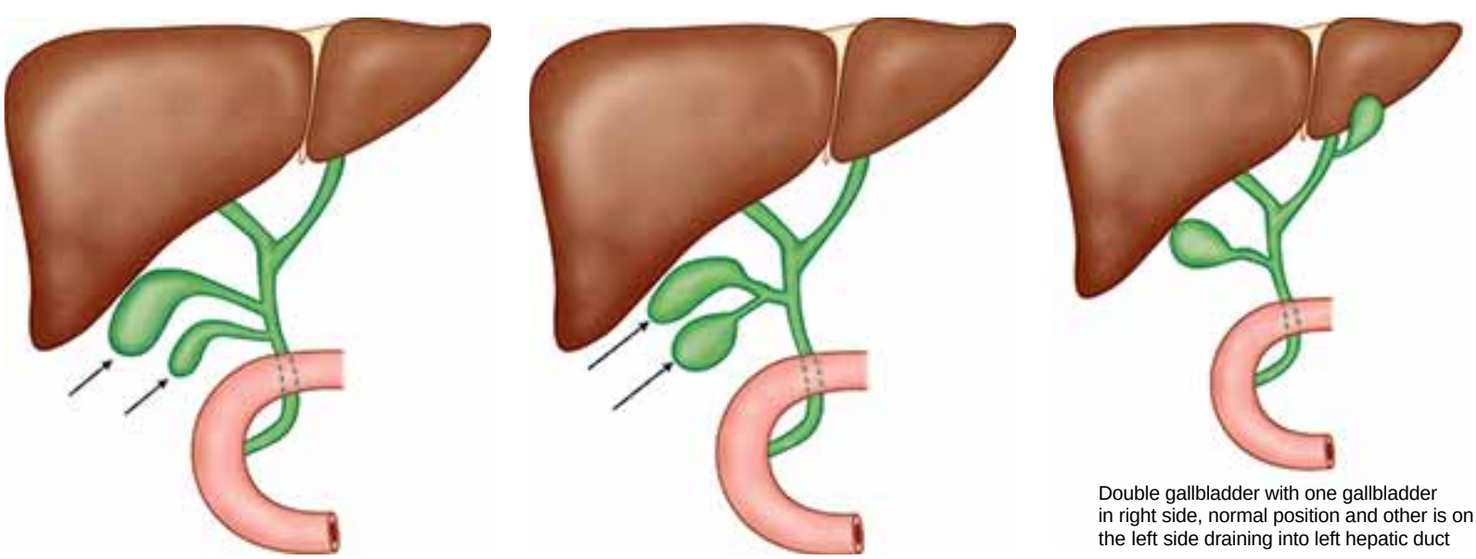

Double gallbladder with one gallbladder
in right side, normal position and other is on
the left side draining into left hepatic duct

Fig. 22-67: Double gallbladder. One may be intrahepatic. It may have separate cystic ducts joining CBD or two cystic ducts join to form single duct to join the CBD. One gallbladder may be on right side, other one on left side.

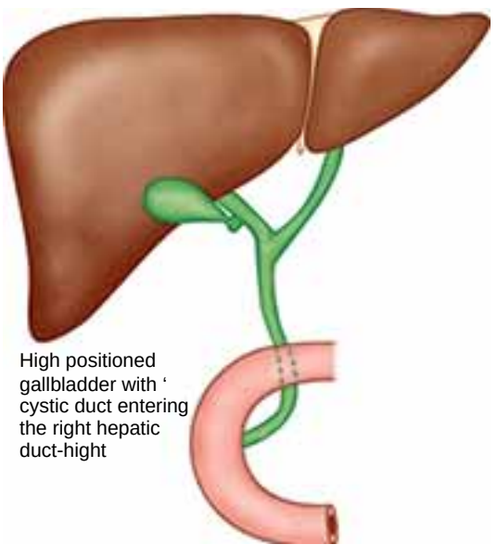


Fig. 22-68: High position gallbladder.

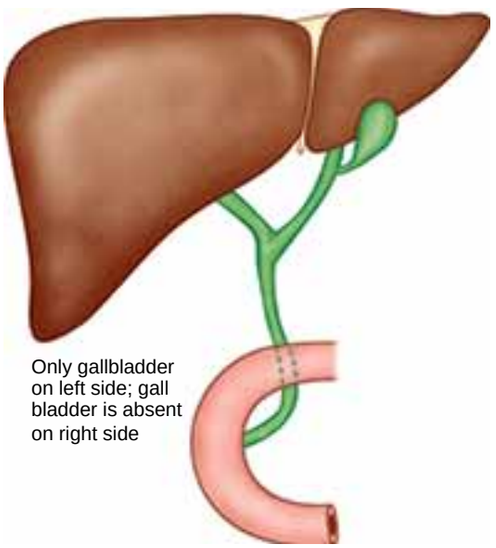


Fig. 22-70: gallbladder is present only on left side joining left hepatic duct.

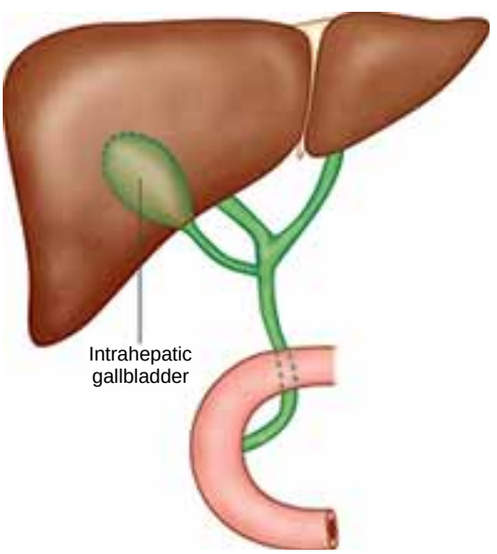


Fig. 22-69: Intrahepatic gallbladder.

problem. Mannitol probably and also proper hydration prevents this problem in tubules. (3) *Bleeding tendencies*—Vitamin K absorption from the intestine is reduced due to reduced luminal bile acids in the lumen. It prolongs the prothrombin time. This can be corrected by giving IM or IV vitamin K. Endotoxin absorption is increased due to reduced bile acids in the gut which causes recurrent mild disseminated intravascular coagulation (DIC) and raise in fibrin degradation products. It causes tendency for bleeding during surgery and postoperative period. Additionally defective coagulation factor synthesis, hypersplenism (if there is cirrhosis) and fibrinolysins in circulation aggravates the thrombocytopaenia. (4) *Nutritional deficiencies*—Obstructive jaundice causes severe malnutrition with anorexia and weight loss. Pancreatic head or periampullary pathology causes duodenal obstruction and also poor exocrine and endocrine function of the pancreas. (5) *Altered body resistance and immunity with sepsis*—Obstructive jaundice causes defect in T cell proliferation, phagocytosis, delayed hypersensitivity reaction. It reduces the defensive function of the Kupffer cell to phagocytose and neutralize endotoxins. (6) *Gut endotoxins* are increased due to reduced gut bile acids (bile acids emulsify endotoxins); there will be increased bacterial translocation across the gut; this overall increase the sepsis rate in obstructive jaundice patient. (7) Obstructive jaundice reduces the *activity of propylhydroxylase enzyme* in the skin (enzyme

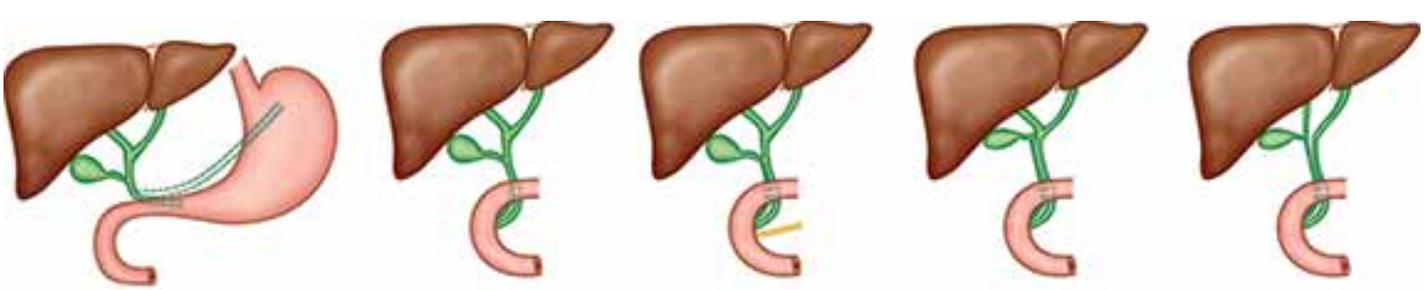


Fig. 22-71: Duplications of common bile duct.

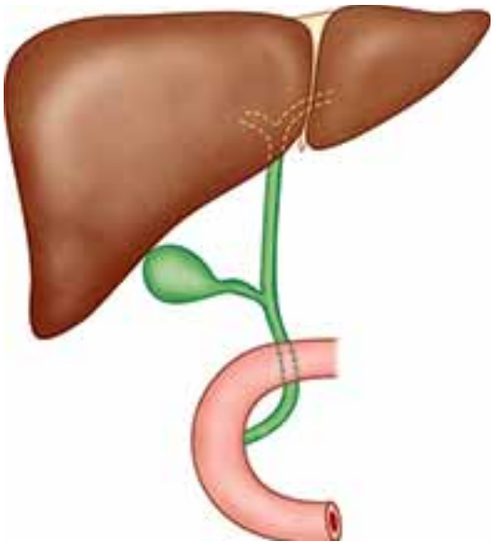


Fig. 22-72: Right and left hepatic duct junction is intrahepatic deep to hepatic plate/hilum.

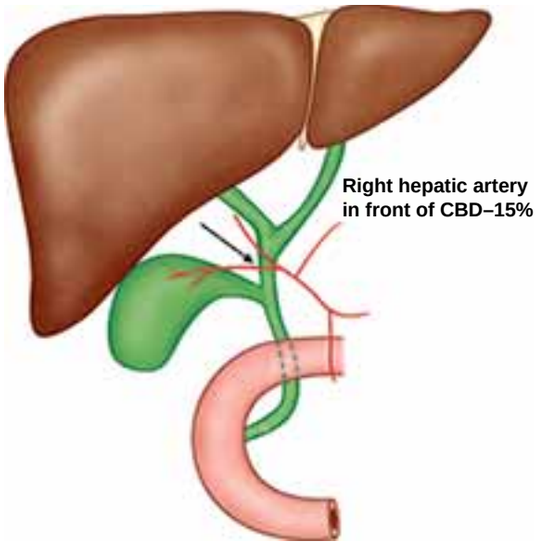


Fig. 22-74: Cystic artery originates from right hepatic artery which is anterior to common bile duct.

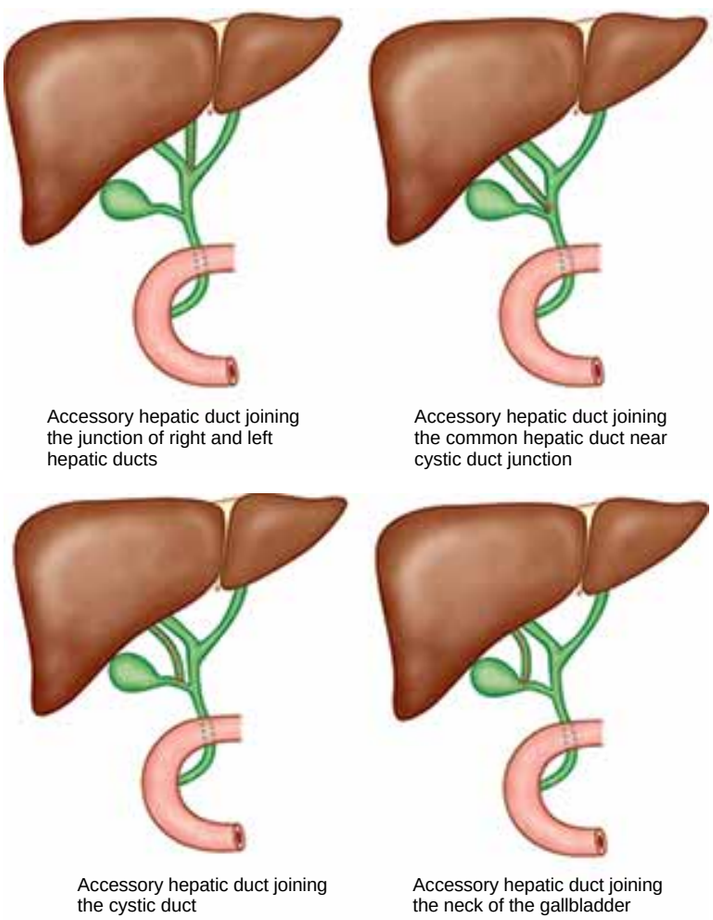

Accessory hepatic duct joining the junction of right and left hepatic ducts
Accessory hepatic duct joining the common hepatic duct near cystic duct junction
Accessory hepatic duct joining the cystic duct
Accessory hepatic duct joining the neck of the gallbladder

Fig. 22-73: Different types of multiple hepatic ducts.

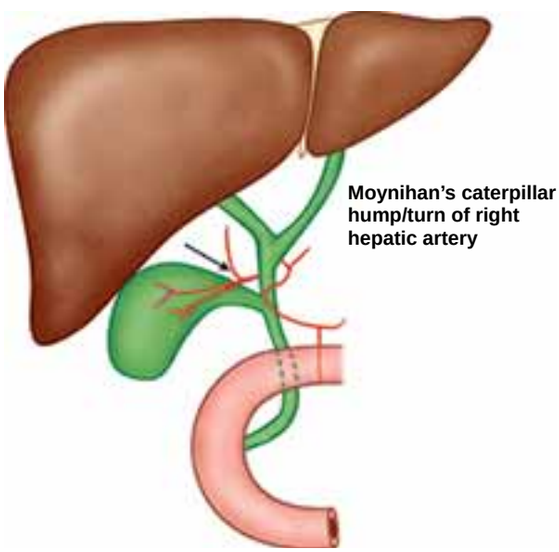


Fig. 22-75: Moynihan's caterpillar turn/hump is bending of right hepatic artery in front of/close to cystic duct. It may get injured during cholecystectomy causing torrential haemorrhage.

helps proline attachment to collagen) and so diminishes the effective collagen formation and its strength. So burst abdomen and incisional hernia is common. (8) *Cardiac problems*—Obstructive jaundice causes decreased contractility; poor response to drugs; decreased peripheral vascular resistance; hypovolaemia; raised serum bile acids cause diuresis and natriuresis.

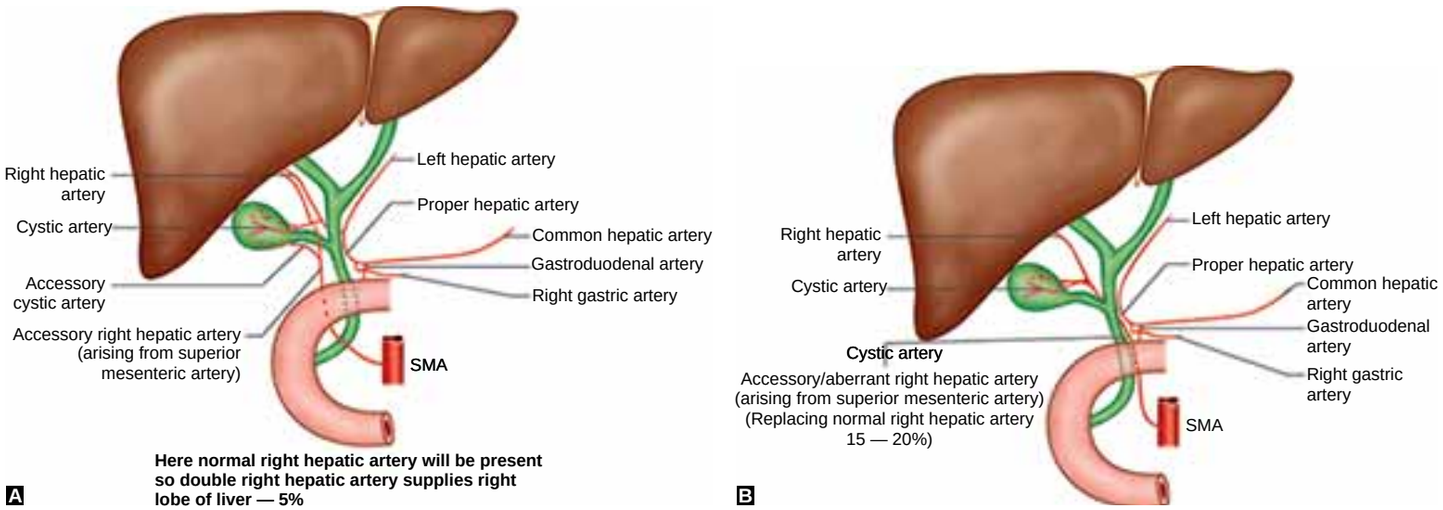
ASSESSMENT

Clinical Assessment

Jaundice (**Fig. 22-79**), fever, chills, urine output, weight loss, mass abdomen to be looked for.

Biochemical and Blood Tests

Liver function tests; serum amylase, lipase; renal function tests; coagulation profile (V, VII, IX, X, prothrombin, fibrinogen); prothrombin time (INR); platelet count; urine-bilirubin, urobilinogen, bile salts; reticulocyte count, osmotic fragility test, Coomb's test. In obstruction—direct bilirubin and serum alkaline phosphatase (very sensitive indicator of obstruction) is raised. But serum alkaline phosphatase is raised in bone diseases also; 5'-nucleotidase and serum


Right hepatic artery
Left hepatic artery
Proper hepatic artery
Cystic artery
Common hepatic artery
Gastroduodenal artery
Accessory cystic artery
Right gastric artery
Accessory right hepatic artery (arising from superior mesenteric artery)
SMA
Here normal right hepatic artery will be present so double right hepatic artery supplies right lobe of liver — 5%
A
Right hepatic artery
Left hepatic artery
Proper hepatic artery
Cystic artery
Common hepatic artery
Gastroduodenal artery
Cystic artery
Right gastric artery
Accessory/aberrant right hepatic artery (arising from superior mesenteric artery) (Replacing normal right hepatic artery 15 — 20%)
SMA
B

Figs 22-76A and B: Accessory right hepatic artery originates from superior mesenteric artery additional to normally located right hepatic artery; aberrant right hepatic artery arising similarly from superior mesenteric artery but replacing the normal right hepatic artery.

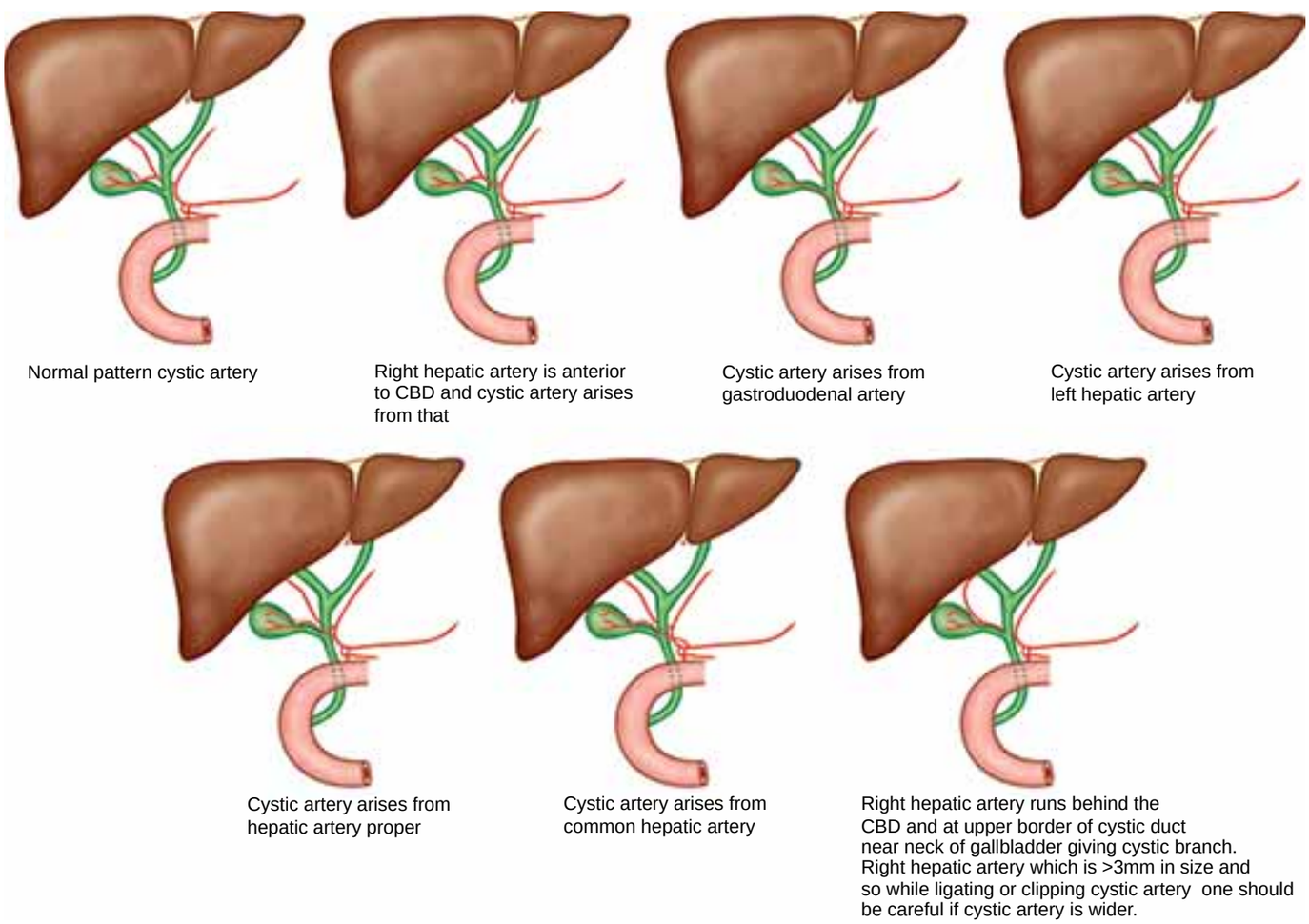

Normal pattern cystic artery
Right hepatic artery is anterior to CBD and cystic artery arises from that
Cystic artery arises from gastroduodenal artery
Cystic artery arises from left hepatic artery
Cystic artery arises from hepatic artery proper
Cystic artery arises from common hepatic artery
Right hepatic artery runs behind the CBD and at upper border of cystic duct near neck of gallbladder giving cystic branch. Right hepatic artery which is >3mm in size and so while ligating or clipping cystic artery one should be careful if cystic artery is wider.

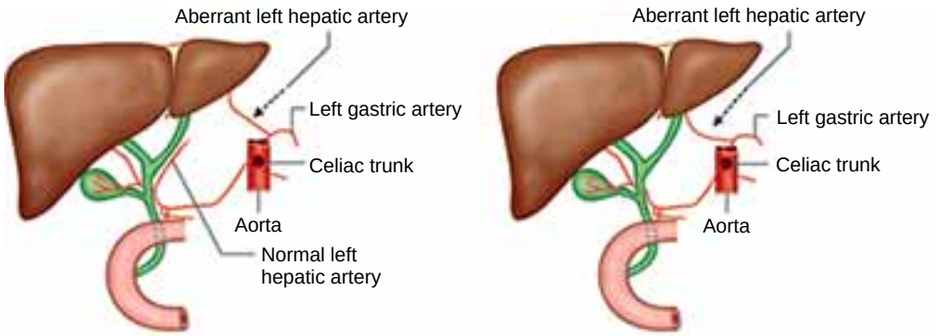
Fig. 22-77: Variations in cystic artery – different from normal.

γ–glutamyl transferase level raise are specific for hepatocytes as they are not found in bone. Serum alanine aminotransferase (ALT; it is predominantly found inside hepatocytes), raise suggests liver injury; degree of liver injury is assessed by serum albumin and prothrombin time. High direct bilirubin more than 20 mg% may suggest malignant obstruction.

Imaging

Plain X-ray abdomen is of less use in identifying the gall stones (10%). It is useful to diagnose biliary fistula, emphysematous cholecystitis.

Ultrasound is good investigation to detect gall stones, and biliary dilatation. Normal size of the CBD is 8 mm; more than 10 mm suggests



Accessory left hepatic artery arising from left gastric artery; here normal left hepatic artery will be present originating from proper hepatic artery

Aberrant left hepatic artery exclusively arises from left gastric artery; here normal left hepatic artery is absent. This artery should be retained while doing gastrectomy during ligating the left gastric artery

Fig. 22-78: Anomalies of left hepatic artery.

Fig. 22-79: Typical obstructive jaundice.

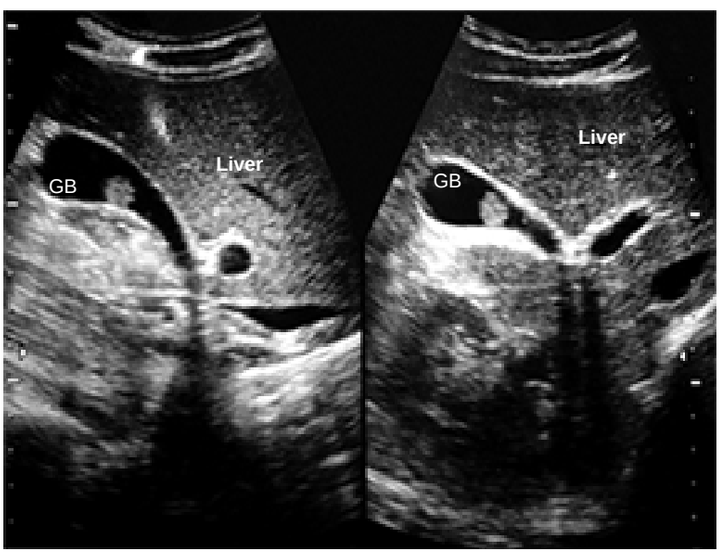


Fig. 22-80: Ultrasound abdomen showing gallbladder stone and normal sized CBD.

dilatation. However, its accuracy rate is only 80%. Stones in CBD and hepatic ducts are difficult to identify by ultrasound. Ultrasound cannot pick up malignancy which is a differential diagnosis for obstructive jaundice **(Fig. 22-80)**.

CT scan is effective in identifying non-dilated ducts and stones in that. Anatomy is better seen with 90% accuracy. CT is better to rule out malignancy in head of pancreas or periampullary region **(Fig. 22-81)**.

MRI and **MRCP** are better to identify the biliary tree. It gives idea about venous anatomy and parenchymal status **(Fig. 22-82)** .

Endoscopic retrograde cholangiopancreatography (ERCP): Through a side viewing gastroduodenoscope, sphincter of Oddi is cannulated, and dye is injected. Biliary and pancreatic trees are visualised. It is done under C-ARM guidance and sedation like midazolam or propofol anaesthesia. Patient is placed in prone position with the head turned towards right. After passing gastroduodenoscope, sphincter is identified and cannulated. Under visualisation 3 mL of water soluble iodine contrast is injected into the bile duct and pancreatic duct. When cannula goes upwards beside vertebra, it signifies that it is in bile duct; and if cannula goes across the vertebra, it is in

Fig. 22-81: (A) CT scan showing dilated CBD. (B) CT scan showing choledochal cyst.

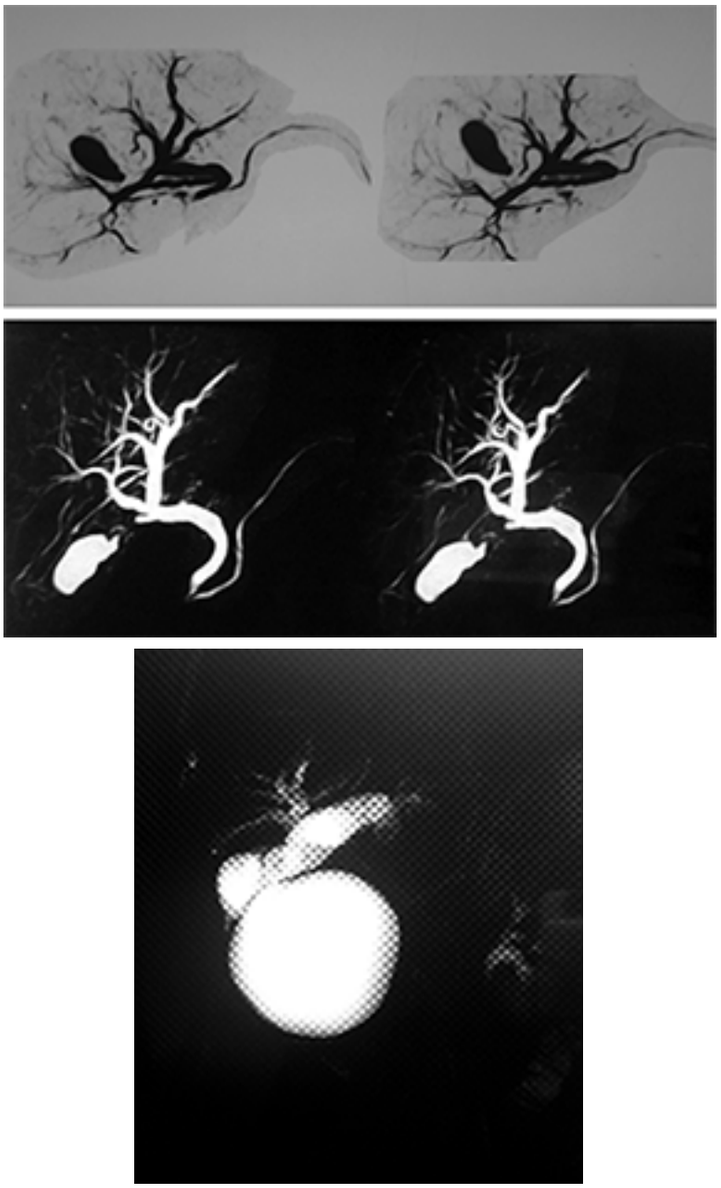


Fig. 22-82: MRI is a useful method to assess biliary anatomy.

pancreatic duct. ***Indications:*** Malignancy—irregular filling defect; chronic pancreatitis—*'chain-of-lakes'* appearance; congenital anomalies; stones; stricture of biliary tree; choledochal cyst; for sampling of biliary and pancreatic juices for analysis and cytology; brush biopsy from tumour site. ***Therapeutic uses:*** Extraction of stone from biliary duct; Nasobiliary drainage; Stenting of tumour in the CBD or in the pancreas; Dilatation of the biliary stricture; endoscopic papillotomy (**Fig. 22-83**).

Complications: Pancreatitis; Duodenal injury, perforation; cholangitis; bleeding from pancreaticoduodenal artery; sphincter stenosis. ***Relative Contraindications:*** Acute pancreatitis; previous gastrectomy.

Percutaneous transhepatic cholangiography (PTC)*:* It is done in case of severe obstructive jaundice under cover of antibiotics and after control of any bleeding tendency—by giving injection vitamin K or FFP transfusion. ***Indications:*** Failure of ERCP; high biliary strictures; Klatskin tumour; high blocks when external caternal catheter drainage is needed; stenting in high tumours with the help of fluoroscopy (C-ARM)/US/CT guided, *Chiba* or *Okuda needle* which is long, flexible, thin, blunt, without a bevelled end (15 cm long and 0.7 mm in diameter) is passed into the liver through right 8th intercostal space in midaxillary line. Once needle is in the dilated biliary radicle, bile is aspirated (sent for culture, cytology, analysis) and then water soluble iodine dye is injected into the same so as to visualise the dilated biliary radicles, also the site and extent of the obstruction, i.e. tumour, stricture. Procedure can be used for therapeutic stenting across the biliary tree through the obstruction either in the hepatic ducts or in the CBD into the duodenum. It is used whenever ERCP fails, in high strictures (in CHD), in Klatskin tumour, in catheter drainage (external) in high blocks, in stenting high tumours. ***Prerequisites for PTC:*** It should have normal prothrombin time (or should be made normal by injection vitamin K or FFP); should be a last and final inevitable method for evaluation; or therapy; blood for transfusion in case of bleed, consent for intervention in need, antibiotic prophylaxis—are a must prior to PTC. ***Complications*****:** Bleeding, biliary leak and biliary peritonitis and septicaemia. PTC has got 95% accuracy rate. It confirms the diagnosis; site and cause of obstruction is determined; specific anatomy is identified.

Note: Chiba is a university in Japan. Okuda is the name of person.

PTBD is percutaneous transhepatic biliary drainage. It can be *external or internal*. It is done through PTC.

Preoperative cholangiogram: It is done during CBD exploration for stricture, residual CBD stones, atresia, choledochal cyst, cholangitis. Fine polythene catheter is passed into the CBD through cystic

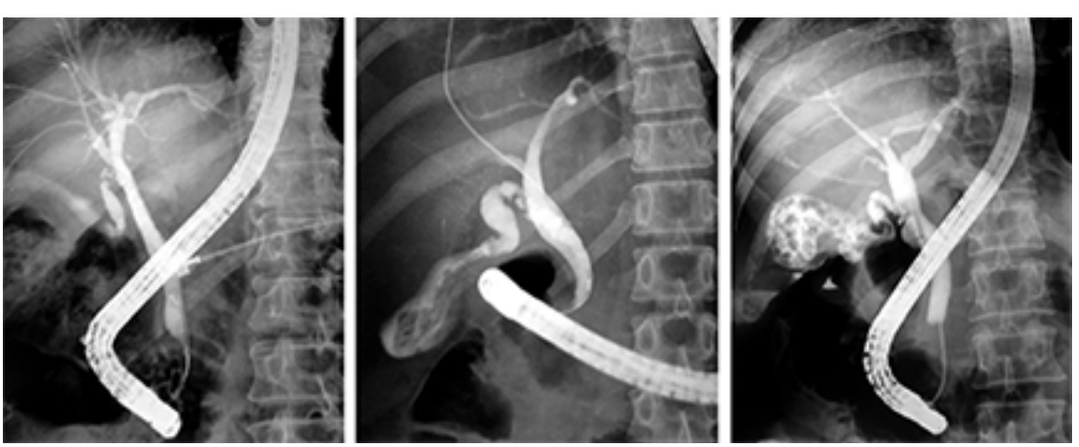


Fig. 22-83: Endoscopic retrograde cholangiopancreatography (ERCP).

duct and dye is injected. *Under C-ARM image-intensifier*, any block or stricture can be identified and completion of the procedure can be confirmed. ***Complications:*** Infection; bile leak. ***Precaution:*** Air should not be present in the syringe, as it may mimic stones **(Fig. 22-84)**.

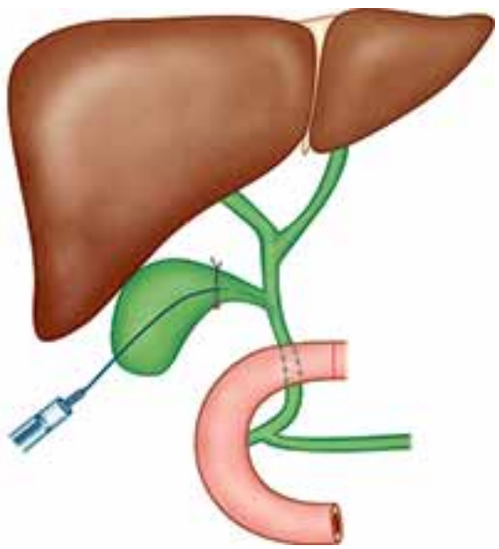


Fig. 22-84: Preoperative cholangiogram. Fine catheter is passed through cystic duct into the CBD. Care should be taken to avoid air getting into the CBD (it will mimic stone). Dye is injected under C-ARM guidance.

Post-operative T-tube cholangiogram: After choledochotomy, *Kehr's T-tube* is *placed in CBD for 14 days* and then water soluble dye is injected into the tube and X-ray is taken. Complete free flow of dye into the duodenum indicates that there is no blockage. T-tube can then be removed safely. Block indicates residual CBD stones. **Residual CBD stones are removed by:** Dormia basket; Fogarty's catheter; Choledochoscope; ERCP.

Biliary scintigraphy: Technetium 99m labeled iminodiacetic acid is (HIDA/PIPIDA) injected IV; it is secreted in bile to give functional nature. It is used in neonatal jaundice, biliary fistulas, acute cholecystitis. It assesses the patency of bile flow like in biliary enteric anastomosis.

Celiac and superior mesenteric angiography: It is useful in bleeding varices in cirrhosis. It is done prior to porta systemic shunt surgery; therapeutic vasopressin injection; diagnosis of hemobilia; during selective embolisation in haemobilia and hepatic artery pseudoaneurysm (postoperative). It can access the resectability of biliary cholangiocarcinomas. It also detects the vascularity and encasement of the major vessels like mesenteric vein and portal vein.

Endoscopic ultrasound (EUS): It detects tumour, its infiltration, lymph node status. Normal lymph node is hyperechoic and indistinct; metastatic lymph nodes are hypoechoic and well-defined. Needle aspiration cytology of lymph node can be done through the EUS.

Laparoscopy

Laparoscopy and laparoscopic ultrasound is very useful in staging the cancer on table and determine the encasement, operability, vessel invasion, peritoneal deposits.

Risk Factors in Obstructive Jaundice

Age >60 years; temperature; haematocrit <30%; leukocytosis; hypoalbuminaemia; raised serum bilirubin, alkaline phosphatase, blood urea nitrogen, serum creatinine, malignant obstruction. Sepsis, renal status, nutrition are most important factors.

Little's mortality index

Mortality score = (0.0016 × serum creatinine in μ mol/L) – (0.0227 × albumin g/L) + (0.0641 × cholangitis score) + 0.6935.

Cholangitis score: 0 – afebrile; 1 – temperature < 37.5°C; 2- > 37.5°C without rigors; 3 - > 37.5°C with rigors and right upper quadrant pain; 4 – fever with shock and or mental changes.

Note: An index of 0.5 or more is associated with high risk for death

PREOPERATIVE PREPARATION

Preoperative hyperalimentation is required if serum albumin is less than 3 gram%; 20% of weight loss; serum transferrin level less than 200 mg%. Adequate hydration either orally or intravenously using normal saline is a must.

Prolonged prothrombin time is common; it is corrected by injecting vitamin K 10 mg IV or IM once a day daily for 5 days; prothrombin time is repeated after 5 days; often fresh frozen plasma is needed to correct the prothrombin time. Platelet infusion is also required often if DIC is anticipated. Epsilon Amino Caproic Acid (EACA) may be useful with shortened clot lysis time and hypofibrinogenaemia.

Renal function should be maintained properly in obstructive jaundice patients by adequate hydration; mannitol therapy; oral bile salts may reduce endotoxin absorption from gut and so its toxic effects on kidney.

Sepsis with cholangitis is a real threat in obstructive jaundice. Such patient (toxic cholangitis—with mental changes and hypotension) requires higher generation antibiotics and emergency decompression of biliary system by ERCP and stenting; otherwise it is life-threatening. Normally bile and biliary systems are sterile. Stasis, obstruction, enteric anastomosis, foreign body precipitates biliary sepsis. *E coli*, *Klebsiella*, *Enterococcus* and *Bacteriodes fragilis* are common organisms found in biliary tree with sepsis. Bile culture, ability of antibiotics to excrete in bile, concentrations in liver and blood; toxic effects are the parameters to decide type of antibiotics chosen. Piperacillin and tazobactum is quiet effective. Prophylactic antibiotics should be given if patient is undergoing surgery or ERCP or otherwise.

Preoperative biliary drainage through transhepatic route in obstructive jaundice routinely is not necessary but in selected patients with severe obstructive jaundice, it may be beneficial.

Cardiac and respiratory problems can occur; detailed cardiac and respiratory evaluations are needed with respiratory physiotherapy.

CHOLECYSTECTOMY

In 1743, Jean Louis Petit did first cholecystostomy for gall stones. Until 1882, cholecystostomy was the procedure used to be practiced for gall stones. In 1882, Carl von Langenbeck did first cholecystectomy. In 1985, Prof Erich Muhe of Boblingen from Germany did first laparoscopic cholecystectomy which he presented in congress of

German surgical society. In 1987, Mouret of Lyon, France reported first laparoscopic cholecystectomy. Jacques Perissat (France) presented first paper on laparoscopic cholecystectomy.

Indications

Gallstones—symptomatic; cholecystitis—acute, chronic; acalculous cholecystitis; empyema gallbladder; mucocoele of gallbladder.

Prophylactic cholecystectomy is done in diabetic patients; congenital haemolytic anaemia; patients who has underwent bariatric surgery; while giving intraarterial chemotherapy through hepatic artery.

Approaches

Open method

Different incisions are—Right subcostal incision (Kocher's); Kehr hockey stick modification (medial end is extended upwards towards xiphisternum); upper midline incision; right paramedian; horizontal incision; Mayo-Robson incision. Right subcostal incision is commonly used.

Open approach is done when laparoscopic approach is not possible; or during laparoscopy difficulty arises and so conversion has been done to open method (failed laparoscopy); or if patient is not fit for general anaesthesia or for pneumoperitoneum **(Figs 22-85 and 22-86)**.

Laparoscopic Approach

Laparoscopic cholecystectomy has become standard and ideal **(Fig. 22-87)**.

Preoperative Preparation

Evaluation by liver function tests, prothrombin time, diabetes, ultrasound (CBD should be assessed properly including its diameter); CT scan when needed to assess the biliary tree, pancreas; gastroduodenoscopy if hiatus hernia, oesophageal varices (portal hypertension) is suspected. If CBD stone is present, ERCP and stenting should be done prior to laparoscopic cholecystectomy. If open cholecystectomy is planned then CBD exploration should be planned in these patients. Preoperative antibiotics are also necessary in cholecystectomy. Cardiac and respiratory assessment is required in these patients. Heparin as a prophylaxis for deep vein thrombosis may be a need.

Fig. 22-85: Gangrene of gallbladder is probably a sure indication of open cholecystectomy. But presently even such gallbladders can be removed laparoscopically by an experienced skilled laparoscopic surgeon only. Learner should convert such gallbladder into open method rather than inviting trouble.

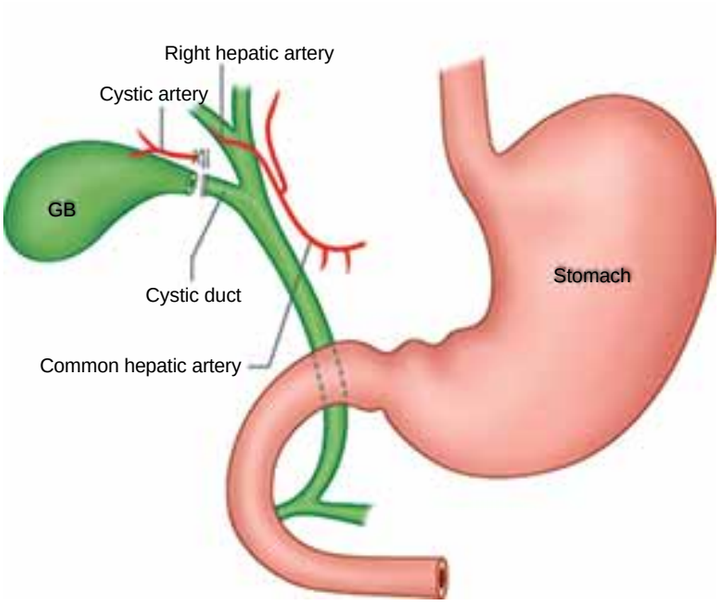


Fig. 22-86: Technique of open cholecystectomy.

TECHNIQUE OF OPEN CHOLECYSTECTOMY

General anaesthesia or epidural anaesthesia is used. Nasogastric tube and urinary catheterisation is passed. Patient is in supine position. C-arm image intensifier/fluoroscopy should be kept in place or cassette changer top should be placed underneath the patient at the level of surgical field. Preoperative antibiotics are given – tazobactum or amoxicillin as common organisms are *Escherichia Coli* and *Streptococcus faecalis*. Heparin should be injected subcutaneously to prevent formation of deep venous thrombosis. Cleaning of entire abdomen is done; draping is done in the incision area. Surgeon stands on the right side; two assistants on left side; during retraction of right costal margin, if needed, one assistant may have to come to right side towards left of the operating surgeon.

Incision: Right subcostal incision is used – 2 cm below the right costal margin. Skin, subcutaneous tissue, external oblique, internal oblique and transverse abdominis muscles are cut (transverse abdominis is often thin and can be split also). Medially rectus sheath is incised up to the midline; a haemostat is passed underneath the rectus muscle and is cut using monopolar cautery. 9th intercostal nerve is divided where it emerges lateral to the rectus muscle border. It causes only slight skin hypoesthesia but not muscle weakness (if possible it can be retained). Vessels underneath should be fulgurated. Rectus muscle after dividing will not retract in upper abdomen due to presence of tendinous intersections. Peritoneum is opened. Peritoneal cavity is explored. Oesophageal hiatus, gallbladder, pancreas, duodenum should also be palpated **(Fig. 22-88)**.

Retraction: Right hand is placed between liver and diaphragm to retract liver downward and allow air to enter above the liver causing

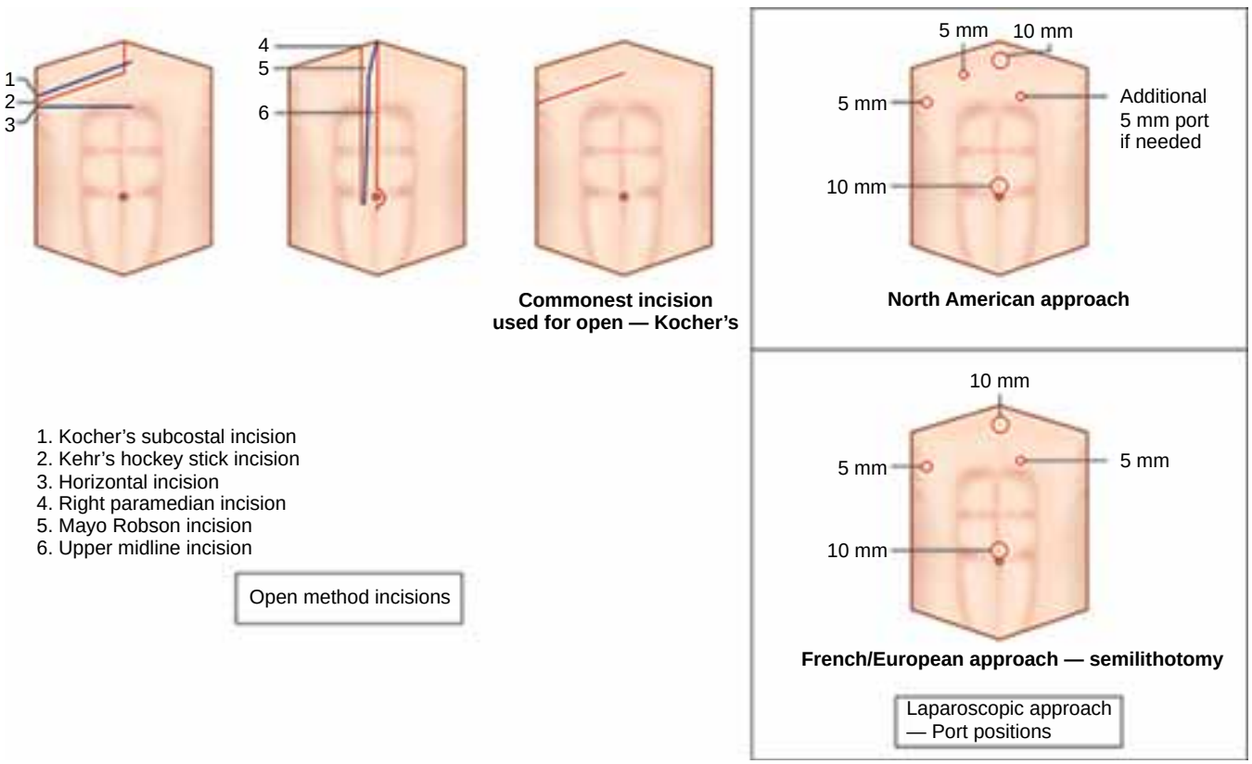


Fig. 22-87: Incisions for open and laparoscopic cholecystectomy.

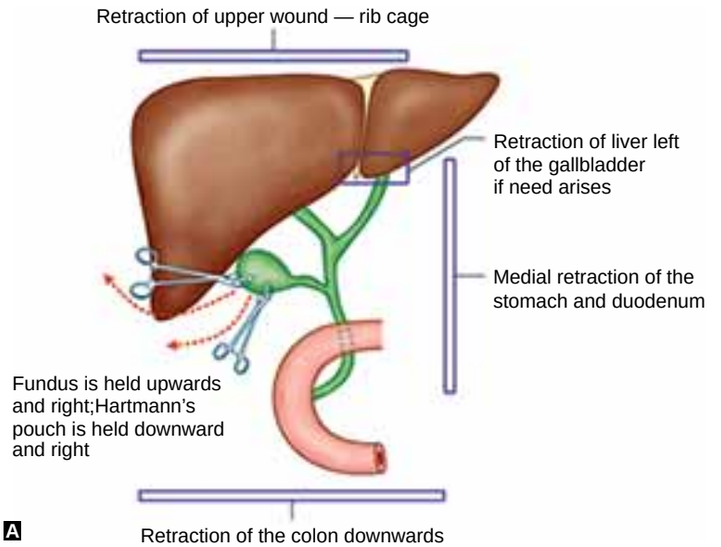
Fig. 22-88: Kocher's right subcostal incision for cholecystectomy.

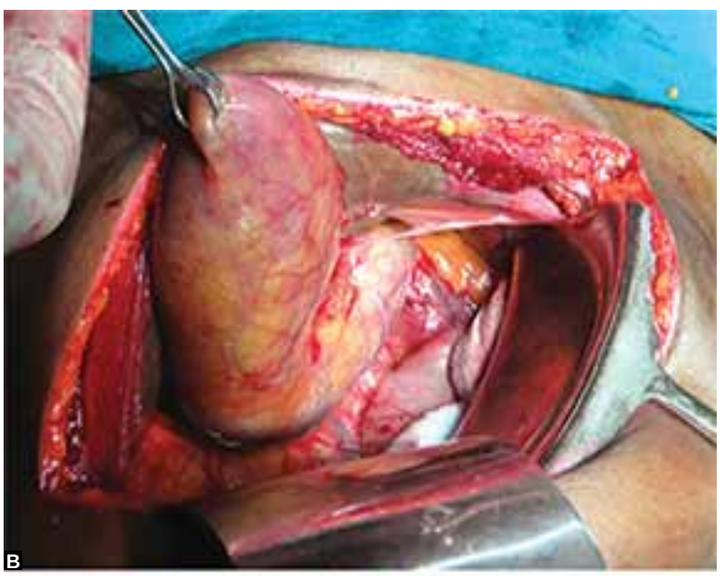
downward displacement of liver to make gallbladder more visible. Often colon and duodenum may be adherent to the gallbladder, they should be dissected by sharp and finger dissection. Colon is pushed downwards; duodenum and stomach medially. Care should be taken not to injure the colon or duodenum. Moist mops are kept on the colon and it is retracted downwards using a Deaver's retractor; another moist mop is kept on the stomach and duodenum and is retracted medially towards left using another Deaver's retractor. Right costal margin is retracted upwards using an abdominal wall Morris retractor with a moist mop underneath. Liver is often retracted upwards from left of the falciform ligament or medial to the gallbladder using another Deaver's retractor **(Fig. 22-89)**.

Often gallbladder is very tense due to mucus or pus or bile which needs aspiration so that gallbladder is made easier to hold and handle **(Fig. 22-90)**.

Two Methods Used for Cholecystectomy

Duct—first method (Calot's first method): Here *Calot's triangle* is dissected. Cystic artery is identified and ligated. Cystic duct is ligated close to the gallbladder. Gallbladder is separated from gallbladder fossa and removed. Haemostasis is maintained. Usually Calot's first method is used.


Retraction of upper wound — rib cage
Retraction of liver left of the gallbladder if need arises
Medial retraction of the stomach and duodenum
Fundus is held upwards and right;Hartmann's pouch is held downward and right
Retraction of the colon downwards
A



Figs 22-89A to C: (A) Method of retraction in open cholecystectomy and CBD exploration—below to the colon; (B) Medially to stomach and duodenum; (C) Above towards left of gallbladder on liver.

Fig. 22-90: Aspiration of the gallbladder is done if gallbladder is tense.

Fundus—first method: It is done in difficult gallbladder due to dense adhesions. Fundus is separated from the liver bed. Dissection is carried proximally until cystic duct and cystic artery are identified, which are then ligated.

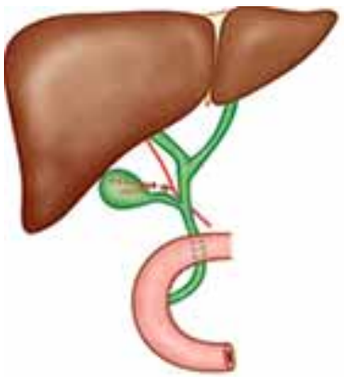
Calot's First (Conventional; Below Upward) Method

Fundus of the gallbladder is held with Babcock's or sponge holding forceps or gallbladder holding forceps. Traction is given to fundus upwards and towards right (outwards). Hartmann's pouch is held with another Babcock's or sponge holding forceps and traction is given downwards and outwards.

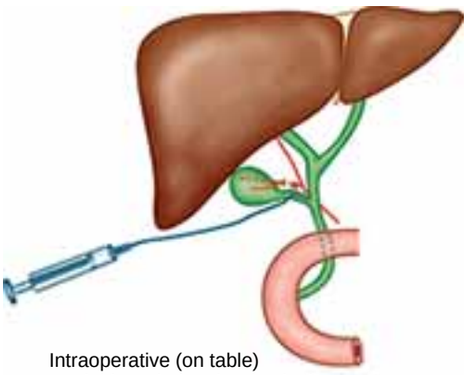
In the Calot's triangle, peritoneum is incised using long curved scissor to expose the cystic duct and artery. With fine dissection using peanut (pledget in haemostat), haemostat and right angle clamp Calot's triangle is dissected to identify the cystic artery, cystic duct, and junction where cystic duct joining the common bile duct. Cystic duct lymph node of Lund will be seen in Calot's triangle lying on the top of cystic artery.

Two silk or vicryl ligatures are passed around the cystic duct. Any stones in the cystic duct are felt and milked proximally into the gallbladder. Entire length of the cystic duct is dissected using sharp and finger dissection. Ligature close to the Hartmann's pouch is ligated (**Fig. 22-91**).

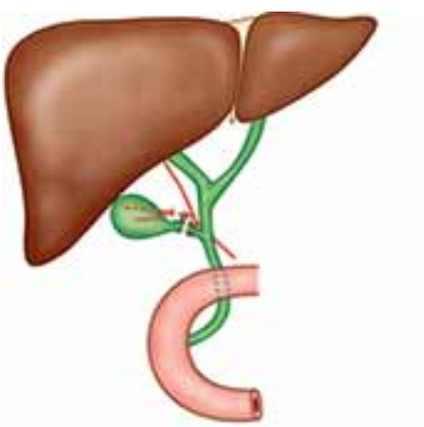
Technique of cystic duct cholangiography—Distal ligature is not ligated instead is held apart with stretching. Cystic duct is incised near its beginning close to the gallbladder just distal to the tied ligature. A fine plastic tube (or infant feeding tube no 5-8 or ureteric catheter) or



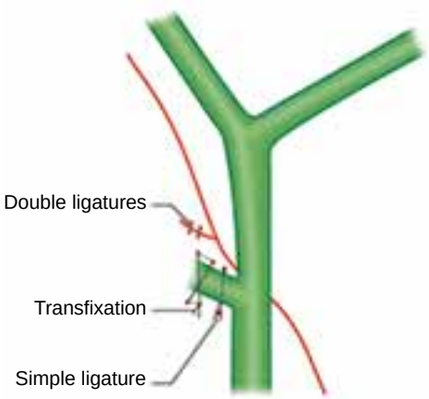
Cystic artery and duct are dissected meticulously. Anomalies should be kept in mind. Cystohepatic junction should be identified. Cystic artery is ligated first (proximally double)



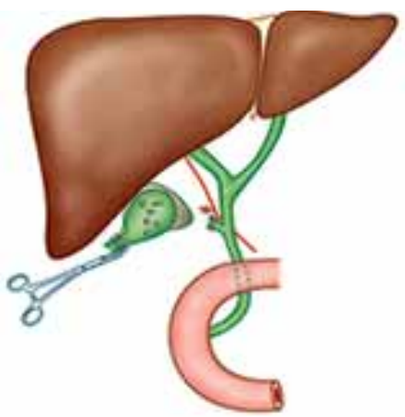
Intraoperative (on table)
cystic duct cholangiogram is done
– Avoid air bubble
– 1:1 sodium diatrizoate with warm saline 50 ml
– Avoid concentrated dye
– Assure that entire biliary tree is filled with dye
– If sphincter spasm is present NTG or glucagon can be injected



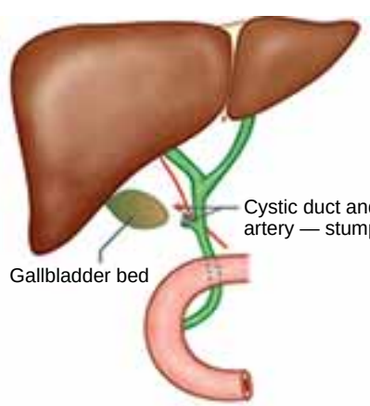
Cystic duct is doubly ligated. Care should be taken to avoid inadvertent placing of the ligature on to the CBD due to traction or kink



Both cystic artery and cystic duct are doubly ligated
– Cystic duct is often transfixed towards stump side; proximally simple ligature is applied



Neck of the gallbladder is held laterally
Gallbladder is dissected off from the liver bed using cautery, scissor and finger dissection
One should avoid opening the liver parenchyma
Bipolar cautery may be used



Gallbladder bed after removal of gallbladder is inspected for bleeding; small bleeders are fulgurated; often surgical, if needed, may be placed on the bed. Safety of CBD is again confirmed. Mops are removed with proper count. Tube drain may be placed if indicated. Wound closed in layers using no. 1 vicryl

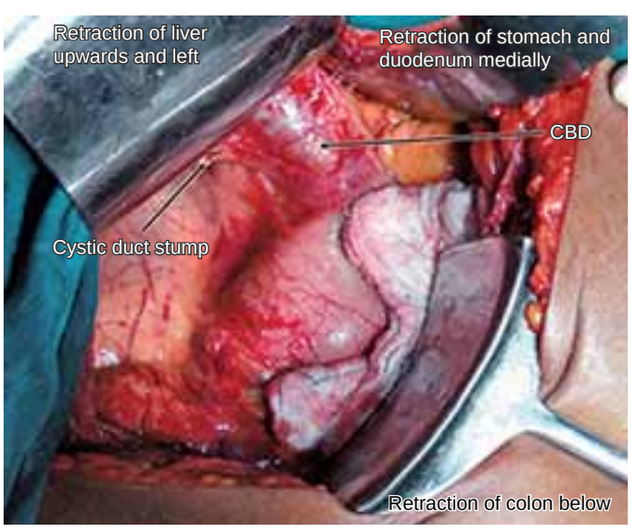

Retraction of liver upwards and left
Retraction of stomach and duodenum medially
CBD
Cystic duct stump
Retraction of colon below

Fig. 22-91: Calot's first method of open cholecystectomy.

cholangiogram catheter (which has got a bead at the tip) of 2 meter length with 50 mL syringe filled with dilute sodium diatrizoate (1:1 with normal saline; 25 mL saline + 25 mL dye). Entire syringe and plastic tube should be devoid of air bubble—very important. Plastic tube negotiated across the cystic duct for 5 mm close to bile duct. Narrow lumen or valve of Heister in the cystic duct may cause difficulty in negotiating the tube. Distal ligature is tied on the catheter with cystic duct. Bile should not be aspirated into the tube to prevent air bubble formation; if surgeon wants to confirm that tip is inside the lumen gently small quantity can be aspirated with care. Left side of the theatre table is tilted upwards for 10 cm to avoid superimposition of the bile duct image with vertebrae. If C-arm is available, dye is injected and under fluoroscopy guidance; bile duct is visualised and also flow into the duodenum. A radiolucent area is identified as common bile duct stone. Often dye will not enter the duodenum due to sphincter spasm; in such situations small dose of nitroglycerin or 1 mg of glucagon intravenously will relieve the spasm to allow the dye to pass into the duodenum. Even with this, dye has not entered the duodenum, then bile duct exploration is indicated. *Findings* to be observed in the cholangiogram are—diameter of the bile duct, any radiolucent area in the biliary tree, status of hepatic ducts, smooth tapering at ampulla of Vater and free flow of dye into the duodenum. Cystic duct cholangiogram ensures and confirms ductal anatomy, may aid in limiting the ductal injury (even though it may not prevent) and decides need for common bile duct exploration.

If C-arm image intensifier is not available, initially 4 mL of dye is injected to take first X-ray film; 2nd X-ray film is taken after injecting remaining part of the dye.

Intraoperative cholangiogram

- Cystic duct cholangiogram—commonly used
  - Real time fluoroscopy—ideal
  - Static film technique—two films should be taken
  - Needle technique in laparoscopic cholecystectomy percutaneous needle is used
- Gallbladder cholangiography
- Infundibular approach (Kumar's)

Precautions while doing cystic duct cholangiography are—avoiding injecting more quantity and more concentrated contrast material as this will cause missing of small calculi and duodenum will be flooded with dye; air bubble should be avoided compulsorily; entire biliary system should be visualised including hepatic ducts; correction of sphincter spasm by drugs while doing the study if needed.

Cystic artery is doubly ligated using silk and divided. Usually cystic artery is above the level of cystic duct and in slight posterior plane than the cystic duct. Cystic artery is in close proximity to liver. Cystic artery should be adequately dissected for about 1 cm using right-angled Mixter instrument; often its branches may need to be ligated independently. Any variations, if possible, should be kept in mind. In adhesions, dissection of artery may take time; as far as possible artery should be dissected and ligated. Occasionally, in dense adhesions where dissection is not possible, then mass ligation may be done if it seems mandatory; but it carries higher chance of ligating or injuring right hepatic artery or hepatic duct. While dissecting the cystic artery, artery may get torn inadvertently; then blind clamping the area with haemostat should be avoided; instead a mop is kept in the place with pressure and after proper retraction and lighting, mop is gently removed to identify the bleeding proximal end of cystic artery which is held with right angle and carefully ligated. Often in such situation, bipolar cautery fulguration helps in controlling the bleeding. If identification of cut end of cystic artery is still difficult, the incision should be extended medially or upward medially towards xiphisternum to get adequate exposure. Too large a cystic artery, if present, it is unlikely to be; rather it could be right hepatic artery (3 mm or more in diameter). *Cystic artery should be ligated first* to allow subsequent Calot's dissection easier; to make cystic duct straight by eliminating the convolutions; to avoid its tearing due to traction on the gallbladder. Accessory cystic artery may be present in anomalous position.

Bile duct should not be extensively dissected unnecessarily; but cystohepatic junction should be delineated properly. Monopolar cautery should be avoided close to bile duct; bipolar cautery is suitable.

Once bile duct exploration is not under strategy, then *cystic duct is doubly ligated* proximally after removing cholangiogram catheter. Simple ligature is placed using vicryl or silk close to cystohepatic junction; just distal to its transfixation suture is placed. Cystic duct is divided. It is *ideal* to place ligatures and then divide the cystic duct rather than clamping, dividing and then ligating the duct. Many feel that cystic duct ligation is done only after complete mobilisation of the gallbladder from liver bed. However, if dissection is adequate in Calot's and assured then cystic duct can be ligated safely prior to dissection of gallbladder from liver bed.

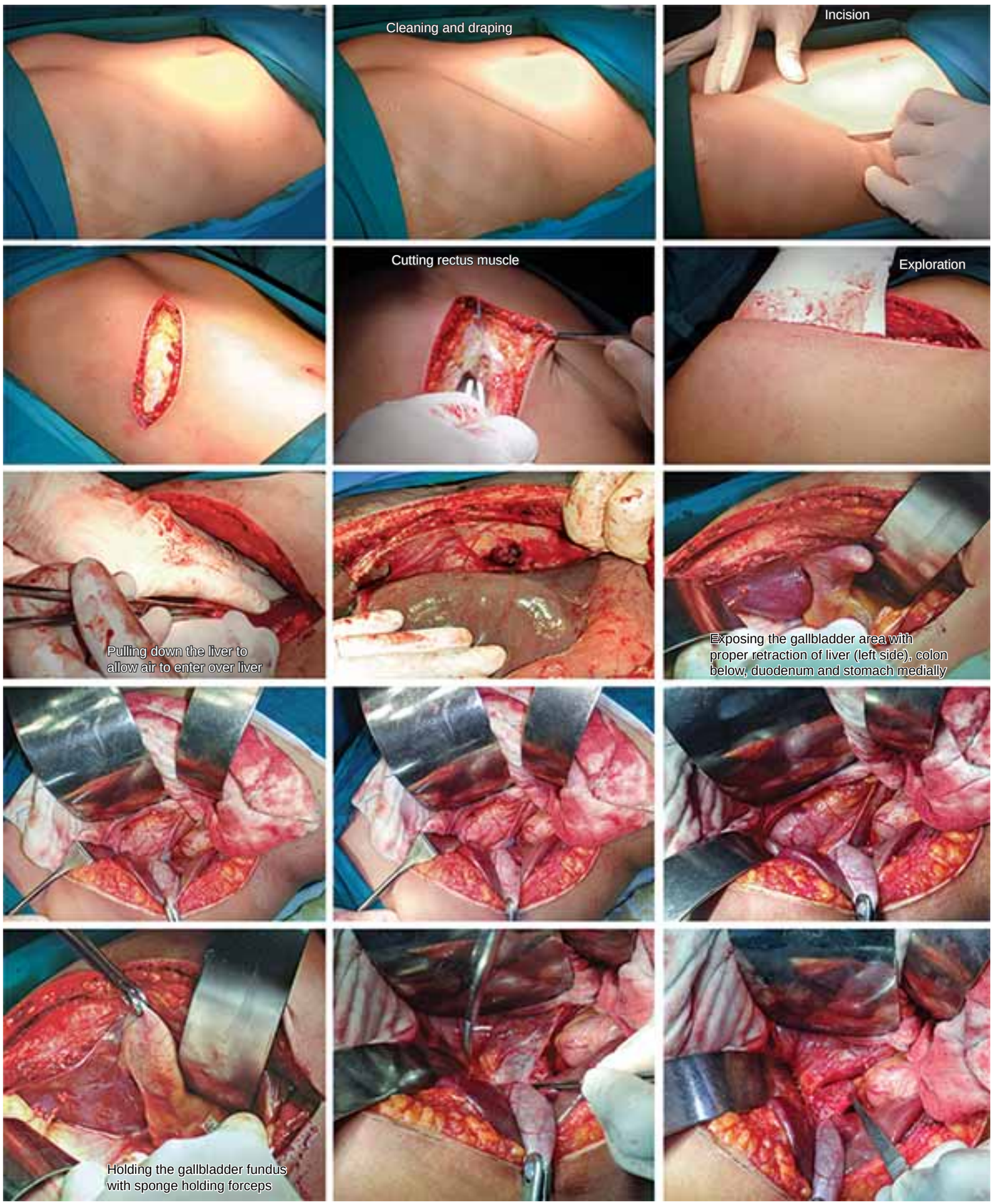
Dissection of the gallbladder from the liver bed: Usually it is easier to dissect the gallbladder from the liver by giving traction to fundus and Hartmann's pouch. Cystic duct stump is held with a haemostat to give outward traction to make peritoneal fold between gallbladder and liver stretched and fold is incised to proceed with the dissection. Dissection should be close to the gallbladder wall without injuring the liver tissue. Dissection begins from Calot's area towards fundus. Dissection is done using scissor or monopolar cautery or using peanut. Plane of dissection is deep to mucosa of the gallbladder. All small bleeders from the liver surface should be fulgurated. Care is taken to look for direct entry of accessory duct from liver to gallbladder; if present, should be ligated securely to prevent bile leak. After removal of gallbladder, mop is kept in place for few minutes. Often gelfoam or surgical may be kept to prevent oozing from the liver bed. Occasionally *under running of the bleeding point* using 4-0 vicryl may be useful. Catching with a haemostat and ligating should not be attempted in liver bed.

Complete haemostasis is achieved. Common bile duct is again palpated for confirmation that stones not missed. It is done by palpating supraduodenal portion of the common bile duct and also pancreatic portion by placing fingers behind the second part of the duodenum. Mops are removed; counts should be checked **(Figs 22-92 and 22-93)**.

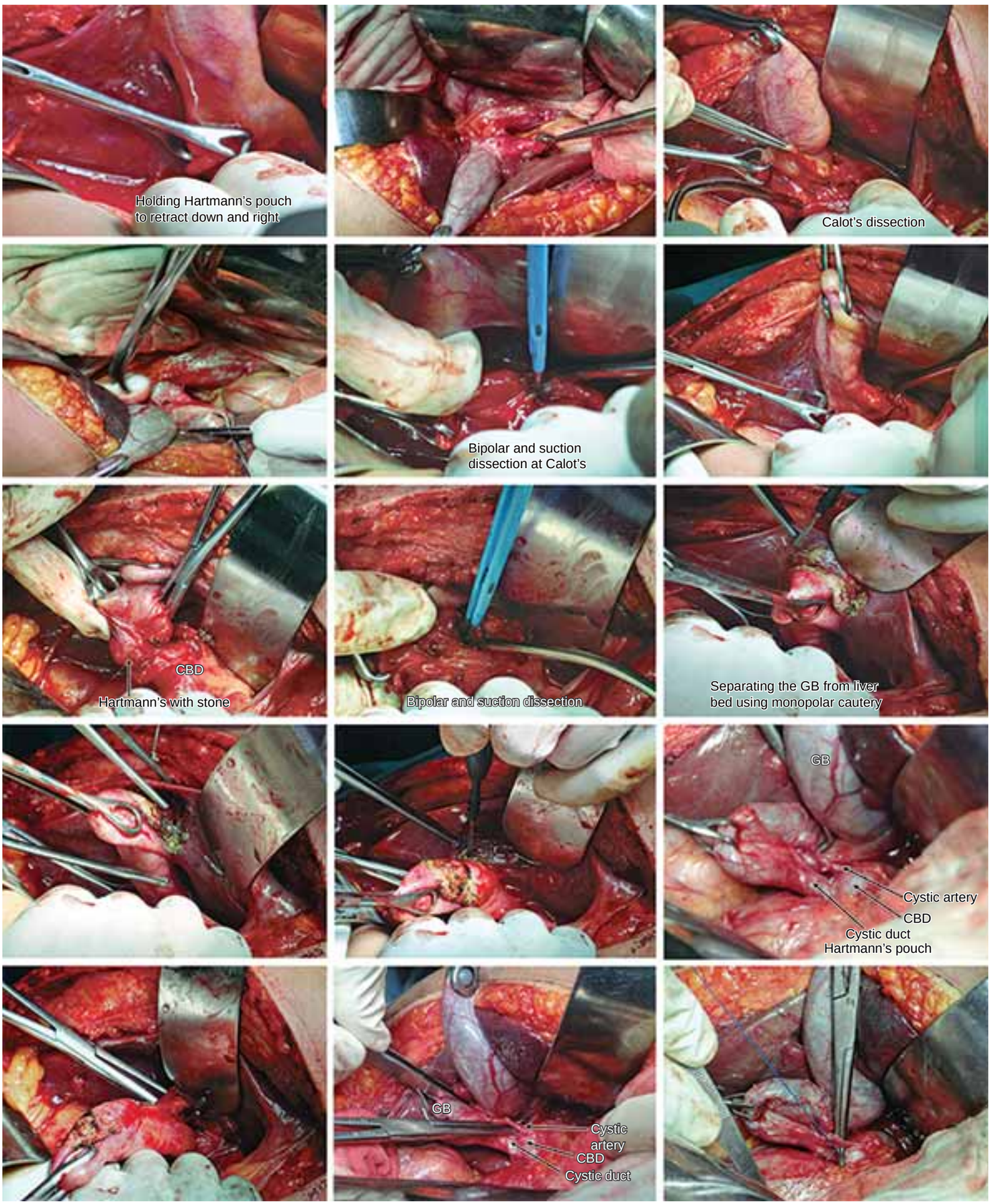
Tube or Jackson Pratt closed suction drain is placed when there is acute cholecystitis or in difficult gallbladder surgery. Abdominal wall is closed as single or two layers using vicryl. Skin can be approximated using stapler or nylon.

Fundus First Method (Above Downward)

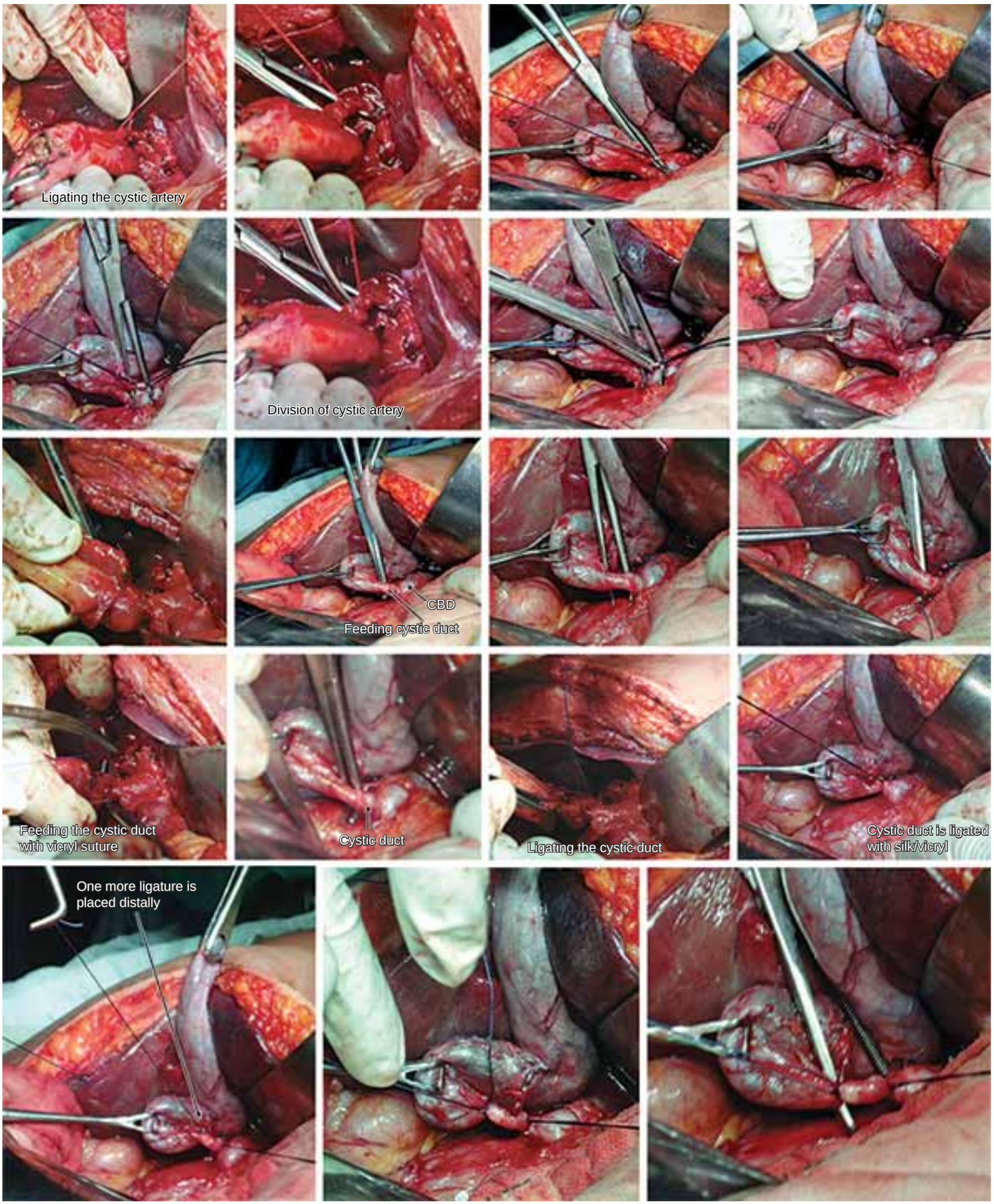
Here after opening the abdomen and exposure with proper retraction instead of dissecting the Calot's, fundus of the gallbladder is held with sponge holding forceps. Using sharp scissor or monopolar cautery, fundus and body of gallbladder is dissected from its liver bed from fundus, to begin with, towards neck and Calot's triangle. Blunt dissection using peanut or suction apparatus is very useful. One should avoid entering the parenchyma of liver. It is done in difficult cases wherein Calot's is difficult to dissect to begin with. Fundus first method


Cleaning and draping
Incision
Cutting rectus muscle
Exploration
Pulling down the liver to allow air to enter over liver
Exposing the gallbladder area with proper retraction of liver (left side), colon below, duodenum and stomach medially
Holding the gallbladder fundus with sponge holding forceps

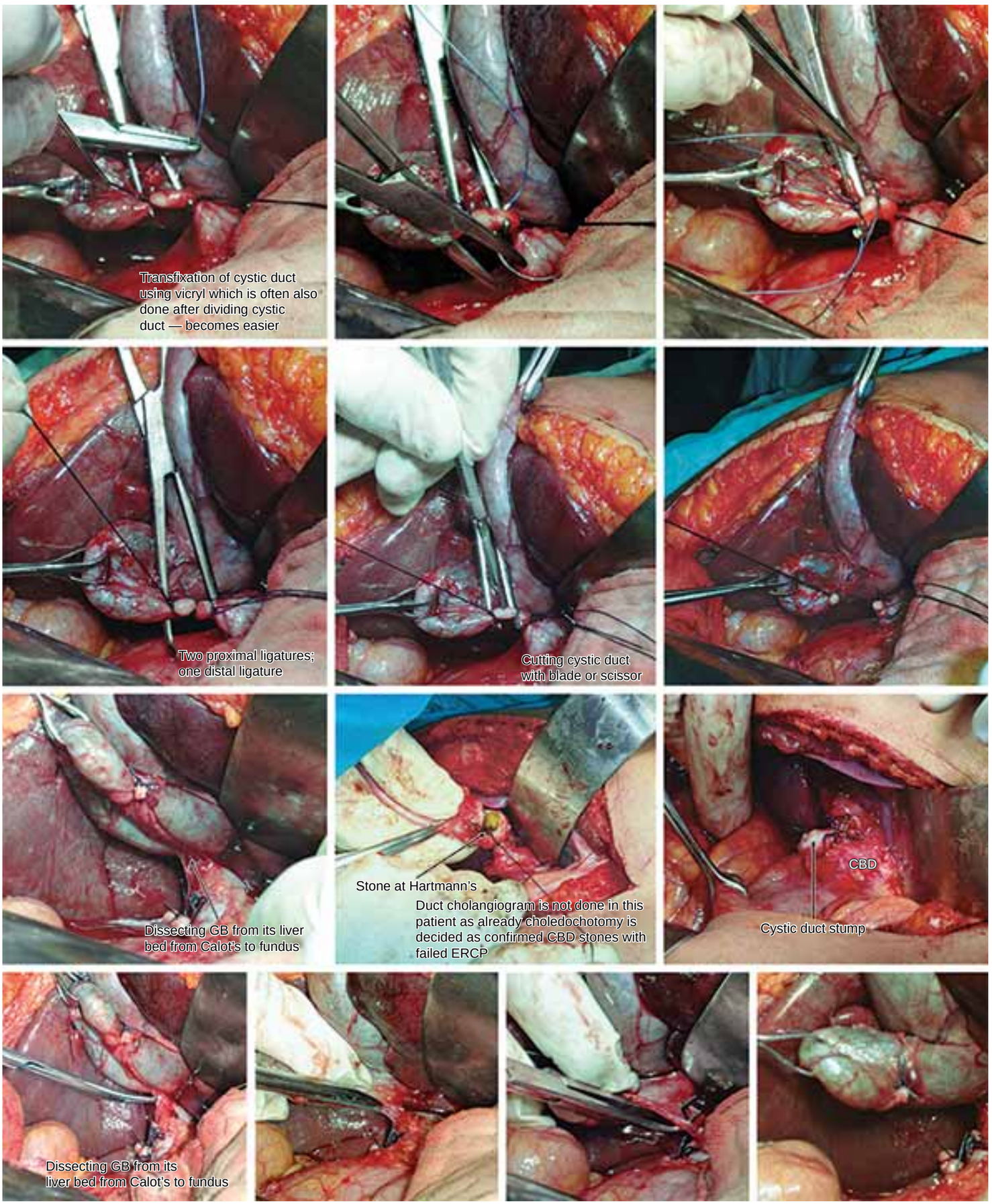
Figs 22-92(1)


Holding Hartmann's pouch to retract down and right
Calot's dissection
Bipolar and suction dissection at Calot's
CBD
Hartmann's with stone
Bipolar and suction dissection
Separating the GB from liver bed using monopolar cautery
GB
Cystic artery
CBD
Cystic duct
Hartmann's pouch
GB
Cystic artery
CBD
Cystic duct

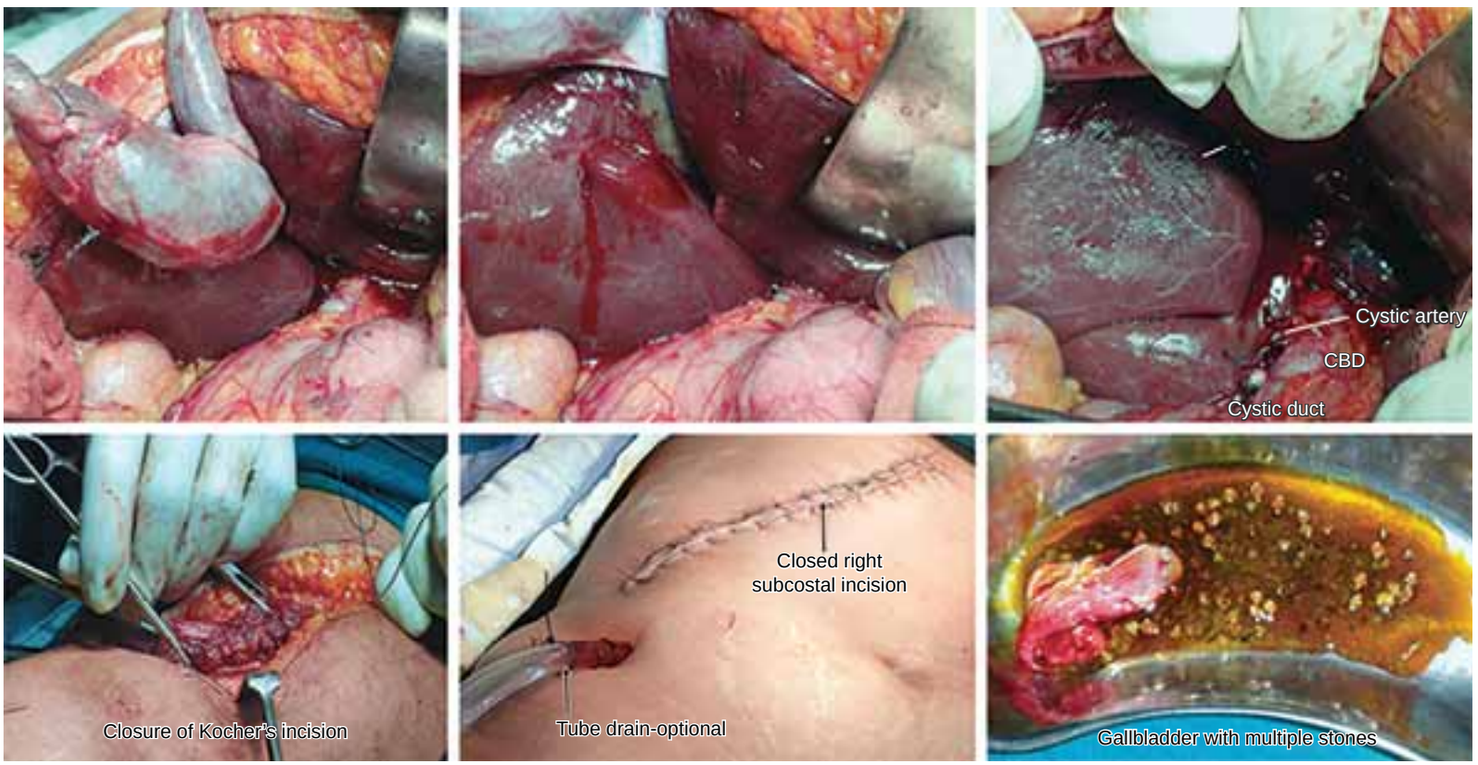
Figs 22-92(2)


Ligating the cystic artery
Division of cystic artery
CBD
Feeding cystic duct
Feeding the cystic duct with vicryl suture
Cystic duct
Ligating the cystic duct
Cystic duct is ligated with silk/vicryl
One more ligature is placed distally

Figs 22-92(3)


Transfixation of cystic duct using vicryl which is often also done after dividing cystic duct — becomes easier
Two proximal ligatures; one distal ligature
Cutting cystic duct with blade or scissor
Dissecting GB from its liver bed from Calot's to fundus
Stone at Hartmann's
Duct cholangiogram is not done in this patient as already choledochotomy is decided as confirmed CBD stones with failed ERCP
CBD
Cystic duct stump
Dissecting GB from its liver bed from Calot's to fundus

Figs 22-92(4)



Figs 22-92(5)

Figs 22-92(1 to 5): Open cholecystectomy—steps. In one patient after difficult Calot's dissection, gallbladder is separated from liver bed from fundus towards Calot's then cystic duct is ligated. In another patient, Calot's is addressed with ligation of cystic artery and duct, and gallbladder is separated from Calot's towards fundus (from its liver bed).

ensures that common bile duct and hepatic ducts will not be injured. But oozing from the liver bed makes further dissection cumbersome. Once Calot's is reached, cystic artery is ligated and divided. Cystic duct is ligated doubly after doing cystic duct cholangiography by similar method.

Postoperative Care

Nasogastric tube is removed within 24 hours unless there is paralytic ileus. In infected gallbladder, antibiotics are continued. Drain when kept is removed in 4 days.

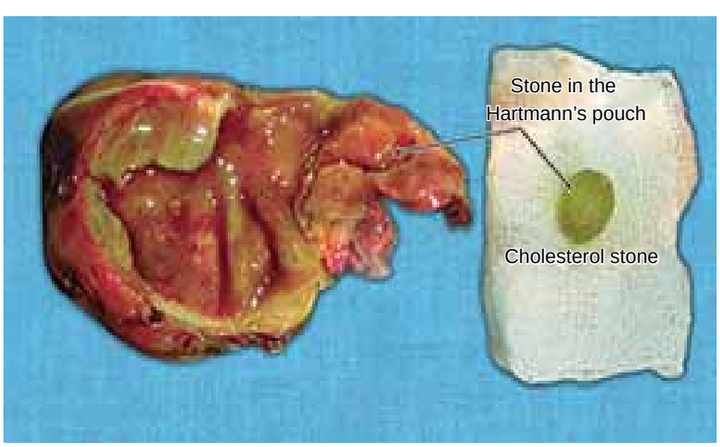


Fig. 22-93: Specimen of gallbladder with cholesterol stone.

Precautions

Size of the common bile duct should not be overestimated; often it is small enough to mimic the cystic duct and inadvertent ligation by mistake is known to occur. Kinking at cystohepatic junction due to traction can cause clamping the junction with bile duct partially and completely.

Anomalies of cystic duct (short or long; may enter right hepatic duct), of right hepatic duct; presence of accessory ducts should be remembered.

Cystic artery while ligating care should be taken of variations of right hepatic artery and chances of ligating the right hepatic artery. Any artery if more than 3 mm in size, one should suspect it as right hepatic artery.

Cystohepatic junction should be identified and dissected prior to ligation of the cystic duct. Caterpillar hump of right hepatic artery is known to exist and easily gets injured while dissecting.

Dissection of gallbladder from liver bed often may be troublesome and is also should be meticulous. It is often observed that surgeon relaxes while dissecting the gallbladder from its bed once Calot's is addressed properly.

Blind clamping and ligation should not be undertaken.

If needed, incision should be *extended* accordingly.

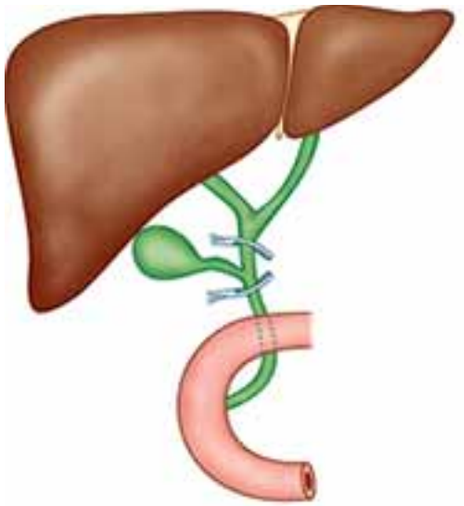
Cystic duct cholangiogram ideally should be done in all cases even though it is not practiced by many surgeons routinely.

Cholecystitis in pregnancy: Ideally if possible cholecystectomy should be postponed and is done 3 months after delivery. If there is secondary choledocholithiasis or if it becomes inevitable then ideal

timing to do surgery is 2nd trimester. Cholecystectomy is safer. But if bile duct exploration is needed cholangiogram whether to be done or not is a debate. It is said that X-ray is safer after 1st trimester. Even then uterus shield should be used if cholangiogram is done. Bile duct stone after choledochotomy can be removed using choledochoscope. CT imaging should be avoided in pregnancy. Ultrasound is the main imaging modality in pregnancy. MRI is safer. Laparoscopic cholecystectomy is becoming an accepted method in 2nd trimester but needs expertise; open trocar placement; low pressure surgery and keeping PCO_2 less than 40 mm Hg are the essential measures to be taken. Fetal monitoring during surgery, obstetrician help and follow up fetal monitor in immediate post-operative period is needed.

Cholecystectomy in cirrhotic patients: In cirrhotics, selection of the patient is important. Liver will be nodular. All adhesions are vascular and often bleed profusely. Dissection of the gallbladder from the liver bed may create technical problems. Preoperative preparation should be adequate like—injection vitamin K; fresh frozen plasma transfusion, platelet transfusions, antibiotic therapy. Even then *laparoscopic cholecystectomy is better than open approach in cirrhotics.* Fundus first method should be used in cirrhotics; harmonic scalpel or other energy sources should be used. Doing partial cholecystectomy by ligating at the of Hartmann's pouch is much safer than dissecting Calot's. Often conversion is needed; still often limiting the procedure towards cholecystostomy may be a compulsion due to technical hurdles. In cirrhotics, one should avoid placing T tube as localisation and track formation is poorer and chances of biliary peritonitis are higher. If at all. T-tube is placed then critical postoperative care is needed. T tube should be removed only after 4 weeks. Profuse bleeding from the liver bed in cirrhotics is a real matter of concern. Often it is difficult to achieve adequate required haemostasis and keeping a pack/mop in the bed to achieve compression for 24-48 hours is the only choice; such packs should be removed in 48 hours under anaesthesia gently with all precautions. Posterior part of the gallbladder can be left alone like that removing only remaining parts. Mucosa of such left out difficult gallbladder is ablated using ideally argon laser or bipolar cautery. Opening of the cystic duct is invaginated using absorbable 3-0 suture material like vicryl.

In patients with coagulative disorders, cholecystectomy should be done by keeping ready adequate number of units of frozen plasma or platelets or factor VIII depends on the type of coagulopathy patient harbours.



Inadvertent clamping of the bile duct below and hepatic duct above during cystic duct ligation is possible

Fig. 22-94: Injury to bile duct can occur if inadvertent clamping has occurred.

Fig. 22-95: Bile leak after open cholecystectomy.

Complications

Injury to colon, duodenum and mesentery can occur whenever there are adhesions.

Bile leak: It is the most distressing complication surgeon faces. Small bile leak through the drain is probably due to either cystic duct stump disruption or accessory duct leak. Usually it is 100-200 mL/day. It usually subsides in 7-10 days. If leak persists ERCP and stenting is needed; it also identifies the bile duct and hepatic duct status. If bile leak is more than 400 mL/day it means probably it is bile duct or hepatic duct injury. It needs proper evaluation with CT scan/MRCP. It is addressed only at a later period once inflammation subsides after 3 months. Nutrition during this period should be maintained adequately. It needs expertise work and needed proper identification, dissection of biliary tree and hepaticojejunostomy **(Figs 22-94 and 22-95)**.

Post-cholecystectomy jaundice may be due to cholangitis, missed bile duct stones, bile duct stricture due to trauma or ligation of bile duct or hepatic duct. ERCP, liver function tests proper imaging to identify the problem are needed to plan the eventual surgical correction.

Post-operative bleeding is not common. But can occur if cystic artery ligature is slipped or if there is sepsis at the gallbladder bed. Occasionally it could be due to anomalous right hepatic artery which is injured due to inability to identify the vascular anomaly. Infection may cause hepatic artery pseudoaneurysm which may often be life-threatening. It needs CT angiogram and intervention radiology to address the feeding artery of the pseudoaneurysm by glue or other embolisation devices. However, inadvertent embolisation or gluing of the right hepatic artery may cause acute fulminant hepatic necrosis of the liver and may kill the patient. Hogarth Pringle's manoeuvre is

ideal to control bleeding on table by applying pressure using thumb and fingers over the Foramen Winslow.

Sepsis: Subphrenic, pelvic, hepatic abscess can occur occasionally when there is cholangitis, immunosuppression or if surgery done in a badly infected gallbladder. Blood culture, blood count, clinical assessment is a must. Higher generation antibiotics should be started to prevent them going for septicaemia. Abscess can be addressed usually by image guided catheter drainage or aspiration. Open drainage is needed only rarely.

Biliary stricture can occur as late sequelae after cholecystectomy due to bile duct injury. 80% of biliary strictures are post-operative. After cholecystectomy [open or laparoscopic, more common following laparoscopic (0.8%) than open method (0.35%)]. ***Clinical features are*:** Obstructive jaundice; pain abdomen; features of ascending cholangitis; profuse persistent bile leak.

Waltmann Walter syndrome – It is compression of IVC due to collection of fluid in gallbladder fossa and subphrenic space after cholecystectomy; it mimics coronary artery thrombosis.

Bismuth classification of biliary stricture (Fig. 22-96)

I. Low CBD stricture with stump (proximal to stricture) >2 cm
II. Middle CBD stricture with proximal stump <2 cm
III. Hilar. Confluence of right and left hepatic ducts is intact
IV. Separated right and left hepatic ducts
V. Stricture involving intrahepatic ducts

Causes of post-operative stricture

- Too much traction to the GB during ' Fundus first cholecystectomy'
- Blind application of artery forceps in Calot's to control bleeding
- Anomalies of biliary tree
- Inflammatory adhesions at Calot's triangle
- Injury during other surgery like gastrectomy

Management

LFT, prothrombin time, ERCP, CT, MRCP; choledochoduodenostomy or choledochojejunostomy.

Minilaparotomy Cholecystectomy

Here incision of 5 cm length is made lateral to the right rectus in subcostal region. It is done in olden days in thin individuals where

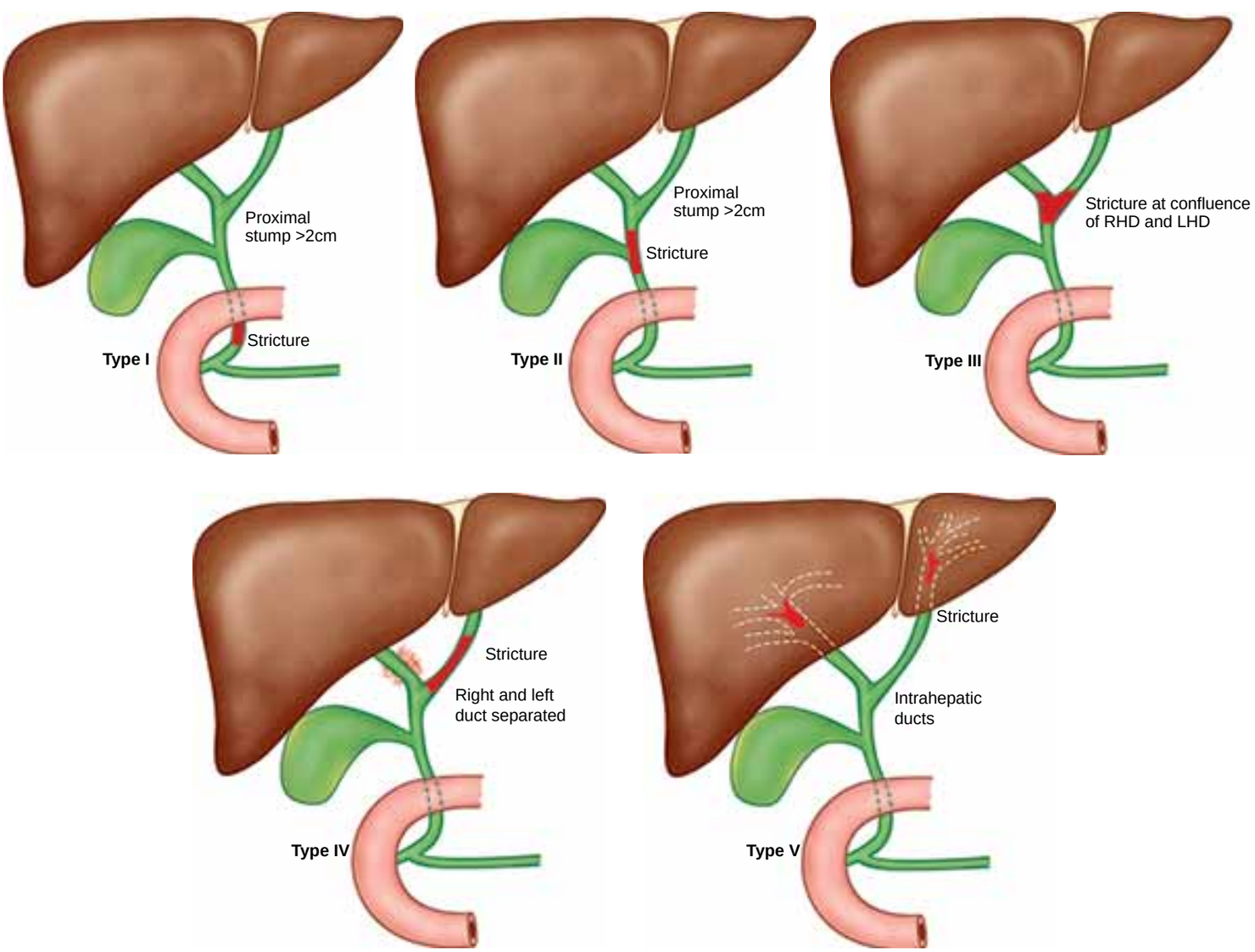


Fig. 22-96: Bismuth classification of biliary stricture.

easy retraction makes Calot's dissection possible. In present era of laparoscopic surgery, minilaparotomy cholecystectomy or any other surgeries should not be done. When open surgery is done, adequate incision with adequate exposure of the dissecting surgical field should be the approach. Hence minilaparotomy has become a surgical legacy.

Partial Cholecystectomy

It is done in severely adherent Calot's triangle difficult for dissections and biliary tree cannot be delineated. It is also useful in cirrhosis with portal hypertension. Here gallbladder is removed distal to the Calot's triangle at Hartmann's pouch level. When there is dense adhesion in the Calot's and dissection is impossible, it is better to do partial cholecystectomy than injuring the bile duct or hepatic artery to lead into dreaded complications. Fundus first dissection is done carefully. When reaching towards the Calot's, care should be taken not to meddle and create complications. Hartmann's pouch is held with Babcock's forceps. Tissue just behind the Hartmann's is ligated and divided. Hartmann's pouch is divided. Gallbladder is removed. Any stones in the Hartmann's are removed; warm saline wash is given. Usually in such situations, cystic duct already sealed without communicating into the bile duct. Mucosa of the retained part of the Hartmann's pouch is fulgurated using bipolar cautery or argon laser. Hartmann's pouch on the cystic duct side is transfixed and ligated using vicryl **(Fig. 22-97)**.

Subtotal cholecystectomy is a similar procedure but it is divided still further away from the Hartmann's pouch at the beginning of the body of the gallbladder. Technically there is hardly any difference.

CHOLECYSTOSTOMY

It is the drainage of the gallbladder exteriorly. It is only a life-saving procedure; not a definitive procedure.

Indications

It is done during process of surgical cholecystitis if cholecystectomy seems not possible with acute cholecystitis or empyema gallbladder or on table anaesthetic problem causes compulsion to terminate the definitive procedure. After cholecystostomy, once patient recovers, definitive procedure of cholecystectomy should be done.

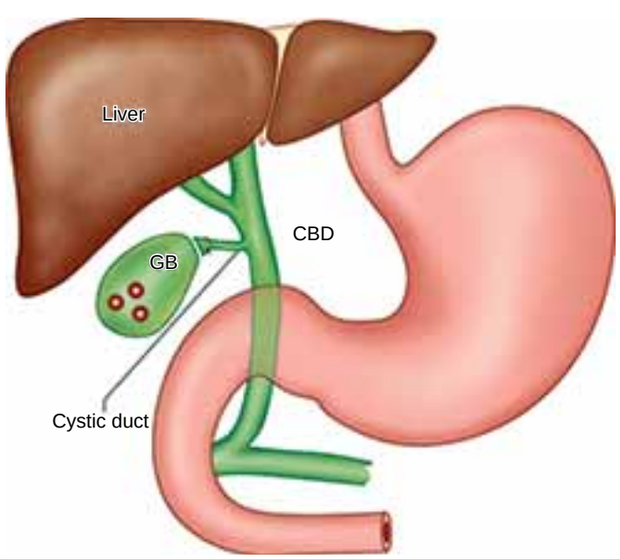


Fig. 22-97: Partial cholecystectomy.

Cholecystostomy is done only in critical ill patients who are on severe sepsis and renal failure **(Fig. 22-98)**.

In olden days, in periampullary carcinoma or carcinoma head of the pancreas with severe obstructive jaundice with bilirubin as high as 30 mg% and general condition is really poor and eventual definitive resectable procedure like Whipple's is feasible, cholecystostomy as initial decompression procedure is done. Nowadays, in carcinoma pancres as if operable, Whipple's operation is done otherwise bypass is done and because of the availability of ERCP, cholecystostomy is rarely done nowadays.

Technique

If cholecystostomy is not decided on table during laparotomy, then right subcostal incision of 5 cm length is made under general or local anaesthesia abdomen is opened; liver is pushed down by placing hand over the liver; gallbladder is identified and felt; it is held with Babcock's forceps. If gallbladder is tense it should be aspirated; otherwise using trocar and cannula contents are decompressed. Fluid should be collected for culture.

Two stay sutures are placed on the fundus of the gallbladder. Gallbladder is incised for about 1 cm in between stay sutures. Contents are aspirated after collecting for culture. All stones are removed using stone removal instruments (Randall stone removal forceps). Warm saline ash is given properly into the gallbladder. Finger is passed into the gallbladder to milk out all stones and contents. Foley's or Malecot's or de Pezzer catheter 22-24 sized is passed into the gallbladder. Purse string suture is passed around the tube by taking bites through the fundus of the gallbladder around the gallbladder. Additional interrupted sutures if needed should be placed. Tube can be brought out through the omentum or omentum may be wrapped around it to reduce the chance of leak. Through a separate stab wound tube is brought out of the abdominal wall. Often tube is also fixed to abdominal wall from inside by placing interrupted sutures between parietal peritoneum and fundus of the gallbladder. Tube is fixed outside using skin suture.

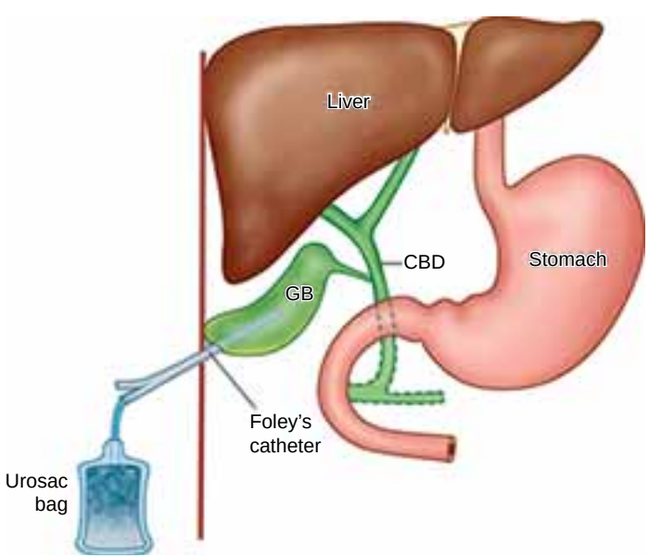


Fig. 22-98: A Foley's or Malecot's catheter is placed in severely ill patients with acute cholecystitis to drain pus initially, and later elective cholecystectomy is done. Procedure is done in elderly, severely ill, empyema GB, emphysematous GB, perforation of GB (cholecystostomy).

Problems

If there is necrosis or gangrene of the gallbladder then cholecystostomy is contraindicated as necrosed part will disrupt and cause biliary peritonitis.

It is totally contraindicated in acute cholangitis where, when there is obstruction ERCP is a must.

Perse cholecystostomy is not done nowadays as in these patients alternatively percutaneous drainage under guidance serves same purpose.

If cystic duct is already blocked by fibrosis cholecystostomy will not function as a bile drainage system. But sepsis will come under control to lead into eventual definitive cholecystectomy.

LAPAROSCOPIC CHOLECYSTECTOMY

Laparoscopic cholecystectomy is the standard technique for removal of gallbladder.

Indications

- Symptomatic gall stone diseases – pain, mucocoele, cholecystitis acute or chronic.
- Acalculous cholecystitis.
- Asymptomatic gall stones—when patient is undergoing bariatric surgery, diabetics, renal transplantation, haemolytic diseases, in children.
- Complications of the gall stones like gall stone ileus, empyema, and perforation also can undergo laparoscopic cholecystectomy; but conversion rate may be more. If during laparoscopic procedure, when dissection becomes difficult surgeon should not be hesitant to convert into open cholecystectomy to avoid serious complications.
- Gall stone dyspepsia where biliary pain is present without the presence of gall stones. Here patient may get relieved of the symptoms by laparoscopic cholecystectomy. Biliary dyskinesia may be an indication.
- Gall bladder polyps—if polyps are multiple, if they are increasing in size, if size is more than 1 cm then laparoscopic cholecystectomy is indicated.

Contraindications

There is a debate about absolute contraindication for laparoscopic cholecystectomy. Patients who are unfit for general anaesthesia are contraindications. In patients with portal hypertension and coagulopathy laparoscopic cholecystectomy still be better than open but adequate precautions should be taken including correction of coagulopathy, need for plasma or platelet transfusions. Proven gallbladder cancer is a sure contraindication for laparoscopic cholecystectomy. Multiple earlier laparotomies, severe dense adhesions in cholecystitis, acute pancreatitis, anomalies in the biliary system, cirrhosis, pregnancy, obesity are the real challenging situations while doing laparoscopic cholecystectomy. Need for a conversion and non-hesitant to convert at right time prior to creation of critical problem are to be kept in mind by surgeons.

Technique

Patient is placed in 15° head up anti-Trendelenburg position with 15° right upward tilt. Probably this is done after insertion of the first camera port in supine position. Nasogastric tube should be passed to decompress the stomach. Urinary catheter is placed otherwise bladder should be emptied before patient is brought into the operation theatre table. It is required in difficult cases or complications are suspected or when prolonged anaesthesia is needed.

After clearing and draping, monitor is kept in the right up facing towards the table; surgeon stands on the left side; camera assistant on the left of the surgeon; scrub nurse on the right side near foot end of the patient. Ideally two monitors on right and left sides should be kept. What is commonly practiced is North American approach with the position explained above. Radiolucent table is essential to do fluoroscopy whenever needed like on table cholangiogram.

Instruments (Fig. 22-99)

1. Veress needle
2. 10 mm port—2 in no.
3. 5 mm port—2 in no.
4. Maryland forceps.
5. Atraumatic (Universal) grasper.
6. Toothed grasper 5 mm.
7. Gallbladder extracting forceps 10 mm.
8. Clip applicator.
9. Suction irrigation.
10. Scissors.
11. Hook/spatula dissector.
12. Endo bag.

Alternatively patient may be kept in semilithotomy position with anti-Trendelenburg tilt; thighs should be kept parallel to ground. Surgeon stands in between legs. Port placements are almost similar but right hand working port is placed in the left hypochondrium to achieve triangulation. This position is called as French or European position.

Camera port (10 mm) is placed at upper umbilical crease line. But it can be placed at changed positions depending on a obesity, previous surgery. Open or closed method can be used. A 10 mm working port is placed in the epigastrium just below the xiphoid process in the subcostal region. After initially puncturing the rectus sheath, it is directed towards right to avoid entering through the falciform ligament. If it passes through the falciform ligament then bleeding may occur as falciform ligament is vascular; falciform ligament may act as a flap to interrupt proper functioning of the port. Third (5 mm) port is placed in the same level at midclavicular line; 4th lateral 5 mm port is placed at anterior axillary or still lateral depending on need.

Abdomen is inspected all round. Gallbladder is identified; presence of adhesions by omentum, colon, stomach and duodenum over the gallbladder is identified. Through lateral 5 mm port toothed instrument is passed and fundus of the gallbladder is held firmly and is pushed upwards towards diaphragm; this allows the opening and visualisation of the Calot's area. If gallbladder is found tense then it is decompressed by aspirating the content using long needle passed directly through abdominal wall into the gallbladder under vision. Fine trocar and cannula also can be used but usually needle aspiration is sufficient.

Release of adhesions is important. Through epigastrium port Maryland instrument is passed using a reducer. Through midclavicular port 5 mm non-toothed atraumatic grasper is passed. Omentum is pulled down from the gallbladder by holding the edge using Maryland very close to the gallbladder. Cautery and blunt traction separates the omentum. Similarly colon, stomach and duodenum are released from the field. Monopolar cautery may injure these structures due to heat generated and so should only be used judiciously. Once adhesions

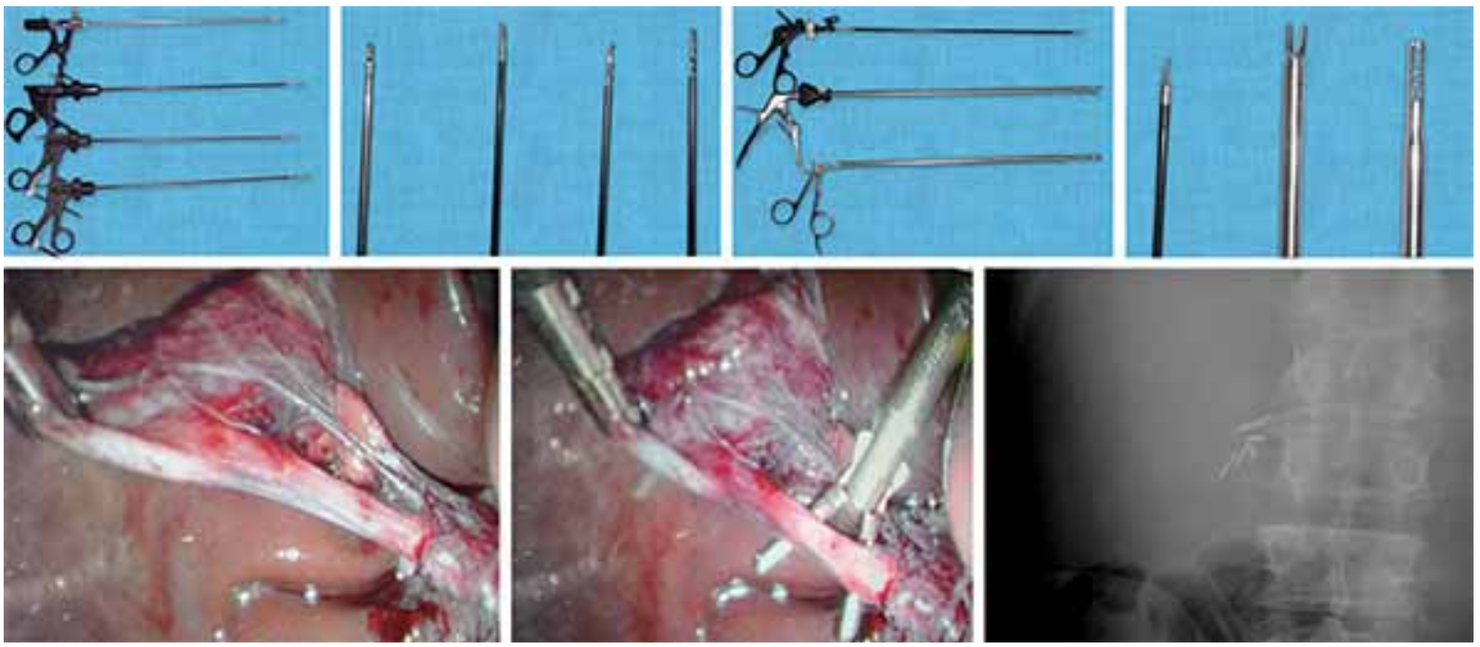


Fig. 22-99: Laparoscopic cholecystectomy instruments and Calot's triangle dissection and X-ray view of the clips placed.

are released, infundibulum is held using the midclavicular port instrument. Infundibulum is held downwards and towards right.

Calot's triangle is dissected using Maryland forceps. In infundibular technique, cystic duct is dissected carefully both in front and behind and traced towards infundibulum to visualise typical flare when cystic duct joins the infundibulum and with a funnel shape. Cystic duct is further dissected from infundibulum towards the cystohepatic junction; i.e. from safety zone to danger zone. Bipolar cautery should be used rather than monopolar cautery. Entire Calot's should be dissected including cystic artery. It should be made sure that only two structures enter the gland. Lymph node of Lund is a good marker to dissect cystic artery; node is anterior to the artery. Calot's dissection should not extend posterior to a constant landmark on the inferior surface of the liver—Rouvier sulcus **(Fig. 22-100)**. This oblique sulcus usually is present in the liver; dissection should be in front of it; never extend posterior level of this landmark.

Another technique is '*critical view of safety*' in which entire Calot's triangle including Hartmann's pouch is dissected off from the liver bed to identify the cystic duct and artery.

Cystic artery is dissected using Maryland forceps; isolated. Any anomalies should be identified. Lymph node of Lund is a good marker to identify which is in front of the artery. Often anterior/superficial and posterior/deep branches are identified. After dissection of entire Calot's and to confirm that only two structures are entering the gallbladder cystic artery is clipped on both sides and divided with curved scissor. Harmonic scalpel can also be used to divide the cystic artery. Cystic artery is divided prior to cystic duct usually.

Then cystic duct is clipped using 10 mm clip applicator through epigastric port. Two clips are applied proximally and one clip distally and divided in between. Blind application of clip should be avoided; clip applied should be away from bile duct. Undue traction during clipping should be avoided. Before clipping gallbladder stone is milked into the gallbladder from the cystic duct if any stones are present.

Gallbladder is detached from the gallbladder using various instruments. Spatula with monopolar cautery is commonly used and safer. Hook is also used; its bend is commonly used; to cut peritoneal edge sharp tip is hooked and fulgurated. Harmonic scalpel is an excellent tool for this. Hartmann's pouch is held using the 5 mm grasper (dolphin nosed) and alternatively changes its position according to its need. Undue deeper fulguration may open up the liver tissue. It is safer to keep the instrument closer to the gallbladder than liver bed. When small peritoneal fold attachment is left near the fundus, bed is retracted to inspect the Calot's and gallbladder bed properly for the clip placement and oozing. Often gallbladder may get opened to spill the stones and bile. Bile should be sucked out properly and stones should be extracted or kept in an extracting bag kept in the peritoneal cavity.

Gallbladder is extracted through the epigastric port; 10 mm stout gallbladder holding instrument (claw-shaped) is used to hold at neck of the removed gallbladder; instrument with 10 mm port is removed with the gallbladder. Often port site rectus sheath and skin incision may need to be widened by few mm. Gallbladder neck once comes out of the wound can be opened and suck out all bile. Stones in the gallbladder can be removed using an artery forceps to make its

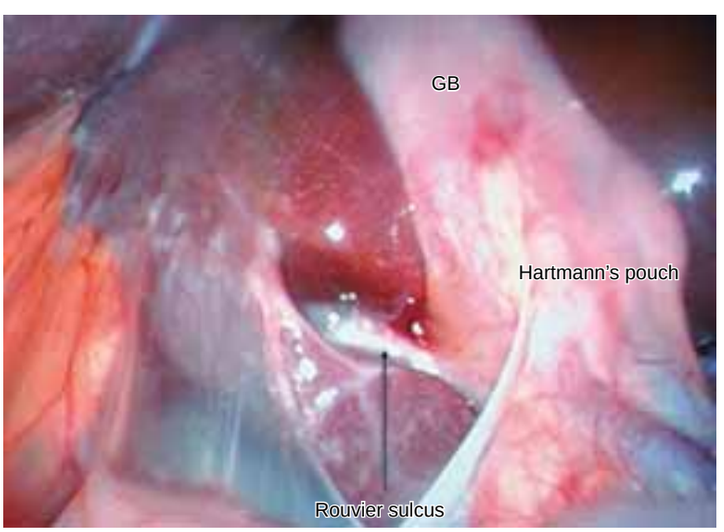
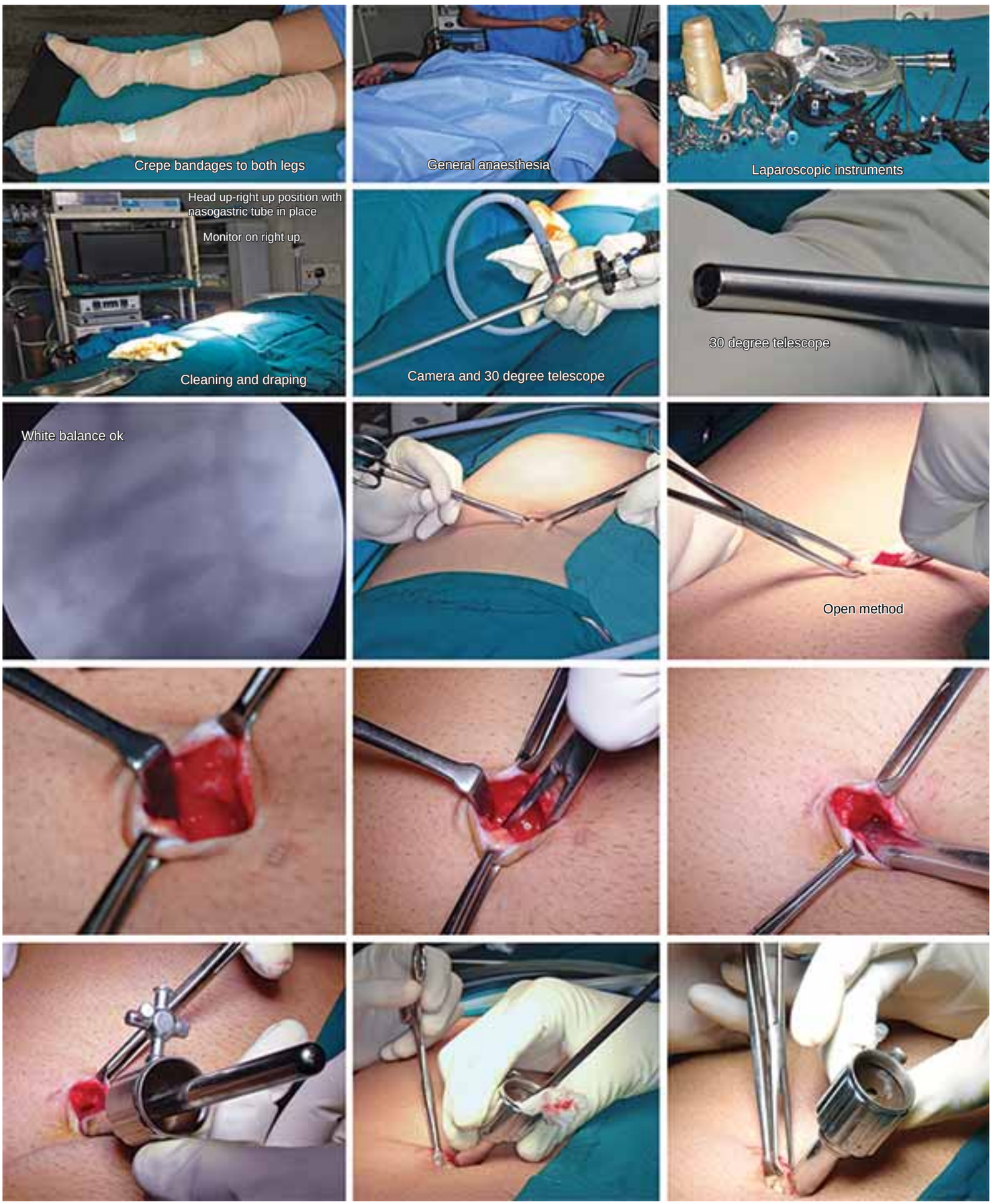
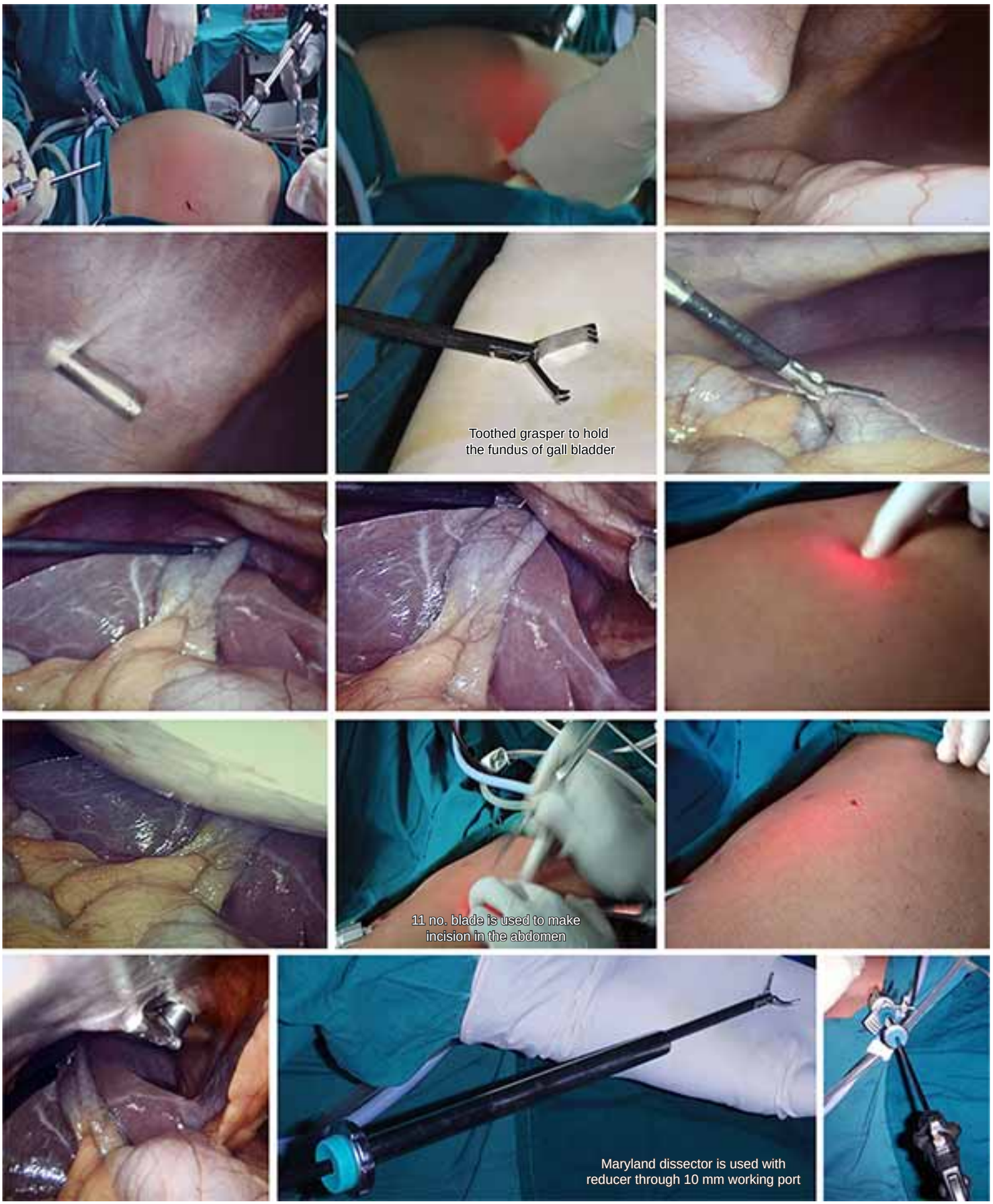


Fig. 22-100: Laparoscopic view of Rouvier sulcus.


Crepe bandages to both legs
General anaesthesia
Laparoscopic instruments
Head up-right up position with nasogastric tube in place
Monitor on right up
Cleaning and draping
Camera and 30 degree telescope
30 degree telescope
White balance ok
Open method

Figs 22-101(1)

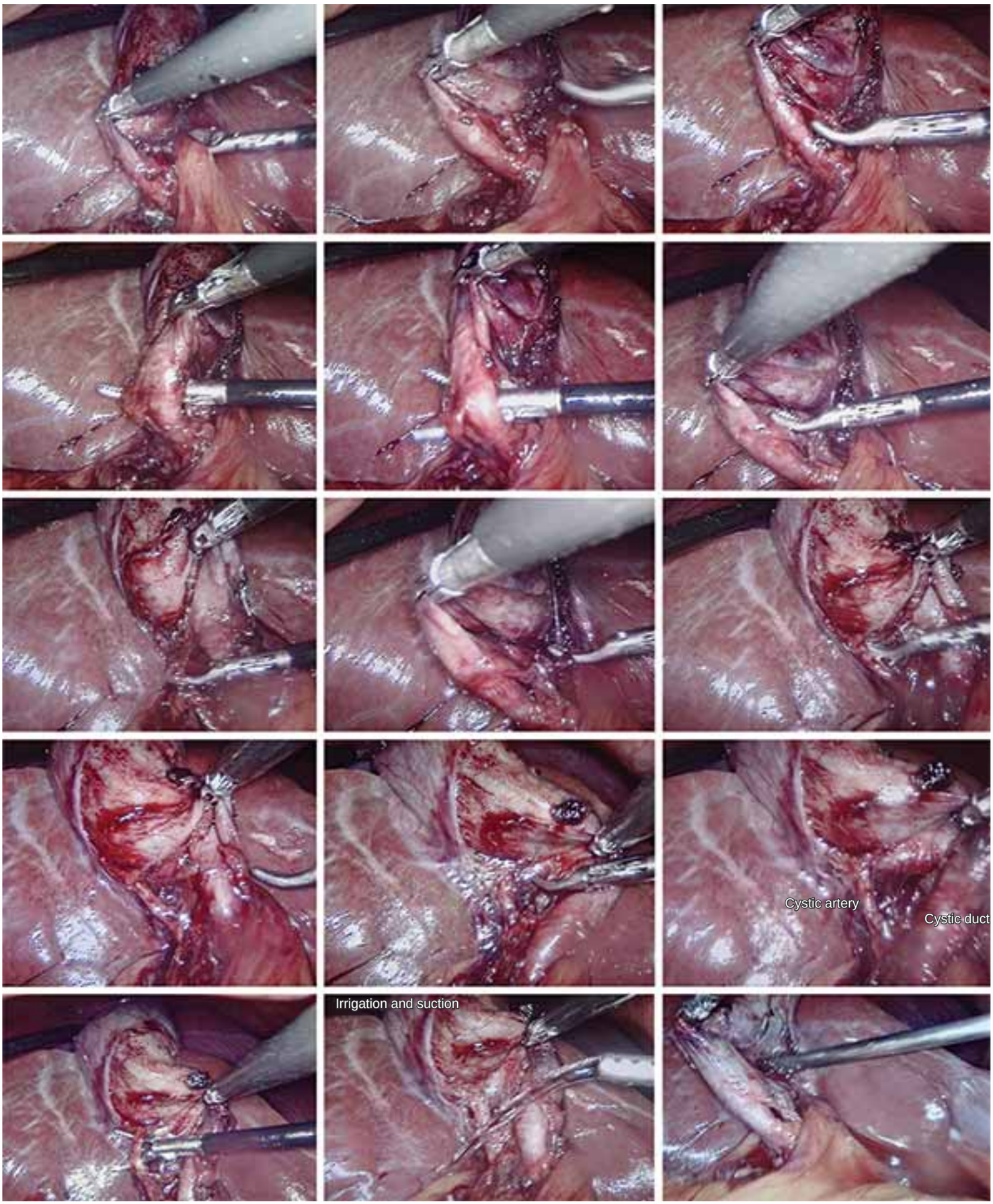
Figs 22-101(2)


Toothed grasper to hold
the fundus of gall bladder
11 no. blade is used to make
incision in the abdomen
Maryland dissector is used with
reducer through 10 mm working port

Figs 22-101(3)

5 mm non-toothed grasper is used to hold and retract the Hartmann's pouch - down and right
5 mm working port retracting fundus of GB
5 mm working port retracting Hartmann's pouch
Camera port
10 mm working port with reducer
Scrub nurse
Surgeon
Cameraman
Releasing the adhesions

Figs 22-101(4)



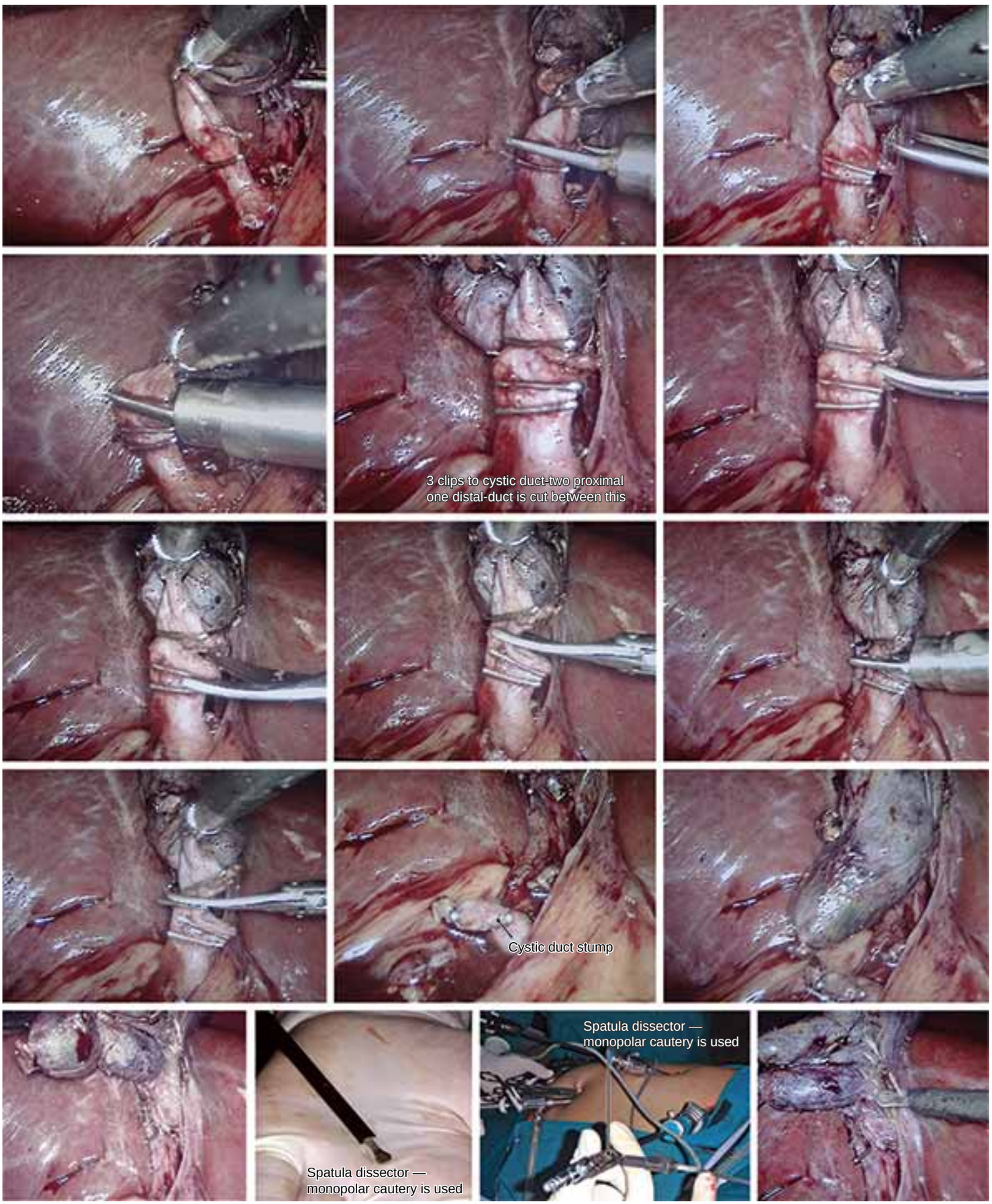
Figs 22-101(5)

Suctioning is done lateral side under liver and paracolic gutter
Bipolar cautery is better in dissecting the Calot's
Rouvier sulcus
Suction device
10mm clip applicator with clip

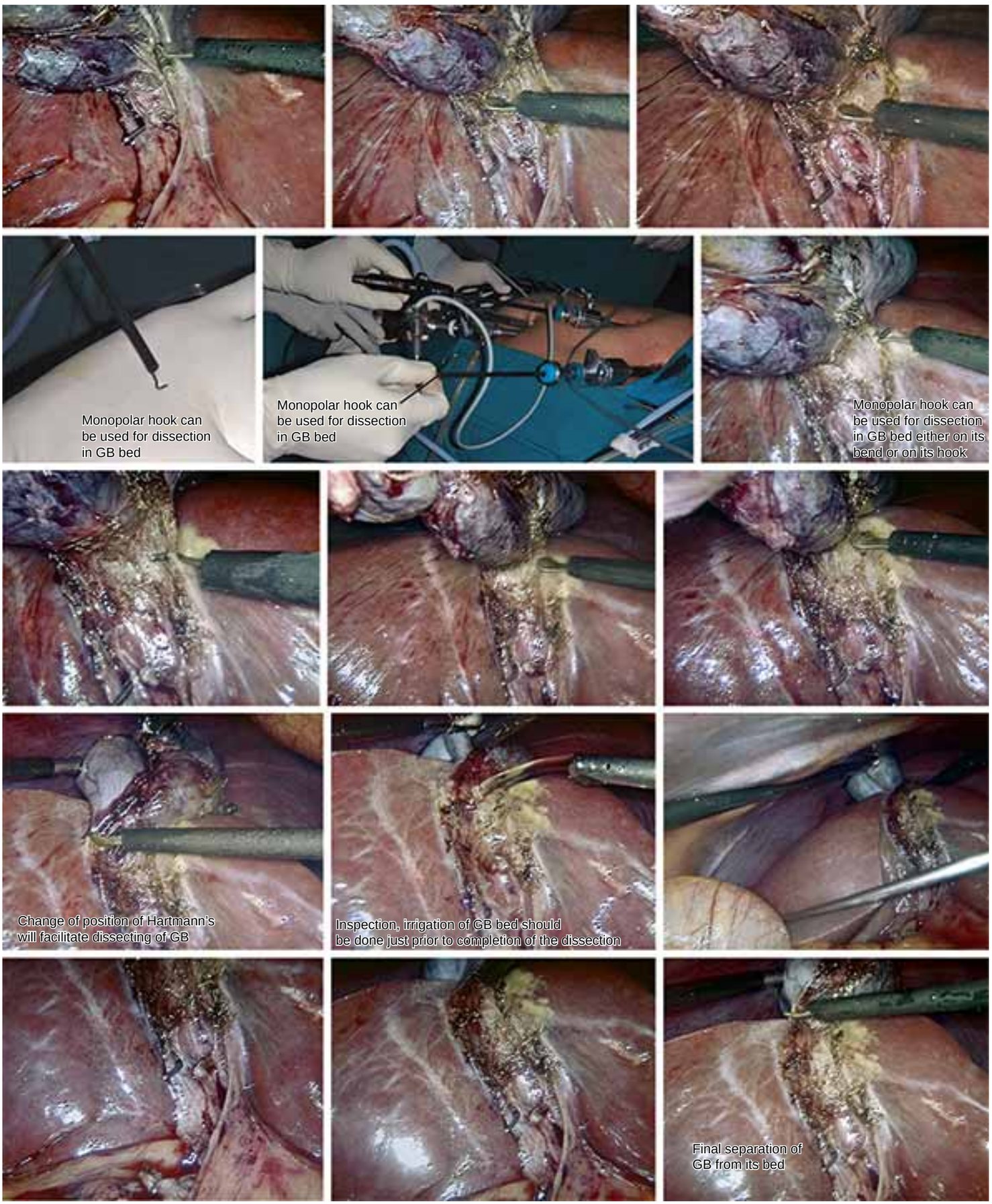
Figs 22-101(6)

Curved scissor
Clip to the cystic artery
First artery should be clipped
Cystic duct isolated
Milking of cystic duct

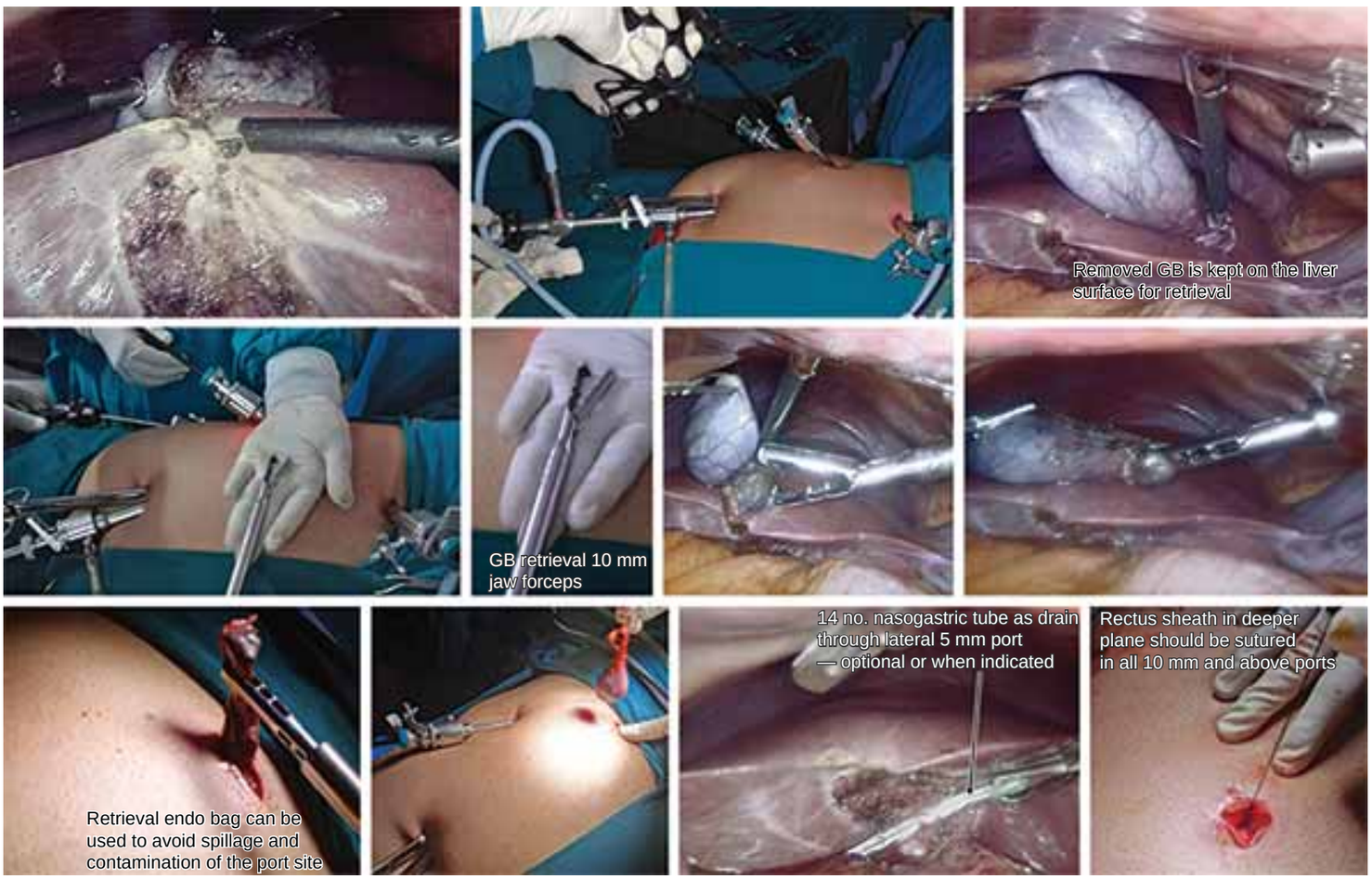
Figs 22-101(7)


3 clips to cystic duct-two proximal
one distal-duct is cut between this
Cystic duct stump
Spatula dissector —
monopolar cautery is used
Spatula dissector —
monopolar cautery is used

Figs 22-101(8)


Monopolar hook can be used for dissection in GB bed
Monopolar hook can be used for dissection in GB bed
Monopolar hook can be used for dissection in GB bed either on its bend or on its hook
Change of position of Hartmann's will facilitate dissecting of GB
Inspection, irrigation of GB bed should be done just prior to completion of the dissection
Final separation of GB from its bed

Figs 22-101(9)


Removed GB is kept on the liver surface for retrieval
GB retrieval 10 mm jaw forceps
Retrieval endo bag can be used to avoid spillage and contamination of the port site
14 no. nasogastric tube as drain through lateral 5 mm port — optional or when indicated
Rectus sheath in deeper plane should be sutured in all 10 mm and above ports

Figs 22-101(10)

Figs 22-101(1 to 10): Technique of laparoscopic cholecystectomy in detail.

removal easier. Gallbladder can be held by passing curved Kocher's clamp through the epigastric port site wound after removing the port temporarily. Retrieval bag can be used to remove the gallbladder and is probably ideal.

Once gallbladder is removed, gallbladder is checked for its opening and contents. Port is placed again. Gallbladder bed and Calot's triangle is checked again. Bed is irrigated and inspected for the final closure.

Usually closure is not necessary. When there is difficulty in dissection or if sepsis is present, then drain is kept. A 14 French nasogastric tube is passed through the lateral 5 mm port is placed in gallbladder bed **(Fig. 22-101)**.

Key steps

1. Place four standard ports.
2. Right up and head up position.
3. Maintain adequate traction on the gallbladder at all times.
4. Posterior dissection at Calot's triangle.
5. Cystic artery and duct are identified dissected properly from safe distal zone (infundibular) to danger proximal zone (CBD level)
6. Clip application after confirming anatomy.
7. Clip artery first then only duct.
8. Dissect gallbladder close to the wall.
9. Inspect gallbladder fossa.
10. Drain the gallbladder bed.
11. Fascial sheaths of all 10 mm port sites should be closed securely.

Trocars are removed, rectus sheaths are closed in 10 mm ports. Skin is sutured or sealed with cyancrylate glue **(Figs 22-102 to 22-104)**.

The drain is removed after 24 hours and oral is started. The patient is mobilised as early as possible and discharged after 48 hours.

Difficult Gallbladder

The safest thing to do when the anatomy of the Calot's triangle is not defined is to convert to open surgery. Conversion should not be taken as a failure but as a wise decision in the interest of the patient. At times, the Calot's triangle is adherent and all planes are lost. In such cases, the suction irrigation device can be used as a blunt dissector and dissection can be done using jet of saline through the channel. One should always be aware of the position of the duodenum and the CBD as they are likely to be damaged. Using a gauze piece to keep the field clean can be done provided utmost care is given and the same is retrieved at the end of the procedure. It is easy to lose track of the small piece and later struggle to find it. Retrograde dissection can be done provided the surgeon is experienced but for the majority of us it may be safe to convert into an open surgery. Subtotal cholecystectomy is an alternative which can be undertaken. Additional instrument using additional port can be tried like fan liver retractor.

Fig. 22-102: Gallbladder specimens removed in different patients – through laparoscopy.

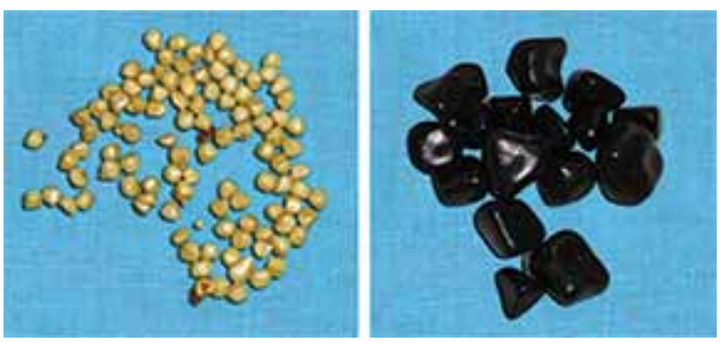


Fig. 22-103: Different gall stone—types.

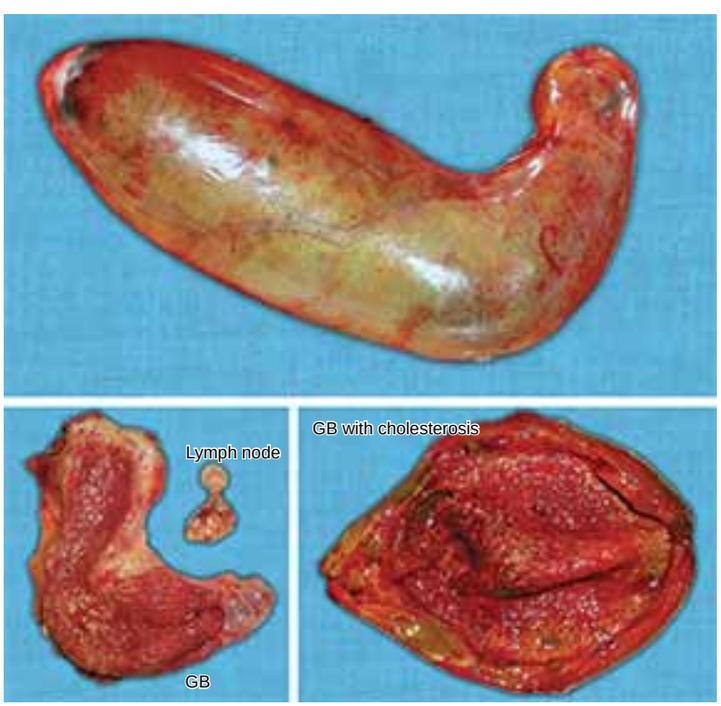


Fig. 22-104: Gallbladder specimens with different pathological look.

Trouble Shooting

1. Difficulty in visualising the Calot's triangle	Reposition the patient. Apply the traction cranially. Clear the viscera away from the operative field. Aspirate the Ryle's tube to deflate the stomach. Apply lateral traction to the Hartmann's pouch.
2. Bleeding at Calot's triangle	Try to perform posterior dissection. Apply compression using gauze piece and wait for 5 minutes. Do not dissect the area blindly which you cannot visualise.
3. Short cystic duct	Confirm the anatomy. Apply intra corporeal knots using silk or vicryl
4. Bleeding from liver bed	Take the gallbladder on the spot and apply pressure keeping the gallbladder on it. Wait for 5 minutes. Stay close to the gallbladder while dissecting.

Complications of Laparoscopic Cholecystectomy

Haemorrhage: It can be from liver bed, slippage of cystic artery ligation or after formation of hepatic artery pseudoaneurysm **(Fig. 22-105)**. Trocar site bleeding can also cause significant difficulty in controlling.

Spillage of stones: They should be extracted carefully. Often it is left behind as stone gets migrated and it is difficult to pick up every stone. Such unidentified stone may cause real problem occasionally. It can cause abscess in subphrenic space or intra-abdominal region; can cause sinus formation, granuloma formation. It can erode various vital structures in the peritoneal cavity causing colocutaneous fistula, duodenal fistula, intestinal obstruction, major vessel thrombosis (middle colic artery), haematuria, and septicaemia.

Biliary tree injuries are due to missed anatomy, over traction on the CBD, anomalies, adhesions, etc. If biliary tree (bile duct or hepatic duct) injury occurs conversion should be done. Type of injury is identified and classified. ERCP stenting may be tried on table. Otherwise choledochojejunostomy should be done. It is unwise to repair a completely transected common bile duct as stricture will develop eventually **(Fig. 22-106)**.

Injury to colon, stomach, and duodenum can occur. Complications specific to laparoscopy should be kept in mind.

Wound infection, incisional hernia can occur.

Pancreatitis, retained stones, biliary stricture are other complications.

SINGLE INCISION LAPAROSCOPIC SURGERY (SILS) IN CHOLECYSTECTOMY (FIG. 22-107)

SILS is an advanced minimally invasive surgical procedure wherein surgeon operates exclusively through a single umbilical entry port. It is also called as single port access surgery (SPA), one port umbilical surgery (OPUS), and single port incision less conventional equipment utilising surgery (SPICES), natural orifice transumbilical surgery (NOTUS).

Whales did tubal ligation in 1969 through single incision; Pelosi did SIL appendicectomy in 1992; Navarra et al, did SIL cholecystectomy in 1997; Pishkun et al. did SIL cholecystectomy in 1999.

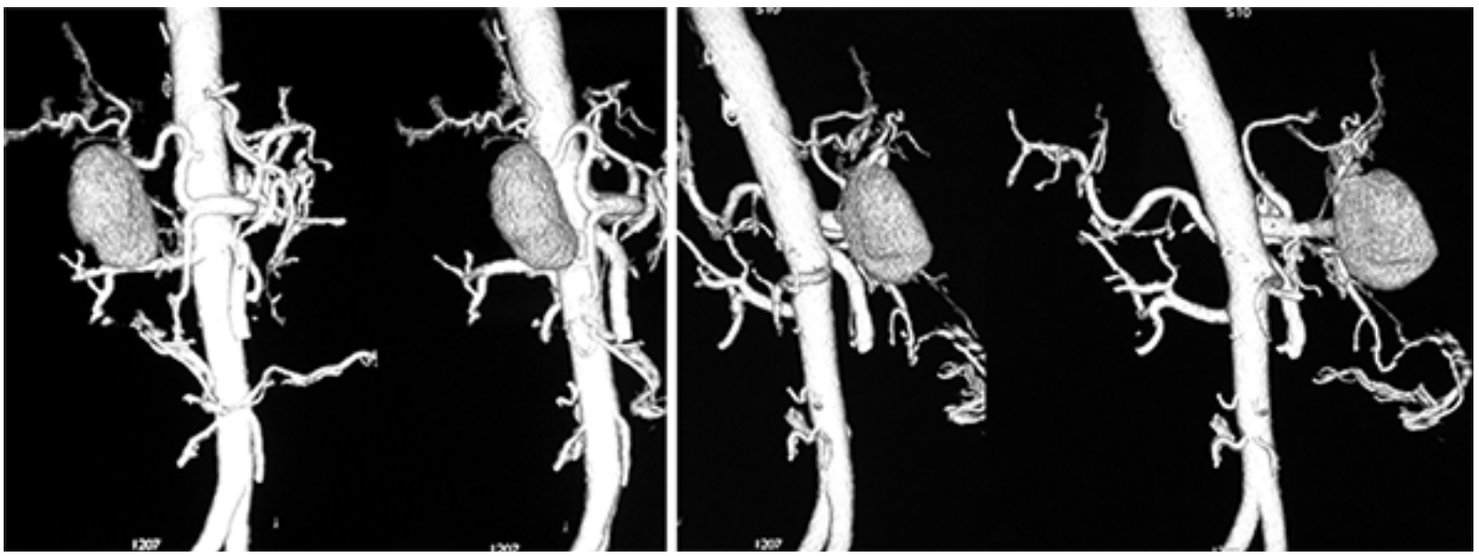
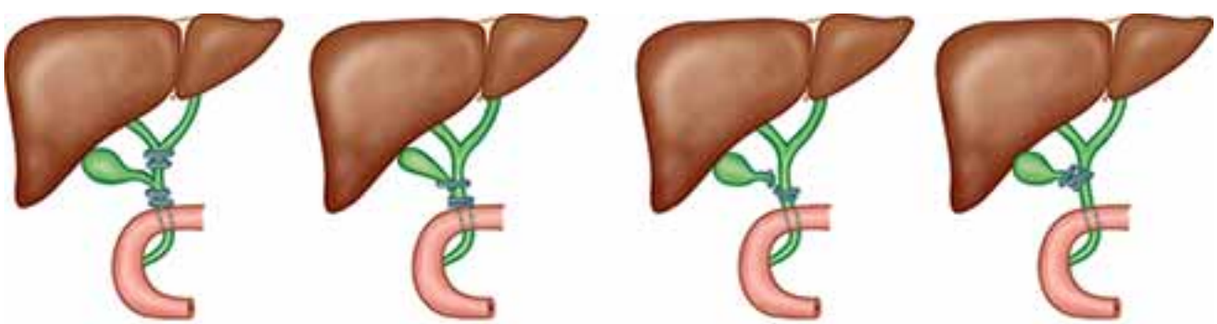


Fig. 22-105: Hepatic artery pseudoaneurysm after laparoscopic cholecystectomy; it is treated successfully by injection of glue and coils through intervention radiology.



Different ways where bile duct and hepatic duct can get injured during laparoscopic surgery-during clipping of the cystic duct

Fig. 22-106: Possible ways by which common bile duct and right hepatic duct can get injured while doing laparoscopic cholecystectomy.

It needs general anaesthesia, specialized umbilical large trocars which accommodates working instruments also, flexible laparoscope, rotatable instruments, articulating handles and harmonic scalpel.

Here through a large 2.5 cm umbilical vertical incision dissection is done by open method to reach peritoneal cavity. Specialised port in which one can pass 10 mm telescope and two 5 mm instruments for work. Instruments are angled and flexible to meet the ergonomic principles to certain extent. Dissection of gallbladder is done in similar fashion like four port technique. Specimen is easily retrieved through umbilical port as it is wider enough. If difficulty arises any time one can add additional ports as required.

Advantages

There is no visible scar like a traditional multiport, faster recovery time, early return to work and cosmetically better.

Disadvantages

Expensive trocars and instruments, skilled work, learning curve, dissection against normal surgical ergonomics. Coaxial orientation of optics and instruments, loss of triangulation – 'Azimuth angle", sword fighting of instruments inside; nutcracking outside—are real problems.

Complications

Umbilical wound pain, infection, umbilical hernia, time consuming because of limited visibility during learning curve complications of cholecystectomy and conversion rate may be more, selection of case is very important.

COMMON BILE DUCT EXPLORATION

It is done to remove the CBD stones after open cholecystectomy. Present era of ERCP with laparoscopic cholecystectomy its indications are not that common unlike in olden days. However, failed ERCP patients needs open choledochotomy and extraction of the biliary tree stones. In olden days, it is indicated if intraoperative duct cholangiography shows stones in CBD; recent history of jaundice; palpable stones in the CBD; CBD diameter more than 10 mm; if ultrasound shows stones in CBD; when in doubt. Many times even if ultrasound is normal with altered liver function in blood parameters should suspect the presence of CBD stones; CT abdomen or MRI is ideal in such situation. One has to remember without confirming the presence or absence of CBD stones, if cholecystectomy is done either by open or laparoscopic approach without a plan to do on table cholangiogram will definitely trouble the surgeon in post-operative period.

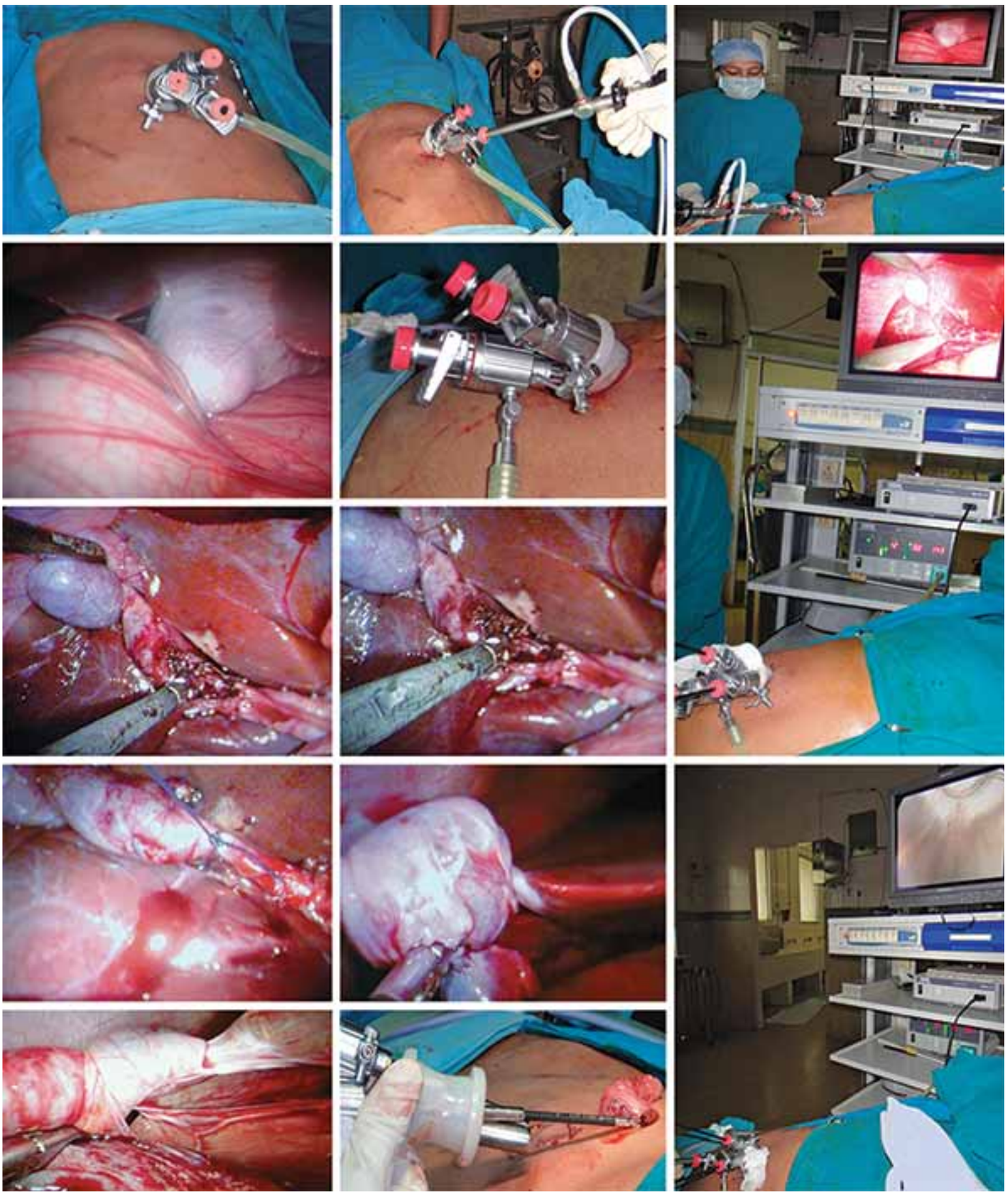


Fig. 22-107: Single incision laparoscopic surgery (SILS) for cholecystectomy.

It is now usual in specified center that by a skilled authentic laparoscopic surgeon, duct cholangiogram and CBD exploration can be done through laparoscopy without opening.

If ERCP has failed or on table during open approach mandatory duct cholangiogram shows stones in the CBD, then CBD exploration is indicated **(Fig. 22-108)**.

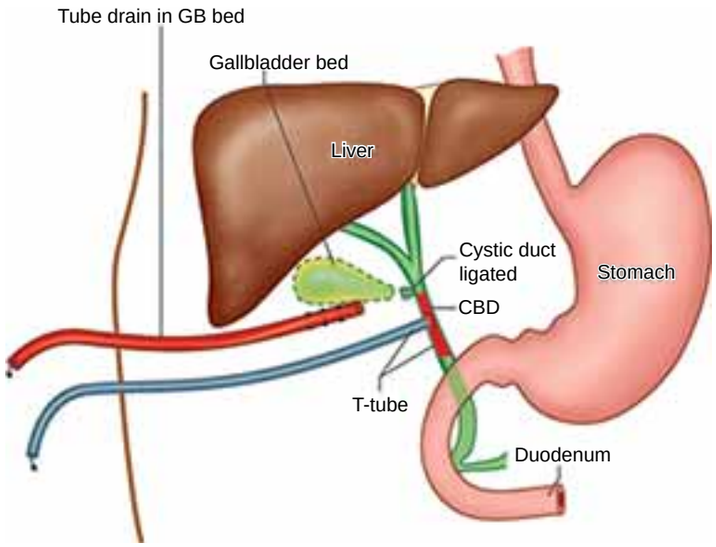


Fig. 22-108: Placement of T-tube in CBD after choledocholithotomy. Note the separate drain placed in the cholecystectomy bed to drain fluid, blood and bile.

Technique

Incision is same as Kocher's incision but may require upwards extension towards xiphisternum or towards left side as partly bucket handle. After exploring the abdomen, cholecystectomy is done in usual manner with on table duct cholangiogram. Kocherisation of the duodenum is a must. Peritoneum on the anterior part of the CBD is incised to expose the CBD for 2-3 cm; small bleeders are cauterised using bipolar cautery; monopolar cautery should not be used. Two stay sutures are placed on the CBD using 3-0 vicryl; one just above the duodenum; another just below the level of the joining of cystic duct. Stay sutures are placed on the anteromedial surface of the CBD. Needle with syringe is passed into the CBD to aspirate bile which is collected for cytology and culture **(Fig. 22-109)**.

Incision is made vertically in the CBD on its anteromedial surface between stay sutures for 1.5-2 cm using no. 15 blade **(Fig. 22-110)**; incision begins at its upper hepatic side downwards towards duodenum just up to above the duodenum; care should be taken not to pass across the posterior wall and so into the portal vein even though it is very rare; suctioning of bile is done (Incision should not be done on the lateral right side of CBD as cystic duct and CBD may have a common channel for 2 cm).

Mobilized 2nd part of the duodenum is held with thumb and fingers of one hand. Any stones if felt is carefully milked upwards towards choledochotomy wound. Stones are removed by different means—pituitary scoop of proper size; Randall's stone forceps; Fogarty catheter; Dormia basket; *choledochoscope (ideal)*; Desjardin's choledocholithotomy forceps; Bake's CBD dilator (malleable no. 3). One should not force the stiff instrument downwards towards the ampulla as it may perforate the pancreatic part of the CBD causing fatal pancreatitis or bleeding or sepsis. 10 F catheter or infant feeding tube can be gently passed through the ampulla and if it is so that means

Fig. 22-109: Needle aspiration of common bile duct is done to aspirate bile which often may be infected.

Fig. 22-110: Pott's scissor is better to cut and extend the incision in the common bile duct after making incision using no 15 blade.

ampulla is adequately patent without obstruction. Repeated warm saline irrigation both below through the CBD and above through the hepatic ducts should be done. First retrograde exploration is done; then downwards. It is easier to negotiate the tube and flush left hepatic duct. One should be careful in passing tube into right hepatic duct as it may get injured causing haemobilia **(Figs 22-111 to 22-114)**.

Fogarty catheter when used is negotiated into the duodenum and confirmed by feeling the duodenum. It is only partially inflated and allowed just to pass through the ampulla proximally; then it is fully inflated to gently pull upwards towards choledochotomy to retrieve the stone along with that.

Ideally choledochoscope is best to visualise and retrieve the stones. Both rigid and flexible choldochoscopes are available. Both are sterilized by ethylene oxide for repeated uses. Flexible scope has got poorer quality of image, costly, damageable, less life-span than rigid one even though

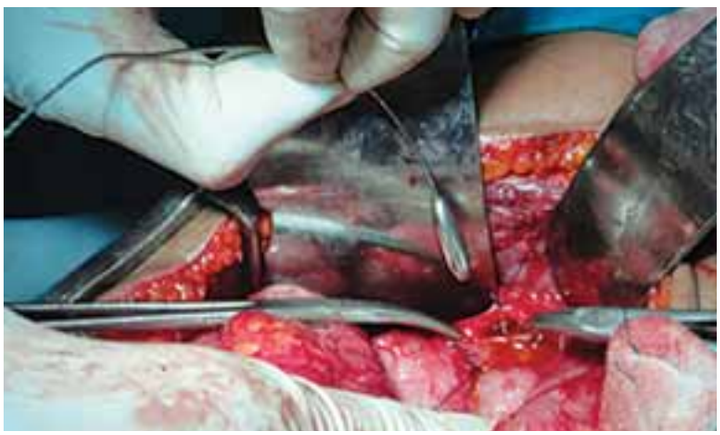


Fig. 22-111: Bakes dilator no. 3 F is used; one should be gentle while using it as forcible push may damage pancreas due to bile duct perforation.

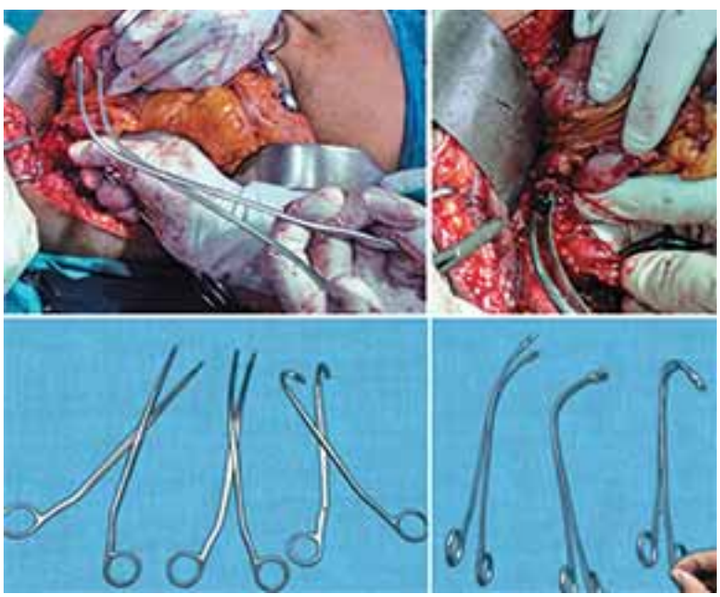


Fig. 22-112: Desjardin's choledocholithotomy forceps to retrieve gallbladder stones.

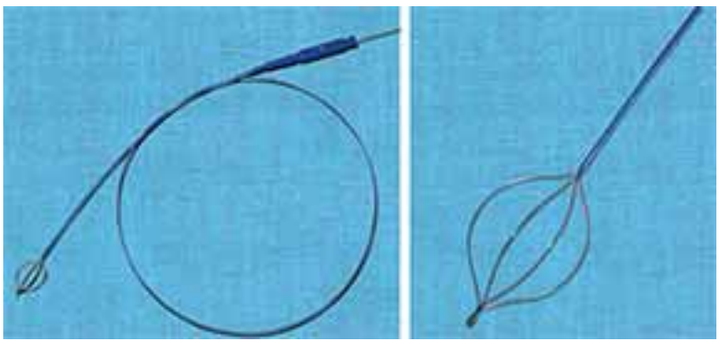


Fig. 22-113: Dormia basket to retrieve stones from CBD.

it is safer easily negotiable into the CBD and hepatic ducts to retrieve the stones. Rigid scope is commonly used; 4 cm and 6 cm rigid scopes are available with 5 (outer) × 3 (inner) mm diameter. If CBD size in less than this which is unlikely is a contraindication for choledochoscope. Warm saline irrigation is done through the choledochoscope (rigid choledochoscope needs continuous saline irrigation like cystoscope of urologists otherwise mucosa cannot be seen). Choledochoscope is used with surgeon standing on the left side of the patient. Scope can be carefully negotiated proximally up to often tertiary ducts. Distally choledochscope is passed with guidance of other hand under Kocherised duodenum. If stones are visualised in distal CBD they are removed using different flexible instruments passed beside the choledochoscope for direct visualisation of the stone for retrieval.

If by all these means, stones are still retained due to impaction in distal CBD, then duodenotomy in 2nd part of the duodenum followed by sphincterotomy is done at 11 o'clock position for 1 cm to retrieve the stone; later sphincteroplasty is done. T-tube should be placed; it has got vertical and horizontal part with a soft flexible junction which makes its removal safer. 16 French size is used (diameter 5 mm). As this size facilitates passage of choledochscope later through the track formed after 21 days in case if there are retained stones **(Fig. 22-115)**.

T-tube (Kehr's T tube) comes in different sizes; 16 F size is usually used. Horizontal limb is cut shorter; each horizontal limb should be 1 cm; lengthy tube inside CBD may precipitate pancreatitis or may traumatise during its removal after 14-21 days. T-tube should be

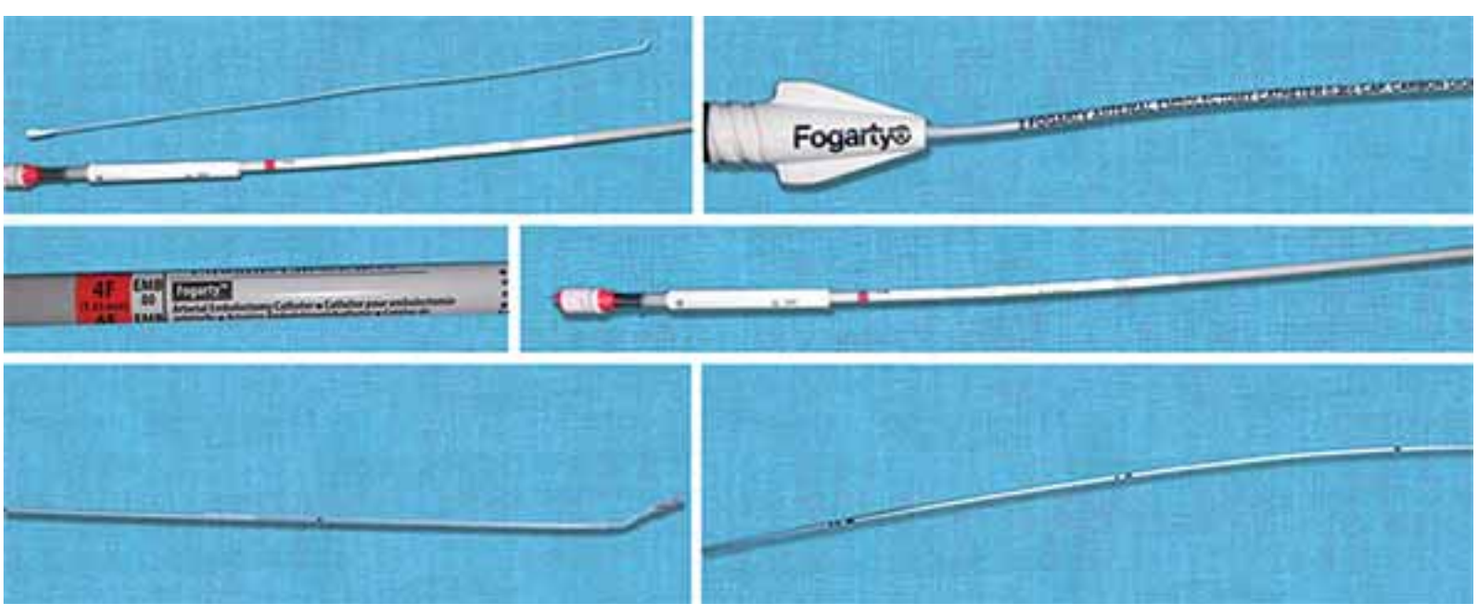


Fig. 22-114: Fogarty catheter often used to retrieve the CBD stones.

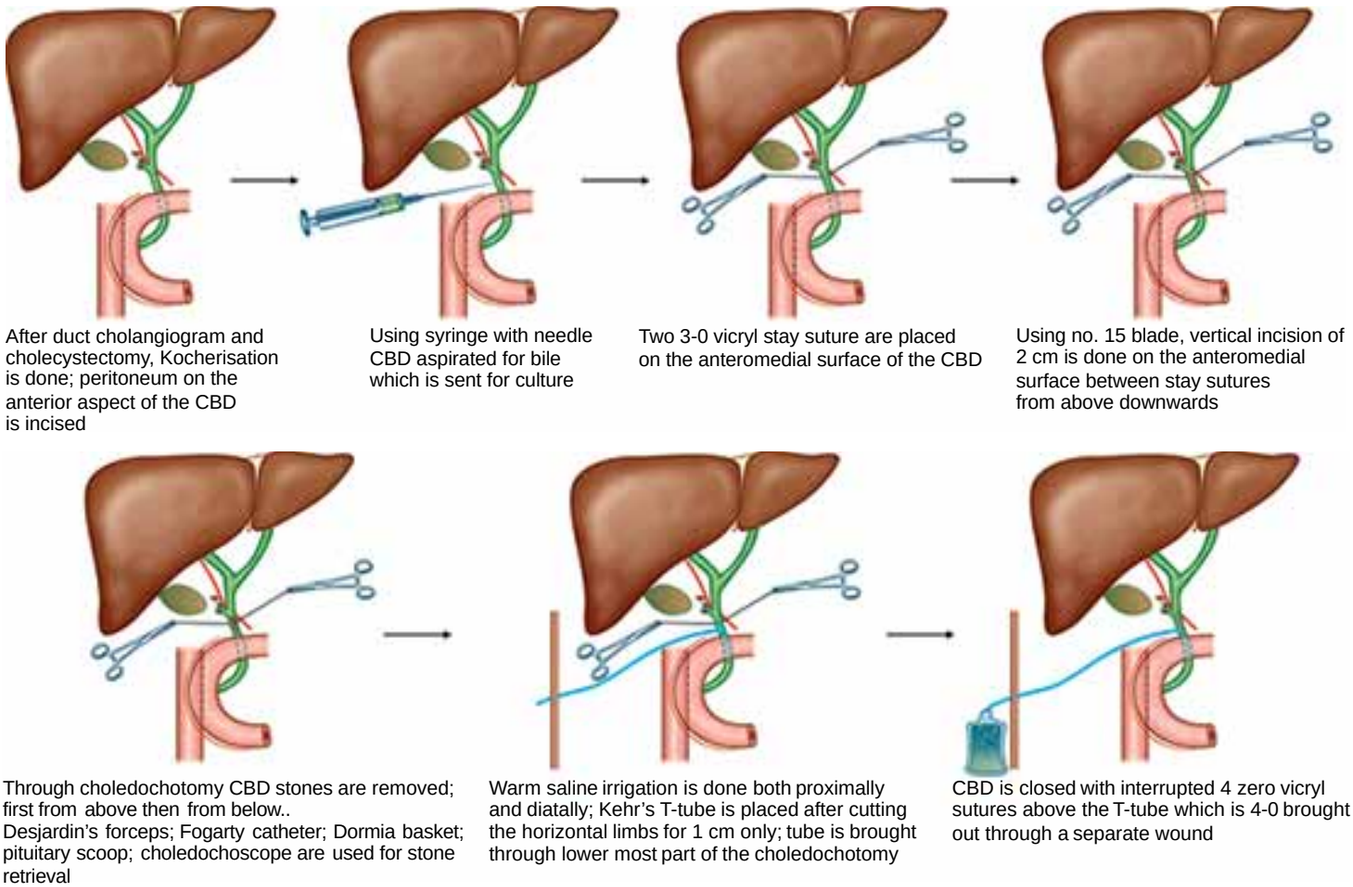

After duct cholangiogram and cholecystectomy, Kocherisation is done; peritoneum on the anterior aspect of the CBD is incised
Using syringe with needle CBD aspirated for bile which is sent for culture
Two 3-0 vicryl stay suture are placed on the anteromedial surface of the CBD
Using no. 15 blade, vertical incision of 2 cm is done on the anteromedial surface between stay sutures from above downwards
Through choledochotomy CBD stones are removed; first from above then from below.. Desjardin's forceps; Fogarty catheter; Dormia basket; pituitary scoop; choledochoscope are used for stone retrieval
Warm saline irrigation is done both proximally and diatally; Kehr's T-tube is placed after cutting the horizontal limbs for 1 cm only; tube is brought through lower most part of the choledochotomy
CBD is closed with interrupted 4 zero vicryl sutures above the T-tube which is 4-0 brought out through a separate wound

Fig. 22-115: Technique of common bile duct exploration and placement of T tube.

brought out at the lower most part of the choledochotomy incision to avoid the disruption of the suture line while removal. T-tube should be ideally made up of latex rubber, not of plastic or polyvinyl. Latex causes extensive reaction to create a track and so as to prevent bile leak into peritoneal cavity and so biliary peritonitis. Different modifications are available. Maingot's split type is also available with a slit on the opposite side of the junction. CBD is closed above the T-tube keeping T-tube at the lower most part of the CBD. Interrupted 3-0 vicryl or 4-0 PDS is used. Patency of the tube should be checked by saline infusion.

Completion on table T-tube cholangiogram is a must. T-tube is brought out of the abdomen through a separate stab incision at anterior axillary line. Tube drain is placed at gallbladder bed **(Fig. 22-116)**.

Postoperative Care

Antibiotics are continued. Nasogastric tube can be removed in 48 hours. Drain is removed in 5-7 days. Post-operative T-tube cholangiogram is done in 1-14 days. In doubtful cases T-tube should be kept in place for 21 days more. Prior to removal, one should confirm that there are no residual stones. Often T-tube is clamped for 24 hours; if patient develops pain, vomiting, pain abdomen, bile leak from side of T-tube, it is probable that there are retained stones.

Problems and Complications

Haemorrhage during surgery may be due to oozing from gallbladder bed, hepatic artery injury, portal vein injury even though it is rare.

Post-operative pancreatitis due to CBD perforation by forcible negotiation of the tube across the ampulla into the duodenum.

Bile leak and bile peritonitis is equally dangerous and life-threatening.

Haemobilia may be due to intrahepatic injury while retrieving the stones from hepatic ducts. Plasma, vitamin K injection is usual treatment. Hepatic angiography confirms the diagnosis. Therapeutic embolization may be required.

Septicaemia, subphrenic abscess can develop mainly in diabetic and old aged.

Residual bile duct stones: It is confirmed by T-tube cholangiogram. Its incidence is 3%; but less if choledochoscope is used. Small stones less than 1 cm is retrieved by saline (1 litre) in heparin (5000 units) infusion into the T-tube. In 5 days often, stone reduces in size. Patient is discharged with T-tube with an advice of daily infusion of 50 mL of saline into the T-tube. Patient is asked to come after 8 weeks for further management of retained stones. During this period track, has formed well. It is managed by Burhenne (radiologist, Canada) method. Under fluoroscopic guidance after removal of T-tube, flexible catheter is passed into the track to reach the duodenum across the stone; Dormia basket is passed through the flexible catheter; gently it is manipulated to trap the stones into the basket under guidance to retrieve the stones; repeated attempts clears all the stones. It has got 90% success rate. Flexible choledochoscopy can be passed (not rigid) through the track to visualise and retrieve the stone. Repeat ERCP, sphincteroplasty, re exploration, choledochoduodenostomy or choledochojejunostomy are other methods in these patients.

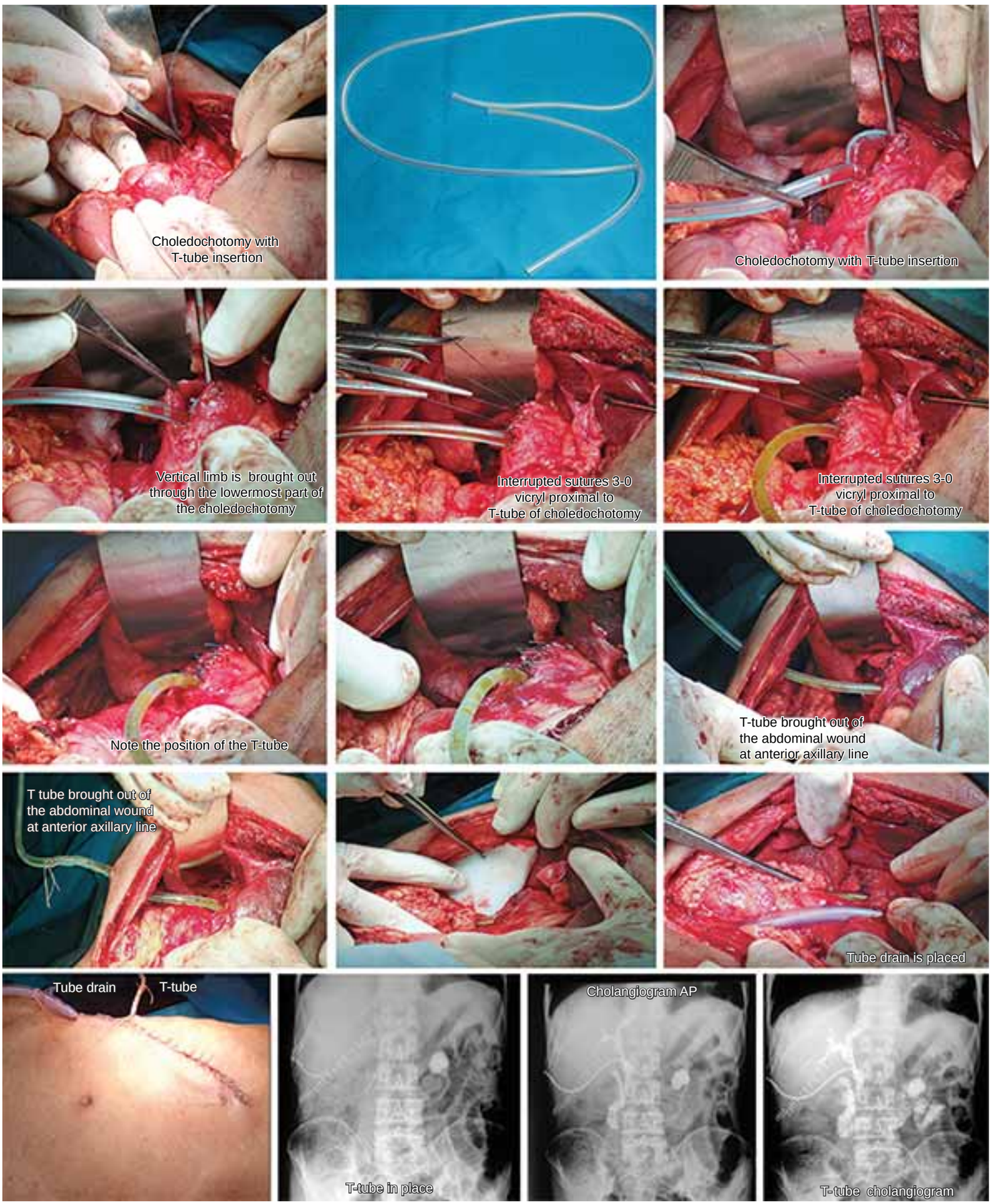

Choledochotomy with T-tube insertion
Choledochotomy with T-tube insertion
Vertical limb is brought out through the lowermost part of the choledochotomy
Interrupted sutures 3-0 vicryl proximal to T-tube of choledochotomy
Interrupted sutures 3-0 vicryl proximal to T-tube of choledochotomy
Note the position of the T-tube
T-tube brought out of the abdominal wound at anterior axillary line
T tube brought out of the abdominal wound at anterior axillary line
Tube drain is placed
Tube drain
T-tube
T-tube in place
Cholangiogram AP
T-tube cholangiogram

Fig. 22-116: Placement of T-tube after CBD exploration and removal of the CBD stone. It is done in secondary CBD stone where stones have slipped from the gallbladder into the CBD.

CHOLEDOCHODUODENOSTOMY

Riedel in 1881 did first choledochoduodenostomy.

Indications

Stones still remained with CBD after CBD exploration for multiple CBD calculi. It could be with primary CBD stones or secondary stones. But commonly such stones are primary one. Retained stones in the hepatic ducts are also indication.

Papillary stenosis: It is often known to occur. It is diagnosed by failure of the dye reaching the duodenum during operative cholangiography and inability to pass 3 mm dilator across CBD into the duodenum.

Impacted distal CBD stone wherein removal is impossible.

Intrahepatic calculi, residual stones after removal of T-tube in earlier operation, diverticula in the duodenum causing CBD obstruction and cholangitis, benign stricture of the distal CBD.

Prerequisite

CBD should be more than 1.5 cm to do choledochoduodenostomy.
Contraindications: CBD if not dilated significantly, sclerosing cholangitis, chronic pancreatitis which needs surgical decompression, malignant obstruction, duodenal oedema.

Technique (Fig. 22-117)

Preparation anaesthesia and position is same as cholecystectomy. Cholecystectomy is done. Kocherisation should be done adequately. Longitudinal choledochotomy is made on the CBD of 2.5 cm in length. Duodenum is incised on its first part longitudinally around 2.2 cm (3 mm lesser than CBD incision). Through the opening ampulla is again palpated to avoid missing malignancy; often choledochoscope can be done to confirm that. Distal end of the choledochotomy is brought to the middle of the lower leaf of the duodenotomy. Middle points of the edges of the choledochotomy is brought towards the ends of the duodenotomy incision; stay sutures are placed using 3-0 vicryl.

Further 3-0 vicryl interrupted sutures are placed initially to complete the posterior layer (knots should be outside ideally); then anterior layer. Finally funnel-shaped choledochoduodenostomy anastomosis is completed. Stoma should be at least 2.5 cm. Abdomen is closed with a tube drain.

Problems

- ***Sump syndrome:*** it is due to creation of blind segment/pouch at distal CBD causing stasis and cholangitis. This pouch contains infected bile, food, calculi (Fig. 22-118).
- Bile leak due to anastomotic disruption can occur.
- Recurrent cholangitis is another problem.

TRANSDUODENAL SPHINCTEROPLASTY

Indications are same as choledochoduodenostomy.

Technique (Fig. 22-119)

After cholecystectomy through Kocher's incision, Kocher's manoeuvre is done; common bile duct is explored. No. 3 Bake's dilator is passed into the CBD but not across the ampulla of Vater. Tip of the dilator is palpated through the anterior duodenal wall which allows the proper placement of the sphincterotomy incision.

Duodenotomy of 4 cm length is made in the 2nd part of the duodenum centring at the level of the ampulla. Retractors are placed into the cut edges of the duodenotomy to expose the ampulla adequately. It is better to place four stay sutures to retract edges at four corners.

Incision is made at 11 o'clock position. It keeps incision away from pancreatic duct entry and also is relatively avascular. Using no. 15 blade or Pott's scissor, tip of the Bake's dilator as a guide incision is made along the orifice. After cutting partially, 4-0 vicryl sutures are placed on either sides of the opened ampulla and held apart to give traction. Pancreatic duct orifice is identified at 5 o'clock position on the posterior aspect. Incision is further extended for 3 mm and

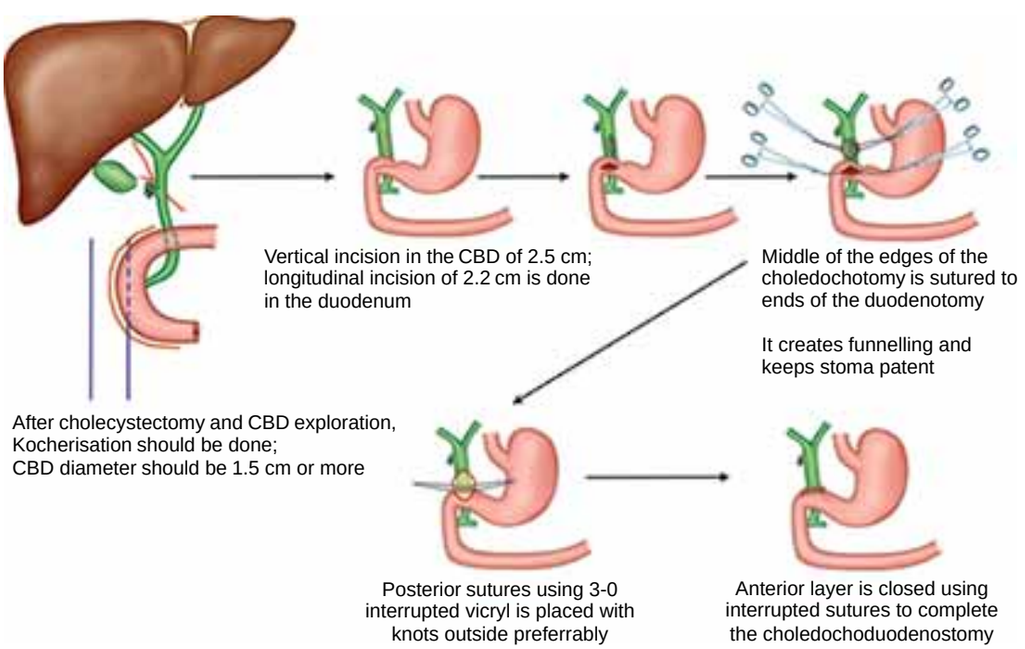

Vertical incision in the CBD of 2.5 cm; longitudinal incision of 2.2 cm is done in the duodenum
Middle of the edges of the choledochotomy is sutured to ends of the duodenotomy
It creates funnelling and keeps stoma patent
After cholecystectomy and CBD exploration, Kocherisation should be done; CBD diameter should be 1.5 cm or more
Posterior sutures using 3-0 interrupted vicryl is placed with knots outside preferrably
Anterior layer is closed using interrupted sutures to complete the choledochoduodenostomy

Fig. 22-117: Choledochoduodenostomy—technique.

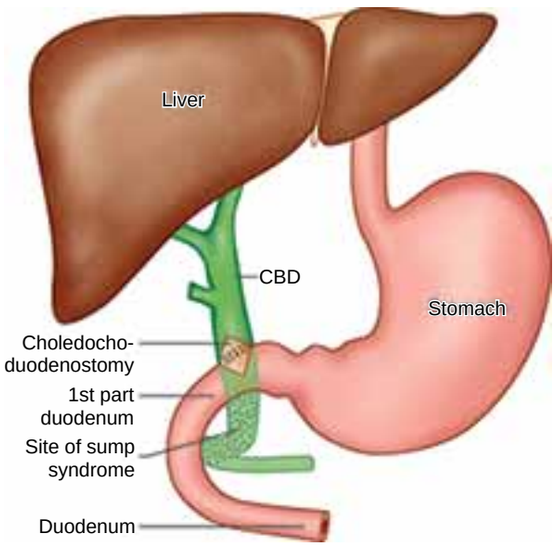


Fig. 22-118: Technique of choledochoduodenostomy for CBD stones. Note the site of possible occurrence of sump syndrome.

additional stay sutures are placed. Pancreatic ductal orifice may be better visualised by injecting secretin one unit/kg IV which stimulates the pancreatic juice flow across the orifice. Incision is continued sequentially every time for 3 mm with a pair of vicryl stay sutures. Sphincterotomy of entire sphincter of Oddi needs 2 cm length of incision along the ampulla. Otherwise length of the sphincterotomy should be length of the CBD diameter. At the apex, figure of eight suture should be placed.

If there is associated chronic pancreatitis and stenosis of the pancreatic duct, if no. 3 Bake's dilator is not negotiable, then pancreatic ductoplasty also should be done. Probe is passed into duct. Duct is incised at its anterior wall for 10 mm using Pott's scissor at 5 o'clock position; technique is as similar as sphincteroplasty of sphincter of Oddi; i.e. every 3 mm incision paired 4-0 vicryl stay sutures; sequentially until adequate ductoplasty (of Wirsung) is achieved.

Choledochotomy is closed with a T-tube; duodenotomy is closed; tube drain is placed. Abdomen closed in layers **(Fig. 22-120)**.

Post-operatively antibiotics are given; nasogastric tube is removed in 48 hours and oral feeding is started. Liver function, serum amylase levels are estimated during feeding post-operative period. Tube drain is removed in 5 days. T-tube is removed in 2 weeks.

Complications

Duodenal fistula, sepsis, subphrenic abscess formation, and pancreatitis are complications.

CHOLEDOCHOJEJUNOSTOMY/ BILIARY ENTERIC ANASTOMOSIS/ HEPATICOJEJUNOSTOMY

Indications

Major ductal injury, inoperable tumour (palliative bypass), chronic pancreatitis; biliary stricture are indications.

Side-to-side or side-to-end choledochojejunostomy can be done. Unless CBD is completely transected and distally ligated in definitive resections like Whipple's operation, end-to-side type is usually not necessary **(Fig. 22-121)**.

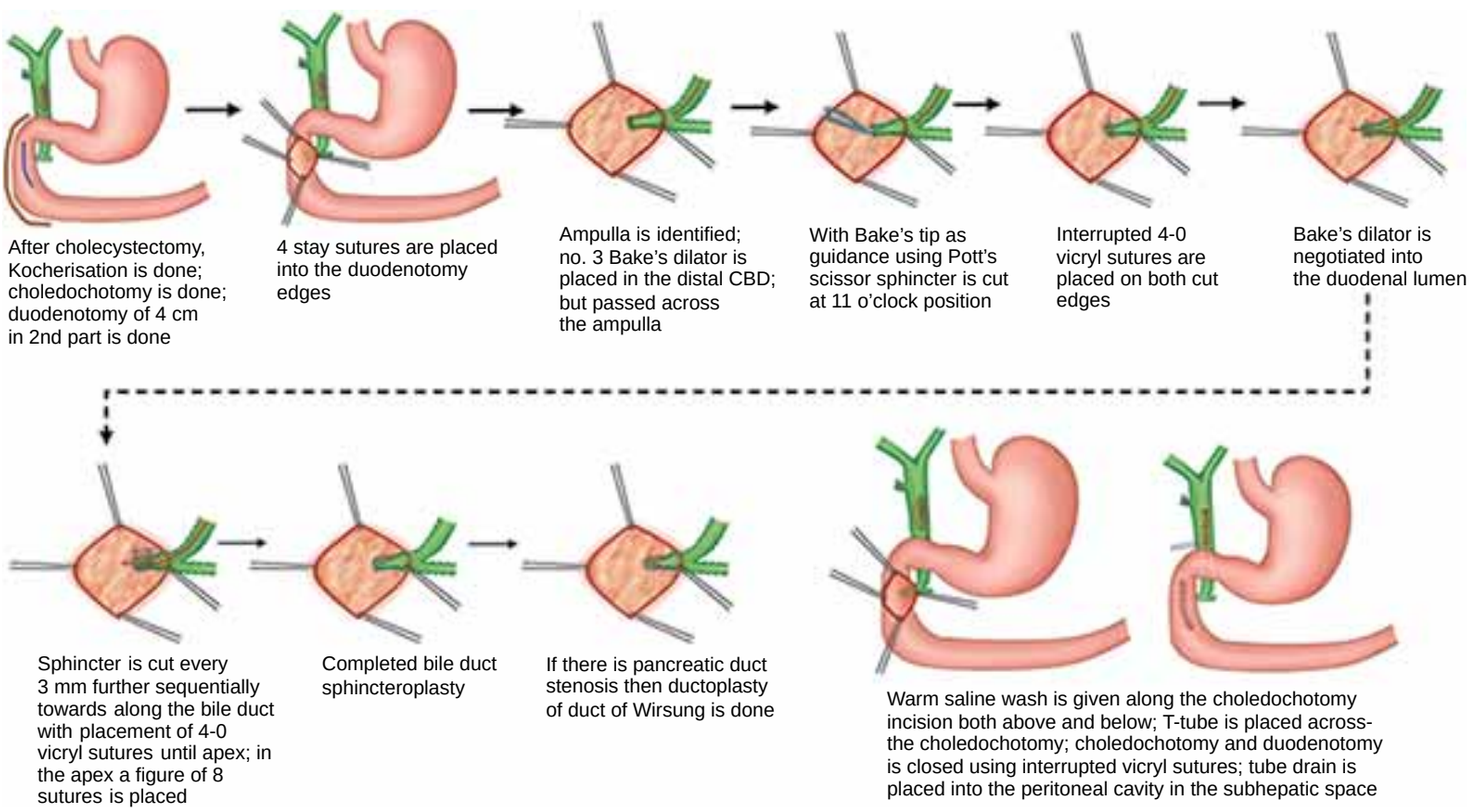

After cholecystectomy, Kocherisation is done; choledochotomy is done; duodenotomy of 4 cm in 2nd part is done
4 stay sutures are placed into the duodenotomy edges
Ampulla is identified; no. 3 Bake's dilator is placed in the distal CBD; but passed across the ampulla
With Bake's tip as guidance using Pott's scissor sphincter is cut at 11 o'clock position
Interrupted 4-0 vicryl sutures are placed on both cut edges
Bake's dilator is negotiated into the duodenal lumen
Sphincter is cut every 3 mm further sequentially towards along the bile duct with placement of 4-0 vicryl sutures until apex; in the apex a figure of 8 sutures is placed
Completed bile duct sphincteroplasty
If there is pancreatic duct stenosis then ductoplasty of duct of Wirsung is done
Warm saline wash is given along the choledochotomy incision both above and below; T-tube is placed across-the choledochotomy; choledochotomy and duodenotomy is closed using interrupted vicryl sutures; tube drain is placed into the peritoneal cavity in the subhepatic space

Fig. 22-119: Technique and steps of transduodenal sphincteroplasty.

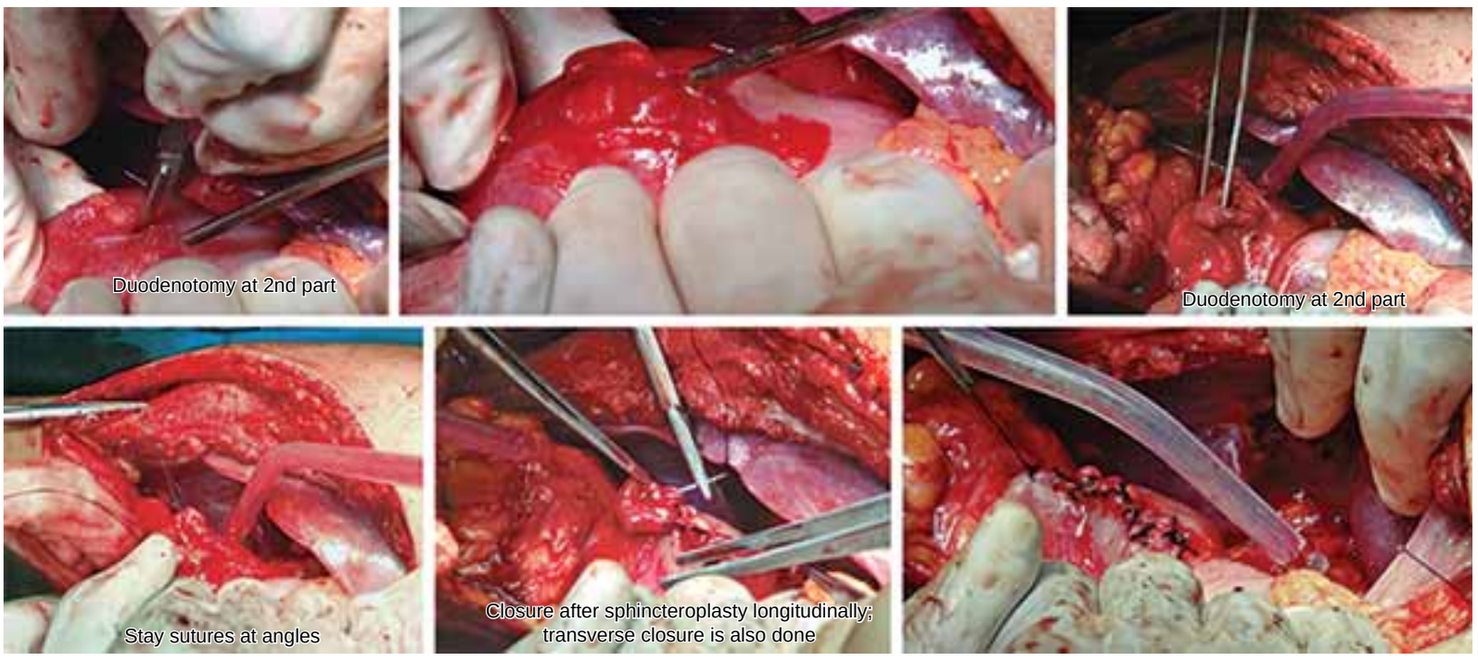

Duodenotomy at 2nd part
Duodenotomy at 2nd part
Stay sutures at angles
Closure after sphincteroplasty longitudinally;
transverse closure is also done

Fig. 22-120: Duodenotomy in transduodenal sphincteroplasty and closure of duodenum ideally transverse; here longitudinal closure was done which is also accepted.

Fig. 22-121: Primary biliary stones in common bile duct and hepatic ducts. It needs choledochojejunostomy.

Technique

After doing cholecystectomy (it facilitates the approach and visualisation and avoids later development of cholecystitis) and choledochotomy or incision on the common hepatic duct, Roux limb is prepared. Technique of dissection and choledochotomy is same as for bile duct exploration. Choledochotomy should be around 2-2.5 cm in length.

Duodenojejunal junction is identified by ligament of Treitz and inferior mesenteric vein. After 2nd arcade of the blood supply in the mesentery, through transillumination arcades are identified and divided using small haemostats. Bipolar or harmonic scalpel can be used. 20 cm from the duodenojejunal junction is the site taken for Roux limb. Jejunum is cut with no. 15 blade between occlusion clamps; or stapler transection can be done. Roux limb is passed across the transverse mesocolon through a rent at right of the middle colic artery to reach the CBD area. Antecolic placement loop can be done if there are lot of adhesions and if there are infiltrations in case of malignancy at mesocolon level. Blood supply of the Roux limb is assessed by its colour and pulsation at its mesentery (**Figs 22-122 and 22-123**).

In *side-to-side anastomosis*, 4-0 vicryl sutures are used. Jejunum is incised over its antimesenteric border 1 cm proximal to the stapled end. Lengthy distal part distal to the proposed anastomosis should not be kept as it may cause blind loop and recurrent infection. Jejunotomy incision should be 2 cm in length (3 mm lesser than choledochotomy incision. Usually 4 interrupted sutures are placed between jejunum (posterior cut edge) and right margin of the CBD with 3-4 mm apart. Jejunal bites should be adequate. Ideally from CBD outside in, then from jejunum inside out bites are taken so that knots are placed outside; but posterior knots can be placed inside by taking bites from inside out and outside if technical difficulty arises. All sutures are placed and kept long with haemostats; only after placing all posterior sutures jejunum is pushed gently into the choledochotomy and knots are tied; all threads are kept long and cut at the end. Anterior sutures are taken similarly with knot placement outside. After taking all bites, knots are tied sequentially at the end. It is logically better to take bite from the middle of the choledochotomy cut edge on both sides to the ends of the jejunostomy so that stoma will be kept patent; however, both ways are adequate enough to maintain the stomal patency **(Figs 22-124 and 22-125)**.

It is often practice that both posterior and anterior suture bites are taken together and kept aside using haemostats. With *parachute technique* (railroading, *Voyles-Blumgart technique*, 1982) jejunum is pushed and posterior and anterior knots are placed sequentially. However, it is often technically difficult especially to identify the corresponding sutures to put knots and may create problem while knotting. If surgeon is not well-practiced with this technique, he should avoid it to prevent problems thereafter.

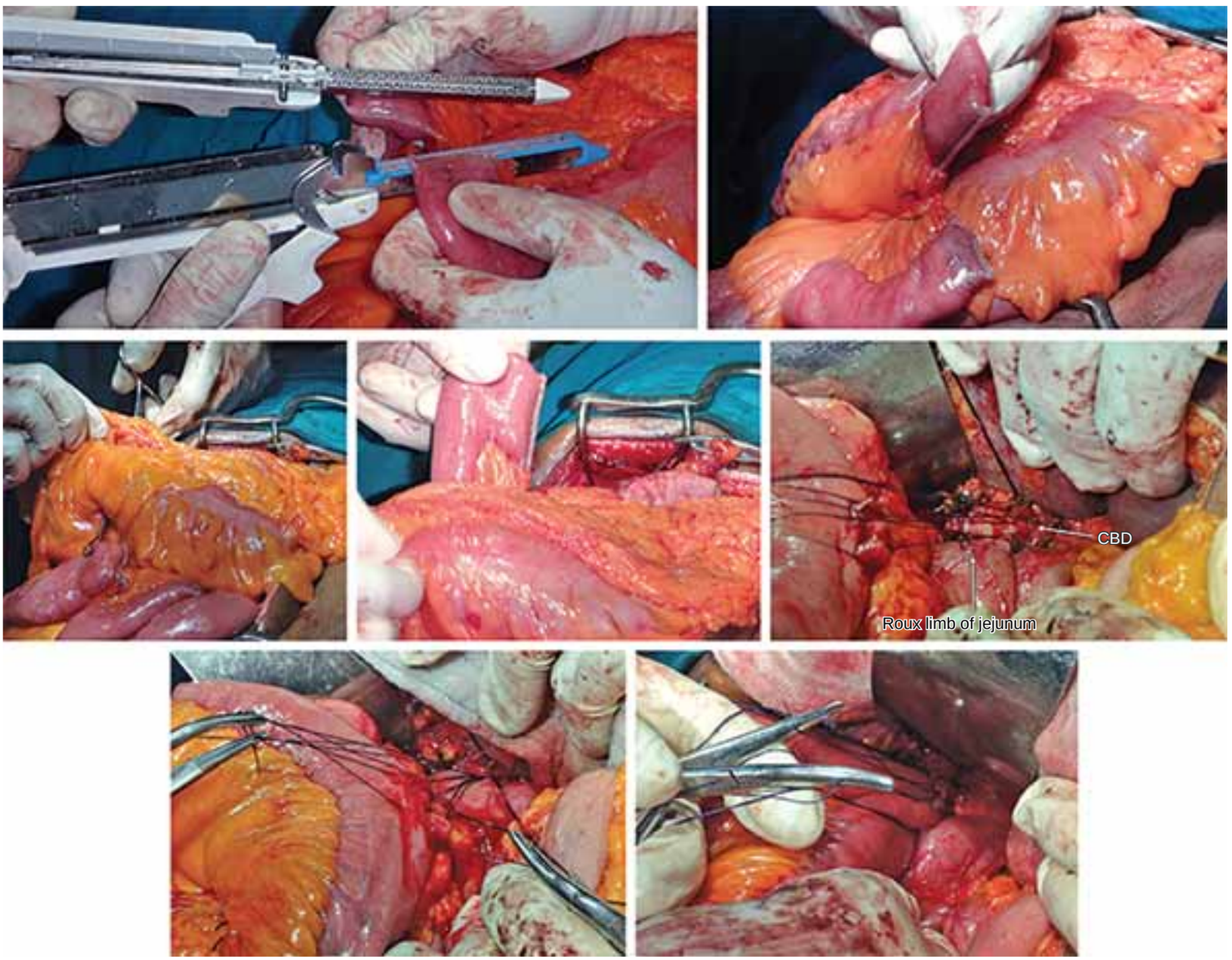


Fig. 22-122: Creation of Roux jejunal loop.

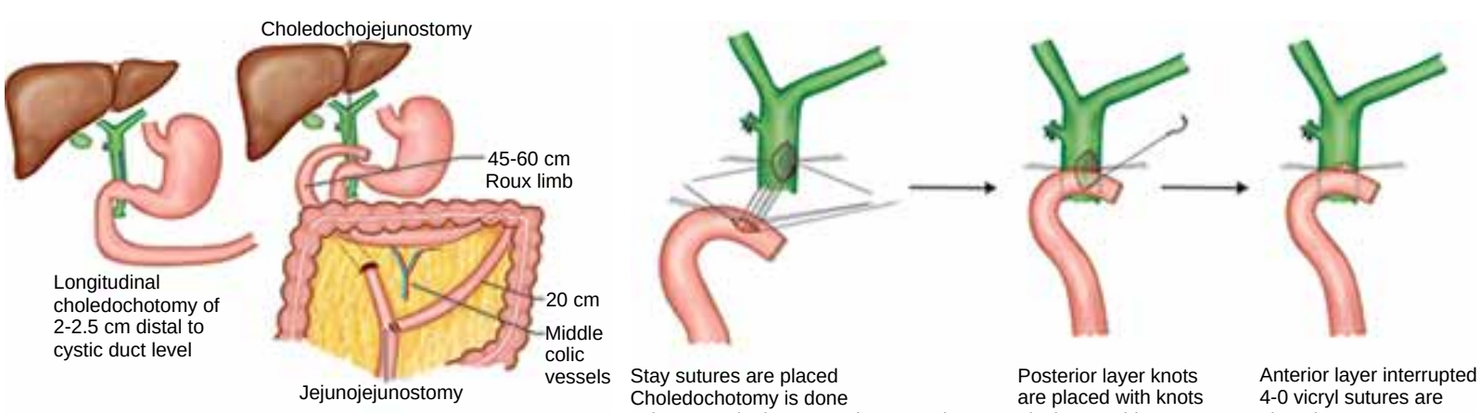
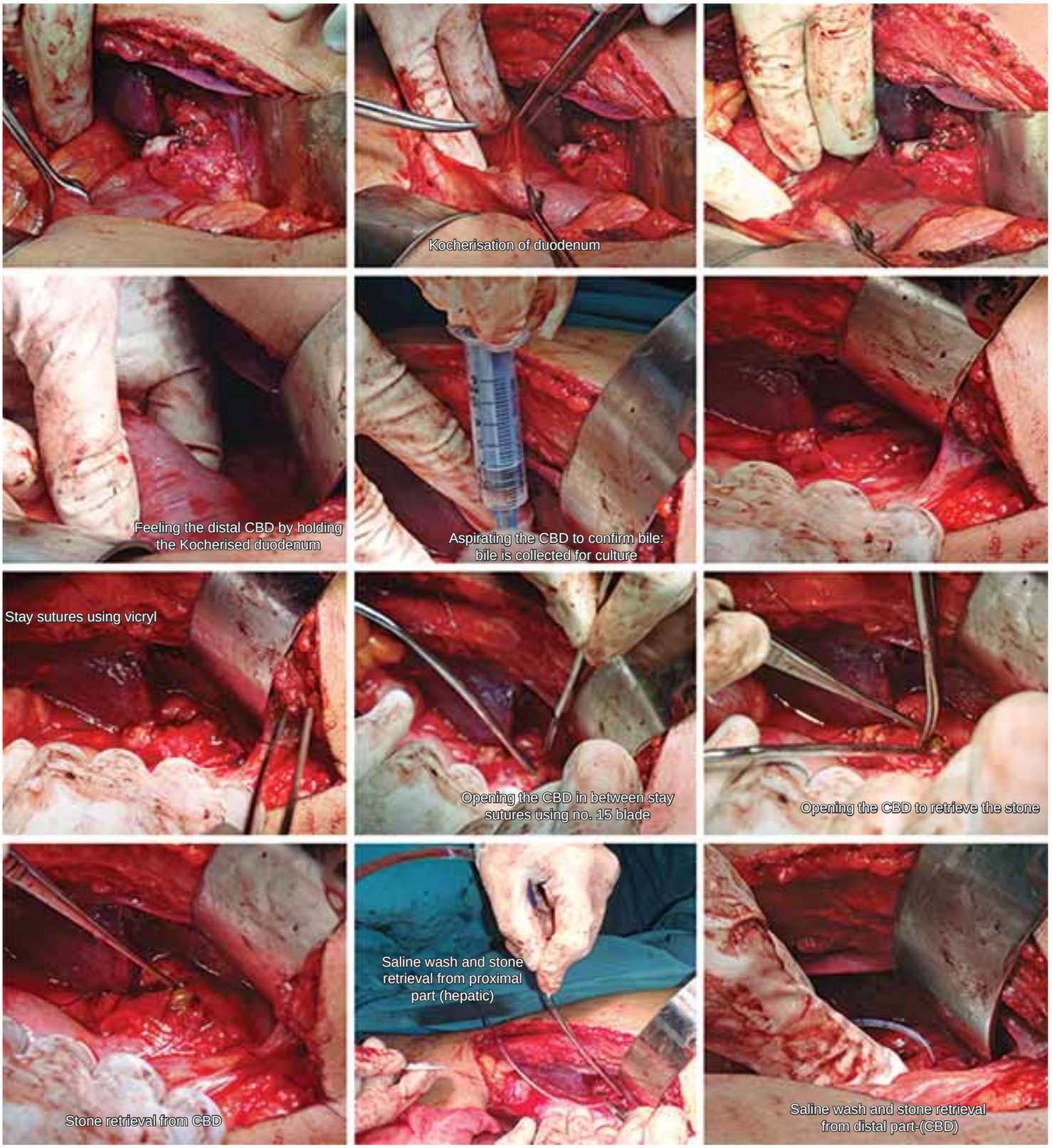


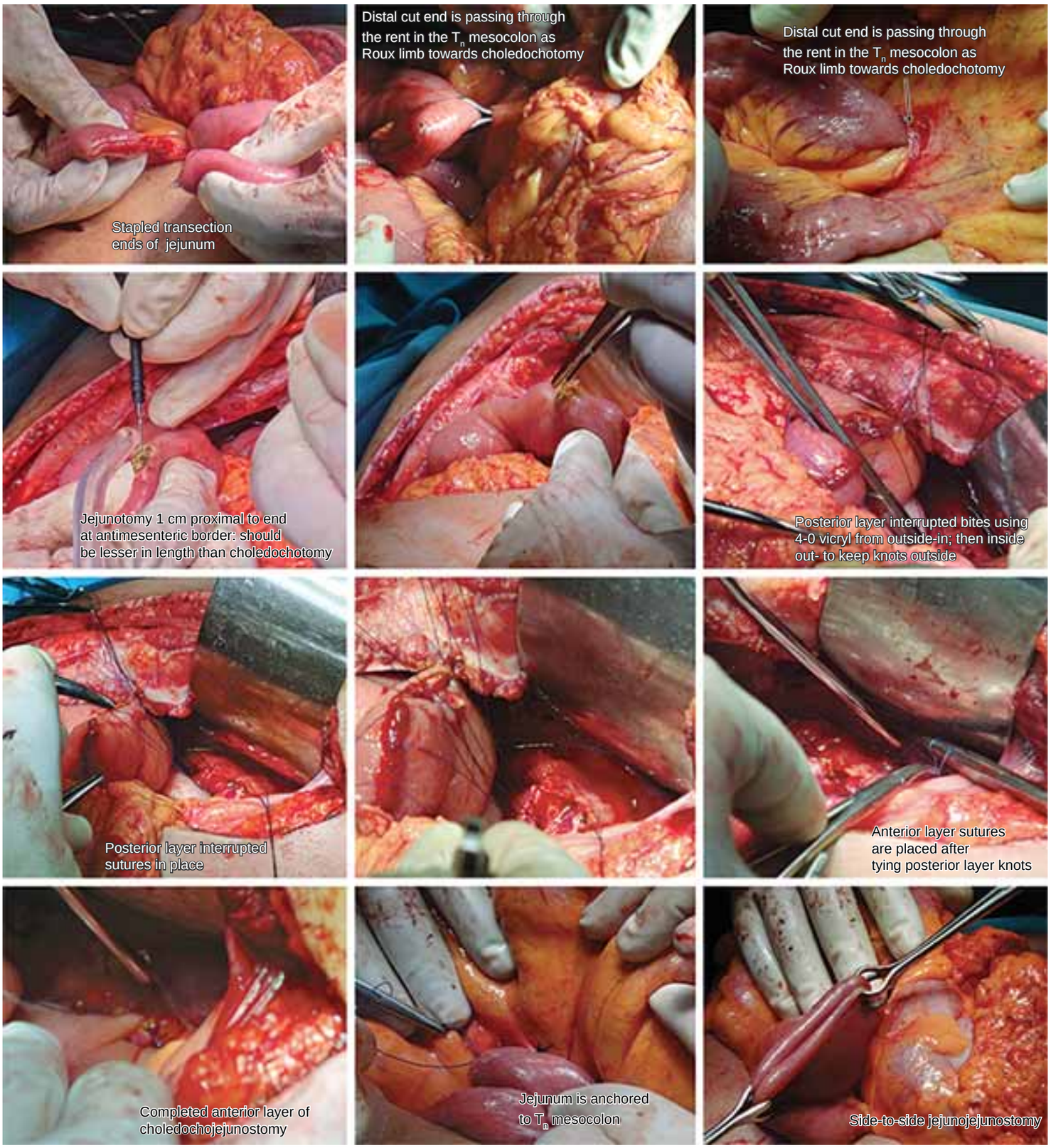
Fig. 22-123: Choledochojejunostomy technique.


Kocherisation of duodenum
Feeling the distal CBD by holding the Kocherised duodenum
Aspirating the CBD to confirm bile: bile is collected for culture
Stay sutures using vicryl
Opening the CBD in between stay sutures using no. 15 blade
Opening the CBD to retrieve the stone
Stone retrieval from CBD
Saline wash and stone retrieval from proximal part (hepatic)
Saline wash and stone retrieval from distal part-(CBD)

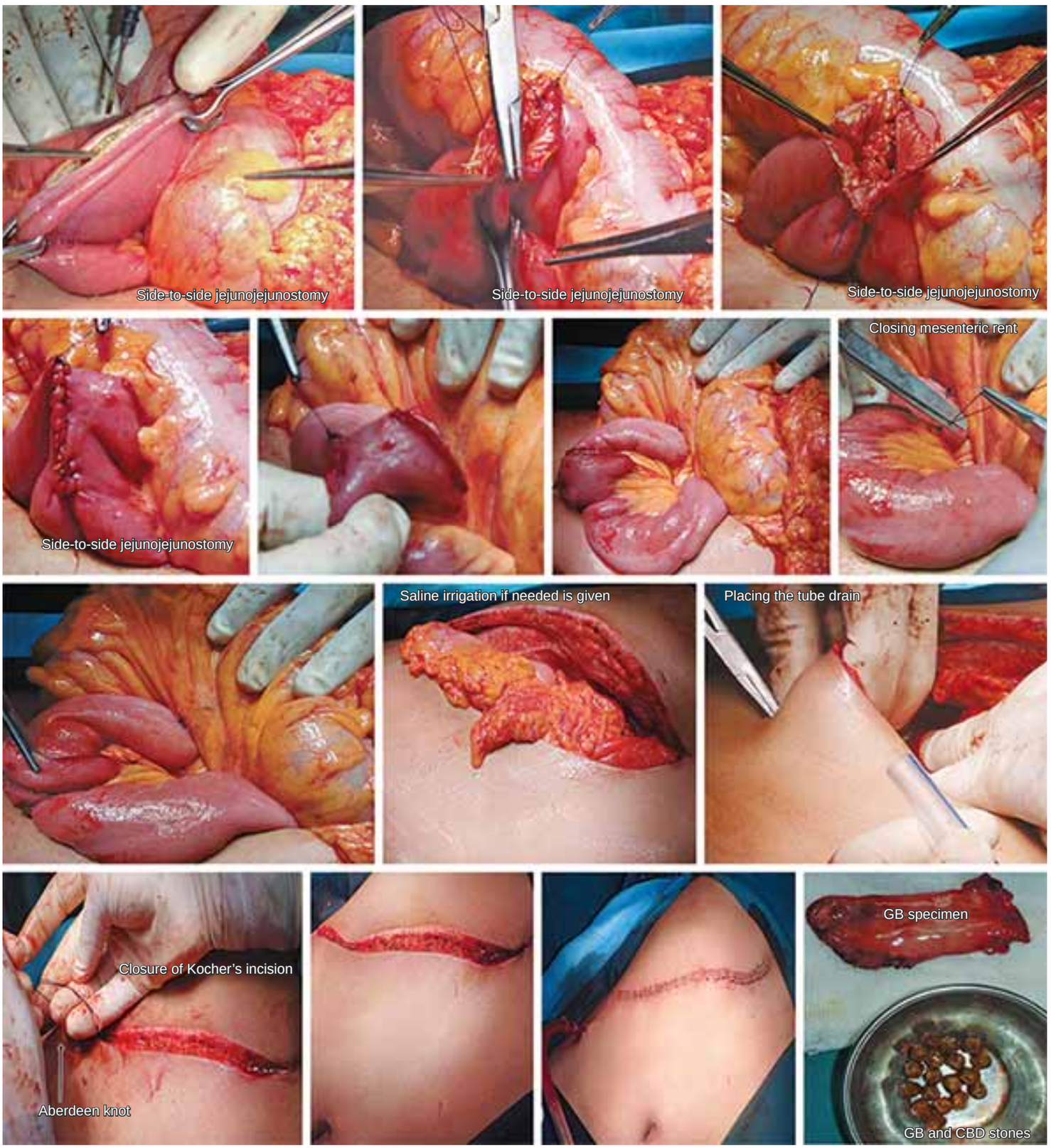
Figs 22-124(1)

ERCP stent removed
Doing scopy to visualise
distal CBD using no 4 or 5 f rigid scope
(Rigid choledochoscopy)
Scope inside the CBD
CBD
Choledochoscope is
done from left side
Identifying the DJ junction
Opening the T_n mesocolon
right of the middle colic vessels
Transillumination test
to check the jejunal vascular arcade
Arcade is carefully ligated
20 cm from DJ jn
Stapler for transection
of the jejunum
Cartridge placement
Placing and locking the
cartridge across the jejunum
Firing the cartridge

Figs 22-124(2)


Stapled transection ends of jejunum
Distal cut end is passing through the rent in the T_n mesocolon as Roux limb towards choledochotomy
Distal cut end is passing through the rent in the T_n mesocolon as Roux limb towards choledochotomy
Jejunotomy 1 cm proximal to end at antimesenteric border: should be lesser in length than choledochotomy
Posterior layer interrupted bites using 4-0 vicryl from outside-in; then inside out- to keep knots outside
Posterior layer interrupted sutures in place
Anterior layer sutures are placed after tying posterior layer knots
Completed anterior layer of choledochojejunostomy
Jejunum is anchored to T_n mesocolon
Side-to-side jejunojejunostomy

Figs 22-124(3)



Figs 22-124(4)

Figs 22-124(1 to 4): Choledochotomy, choledochoscopy, Roux-en-Y side to side choledochojejunostomy with side-to-side enteroenterostomy. Here stapler is used initially to transect the jejunum.

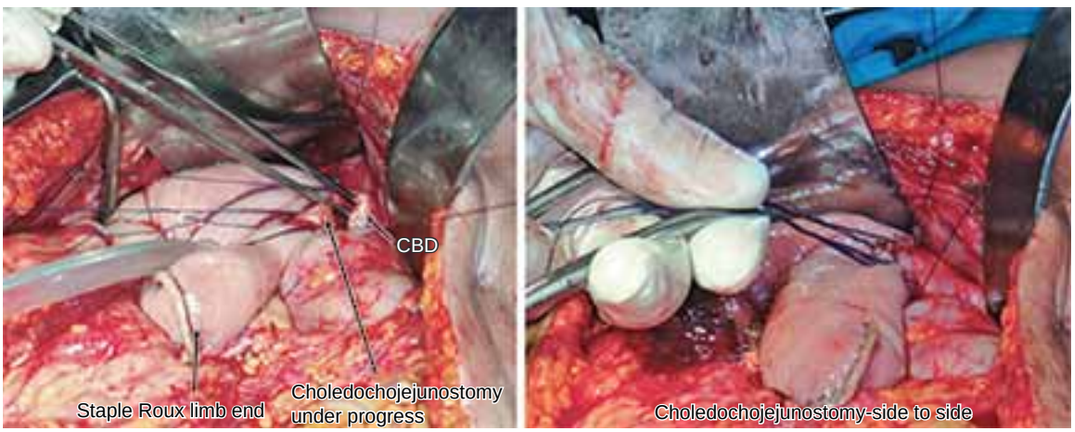


Fig. 22-125: Roux-en-Y side-to-side choledochojejunostomy.

End-to-end anastomosis can be done if CBD diameter is wider. It is done in malignancy with obstruction either after resection or as palliative procedure. Technique is similar like end-to-end anastomosis. Knots are placed outside. Interrupted vicryl sutures are placed.

Side-to-end anastomosis is also can be done between side of bile duct to end of Roux limb provided bile duct is sufficiently dilated **(Fig. 22-126)**.

Stenting of the choledochojejunostomy or hepaticojejunostomy is done often by many but is not mandatory. When it is done, it is brought out through the Roux jejunal limb outside and then through a stab wound through abdomen. T-tube may be passed which is brought out through bile duct proximally. It is usually not necessary. Stenting across the stoma through as biliary radicle across the liver to bring out through the abdominal wall is also practiced but may damage biliary tree and may cause bleeding or haemobilia.

Enteroenterostomy is done 60 cm distal to the stoma to complete the Roux-en-Y anastomosis. This is usually end-to-side either hand sewn or stapler. If initial transection was stapler one; then without dismantling original one, a side to side enteroenterostomy can be done **(Figs 22-127 and 22-128)**.

There is usually not necessary to keep a stent through the choledochojejunostomy. If needed no 8 French tube can be passed across the stoma to reach the efferent loop and is brought out through

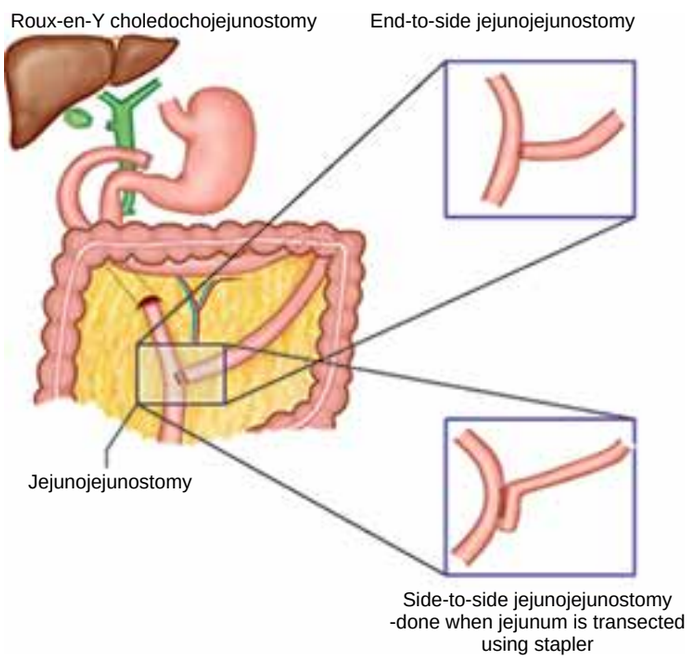
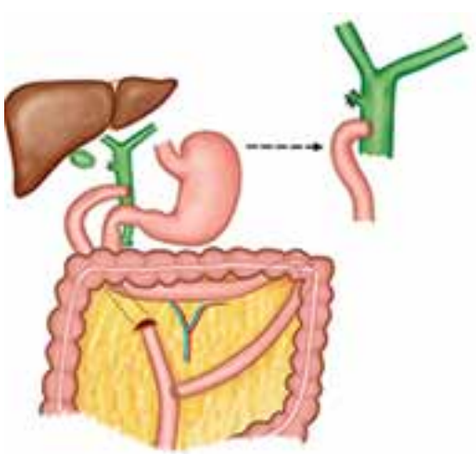


Fig. 22-127: Types of jejunojejunostomy done in Roux-en-Y anastomosis—side-it-side or end-to-side.



Choledochojejunostomy - side to end type; it is done when CBD is dilated very much so that end of the jejunum can be directly anastomosed

Fig. 22-126: Choledochojejunostomy side-to-end.

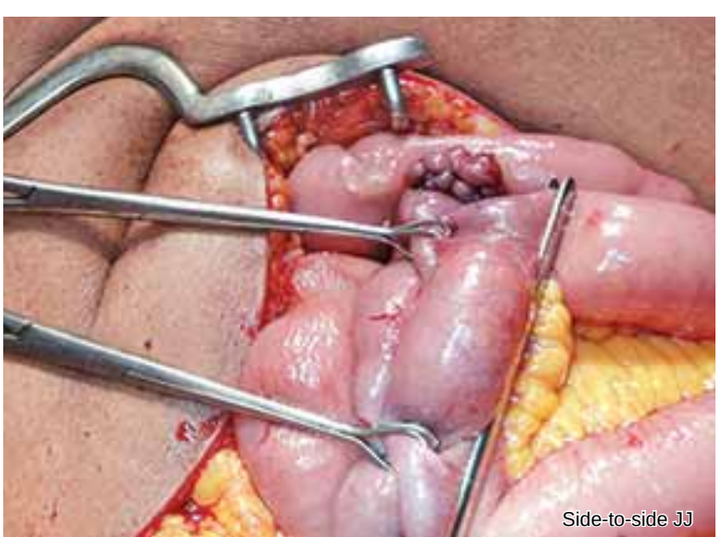


Fig. 22-128: Side-to-side jejunojejunostomy.

a small stab incision in the antimesenteric border which is fixed to parietal wall. Finally tube is brought out through a separate stab wound on the abdominal wall. But displacement, falling of the tube is common.

Hepaticojejunostomy after resection is usually end-to-side of Roux loop **(Fig. 22-129)**. It is also often used in trauma. Here biliary enteric anastomosis is achieved by anastomosing into the right and left hepatic ducts. Often confluence of the right and left hepatic ducts to form common hepatic duct is intrahepatic; it is approached at the base of the segment four by cutting the bridging liver tissue between umbilical fissure and segment 4 liver lobe (quadrate). Through same approach left hepatic duct is approached. Technique of anastomosis is similar – interrupted 4-0 vicryl or PDS posterior layer knots will come outside; as well as anterior layer knots. It is always better to keep the knots outside rather than inside even though many contemplate that inside knots are safer. Approaching left hepatic duct is called as Hepp-Couinaud technique **(Fig. 22-130)**.

If there is duodenal obstruction, gastrojejunostomy also should be done to prevent gastric outlet obstruction which may call for 2nd surgery at a later period. Duodenal obstruction occurs especially when there is associated pancreatitis **(Fig. 22-131)**.

Access loop: Often access loop is used to reach the biliary system. It is done by keeping more length of the distal blind end of the Roux limb to bring close to the abdominal wall and fix it; whenever needed this can be opened and stoma and biliary system can be reached through endoscope. Alternatively Roux blind end can be anastomosed to pylorus near lesser curve which can be used as access to biliary system through endoscope **(Fig. 22-132)**.

Loop choledochojejunostomy with enteroenterostomy (Braun) is not commonly advocated. It is technically easier; there is no transection of the jejunum and dissection of mesenteric arcade. It was the common procedure in olden days. Often when it is done few plication sutures are placed to afferent limb to prevent food getting entered into biliary system (to avoid cholangitis)—Kenneth Warren stitch. Loop anastomosis is done nowadays to gallbladder while doing cholecystojejunostomy in advanced malignancies with dilated patent gallbladder **(Fig. 22-133)**.

Fig. 22-129: Hepaticojejunostomy Roux-en-Y anastomosis.

RADICAL/EXTENDED CHOLECYSTECTOMY

It is done in operable cases of carcinoma of gallbladder.

Cholecystectomy with resection of liver segments IV and V—*extended cholecystectomy with perihepatic nodal clearance*. At least 2 cm margin in the liver from the gallbladder bed should be cleared. All pericholedochal lymph nodes should be removed. Frozen section biopsy from cystic duct stump should be done to identify for the existence of microscopic tumour. If present, CBD resection and hepaticojejunostomy is done. *Open approach* rather than laparoscopic is ideal for carcinoma gallbladder. Hemihepatectomy with cholecystectomy with nodal clearance.

If patient has undergone laparoscopic cholecystectomy and histology confirmed carcinoma, then staging should be done. All port areas should be reexcised to prevent *port site recurrence*. Often extended resection of segment IV and lymph nodes may be needed. Spillage of bile during laparoscopic cholecystectomy is common (30% in non-malignant GB, 50% in carcinoma GB).

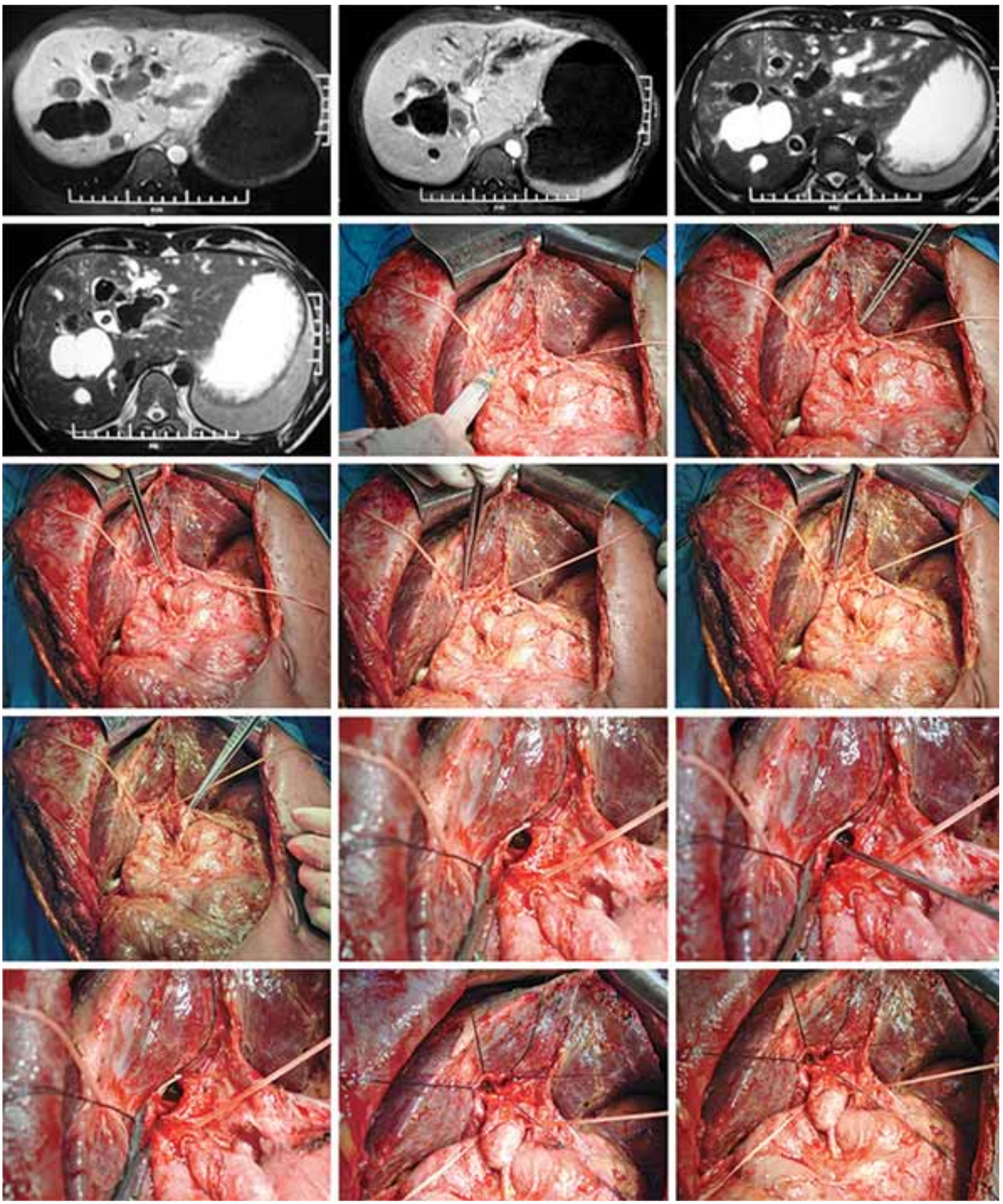
Incision is Kocher's incision with extension upwards on its medial aspect or towards opposite side. Initial exploration is done for tumour extent, nodal status, and liver secondaries. Once it is felt that operable extended cholecystectomy is done. Here approach is totally different from traditional approach of cholecystectomy. Liver at gallbladder bed 2 cm away from the bed is marked on the surface; stay sutures are placed on this line and away correspondingly on the liver side. Liver is dissected between these two parallel stay sutures with classic methods—finger reaction, bipolar, ligating or clipping the biliary ductules. Ductules are ligated using 4-0 polypropylene sutures. It is deepened towards the neck of the gallbladder and Calot's triangle. One should not injure posterior sectional/sectorial duct which may come on its way. All lymph nodes are cleared at Calot's, perihepatic and on the bile duct. Cystic artery and duct is ligated close to right hepatic artery and bile duct. Duct margin is sent for frozen section biopsy. If negative wound is closed with a tube drain. If positive then common bile duct is excised (resection of CBD) along with hepaticojejunostomy **(Fig. 22-134)**.

TREATMENT OF BILE DUCT CARCINOMA/ CHOLANGIOCARCINOMA

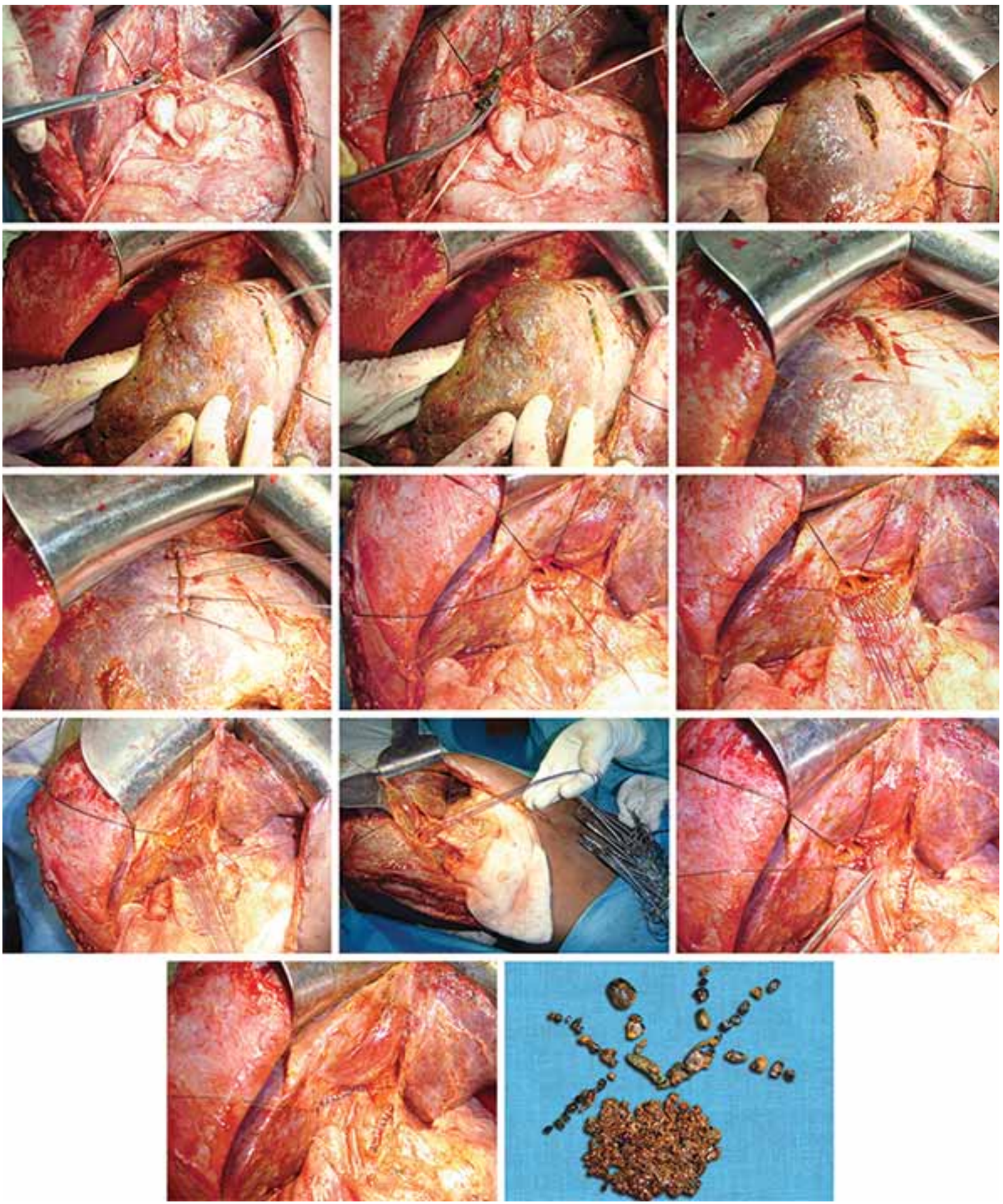
When operable (only 5%), portal region clearance with hemihepatectomy can be done. *Intrahepatic type* is treated with hemihepatectomy. *Perihilar* is treated with hemihepatectomy or extensive bile duct resection, nodal clearance, caudate lobe removal, cholecystectomy. Distal tumour is treated with Whipple's pancreaticoduodenectomy.

Staging laparoscopy with a laparoscopic ultrasound is done. Laparotomy is done if operable with bilateral subcostal with xiphisternum extension (Mercedes Benz incision); on table ultrasound and Doppler is needed to rule out liver metastases and vascularity of the tumour. Celiac axis and hepatoduodenal lymph node dissection is done; CBD is resected distally and frozen section of the distal margin is done; if positive then pancreaticoduodenectomy is added. Hemihepatectomy is often added. Hepatic artery or portal vein involvement needs its resection and vascular grafts for reconstruction with saphenous or external iliac vein. Remnant hepatic duct is sutured to jejunum as Roux-en-Y hepaticojejunostomy using 7-0 PDS.

Most often it is inoperable. Stenting can be done to relieve jaundice, through PTC or ERCP or on table. Chemotherapy—5 FU; gemcitabine,

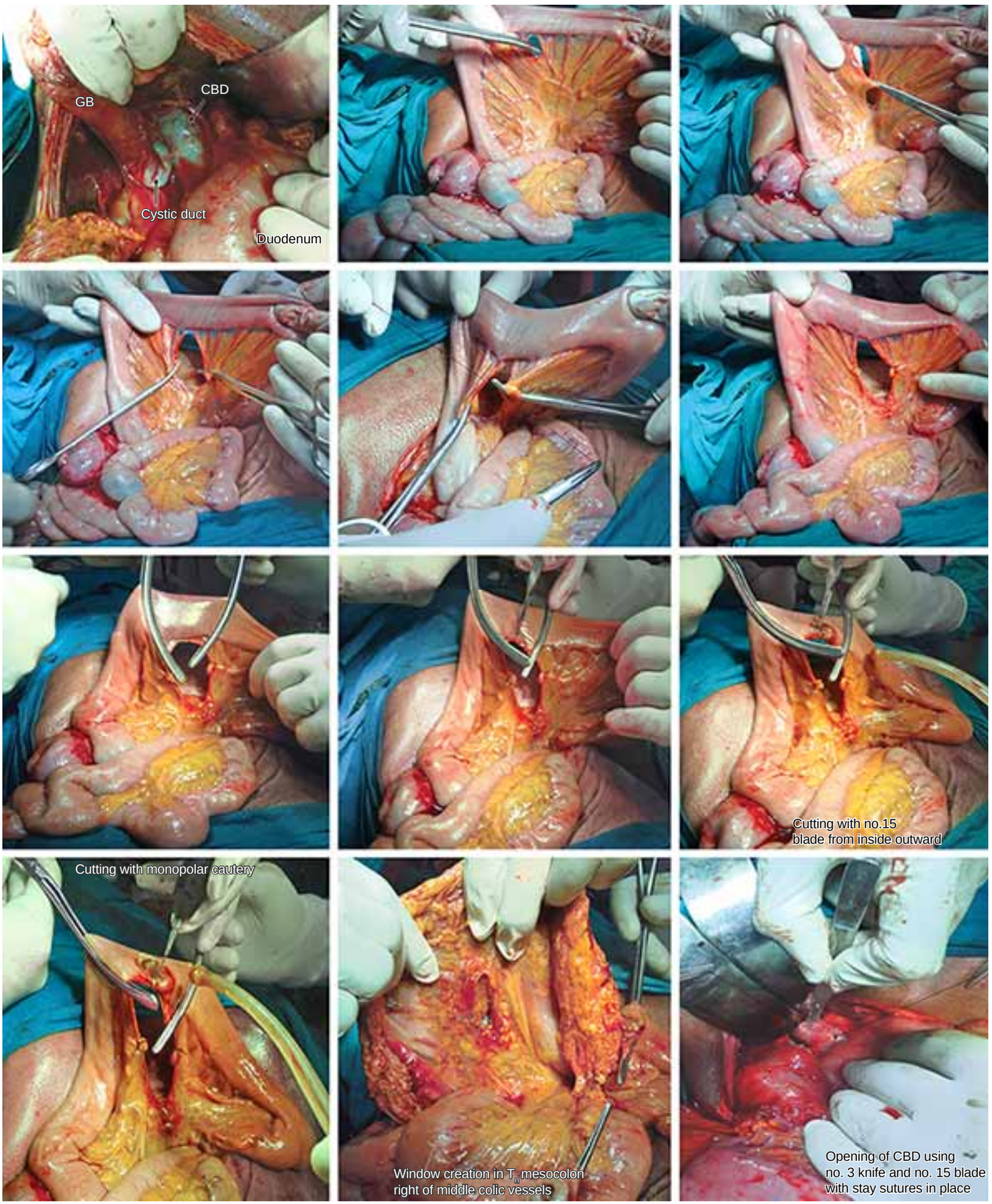


Figs 22-130(1)

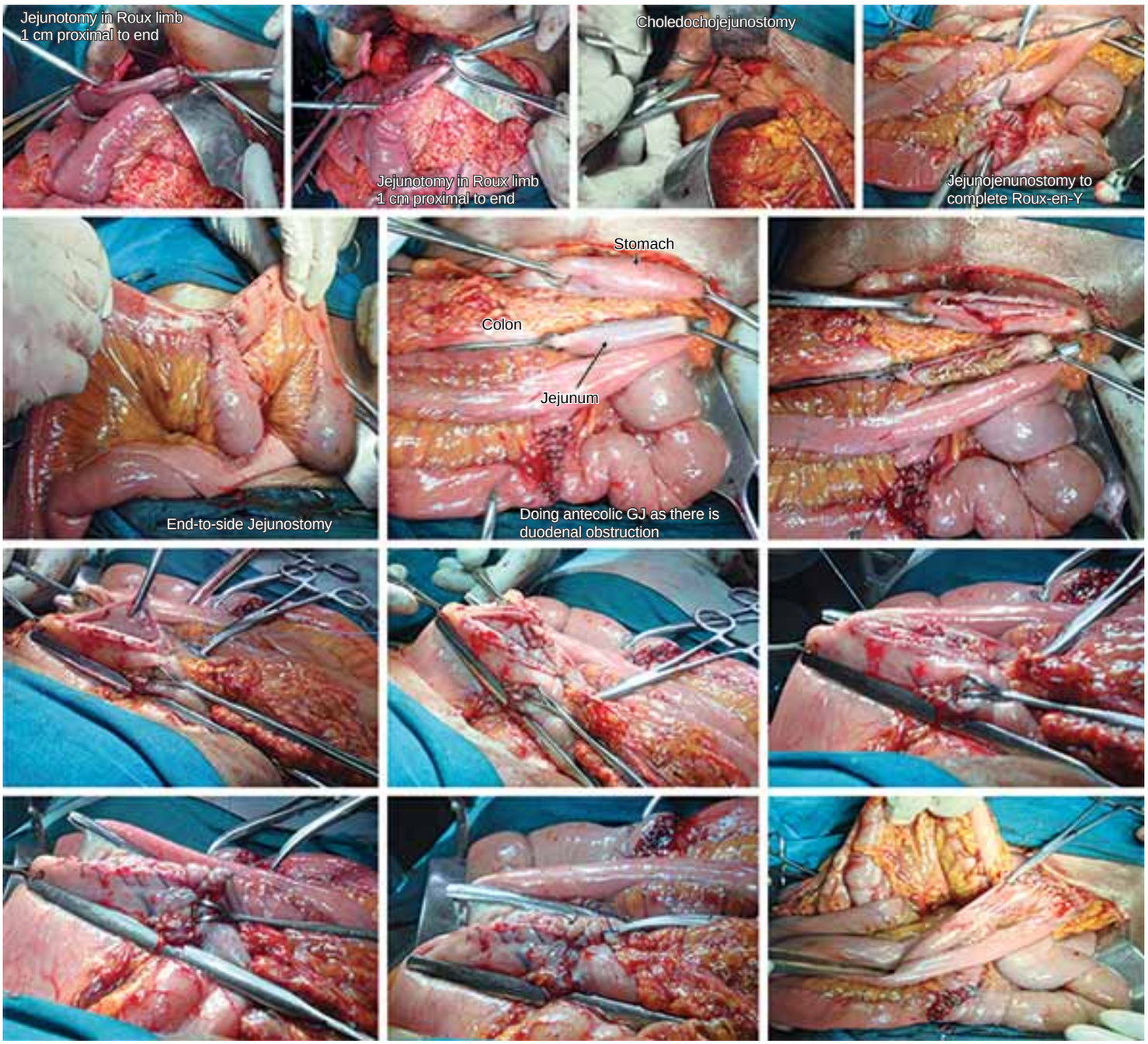


Figs 22-130(2)

Figs 22-130(1 and 2): Redoing of hepaticojejunostomy for retained stones in the hepatic ducts and intrahepatic biliary system (By Dr Arunkumar, Mch GI surgeon).


GB
CBD
Cystic duct
Duodenum
Cutting with no.15 blade from inside outward
Cutting with monopolar cautery
Window creation in T_0 mesocolon right of middle colic vessels
Opening of CBD using no. 3 knife and no. 15 blade with stay sutures in place

Figs 22-131(1)



Figs 22-131(1)

Figs 22-131(1 and 2): Choledochojenunostomy (Roux-en-Y) with gastrojejunostomy (GJ) for duodenal obstruction.

cis platin; chemotherapy with external beam radiotherapy (ERBT) are other options.

Klatskin Tumour

It is cholangiocarcinoma at the confluence of the hepatic ducts and common hepatic duct above the level of the cystic duct (20% of cholangiocarcinomas). *It causes obstructive jaundice with hydrohepatosis without enlargement of gallbladder.* Management is like cholangiocarcinoma. Hilar resection with hepaticojejunostomy; segment III left hepaticojejunostomy—Blumgart's; Longmire's left hepaticojejunostomy after left liver lobe resection; Cattell's hepaticojejunostomy; Smith's mucosal graft hepaticojejunostomy; Palliative PTC with stenting/ERCP stenting, intraoperative stenting. Metal stents show long period of patency (12 months) than polyethylene stents (4 months) **(Fig. 22-135)**.

BILE DUCT INJURIES

Causes

Cholecystectomy—open or laparoscopic; trauma; instrumentation—ERCP, baby endoscope, choledochoscope; other surgeries—pancreatic, duodenal, gastric; anomalous biliary system increases the risk of injury.

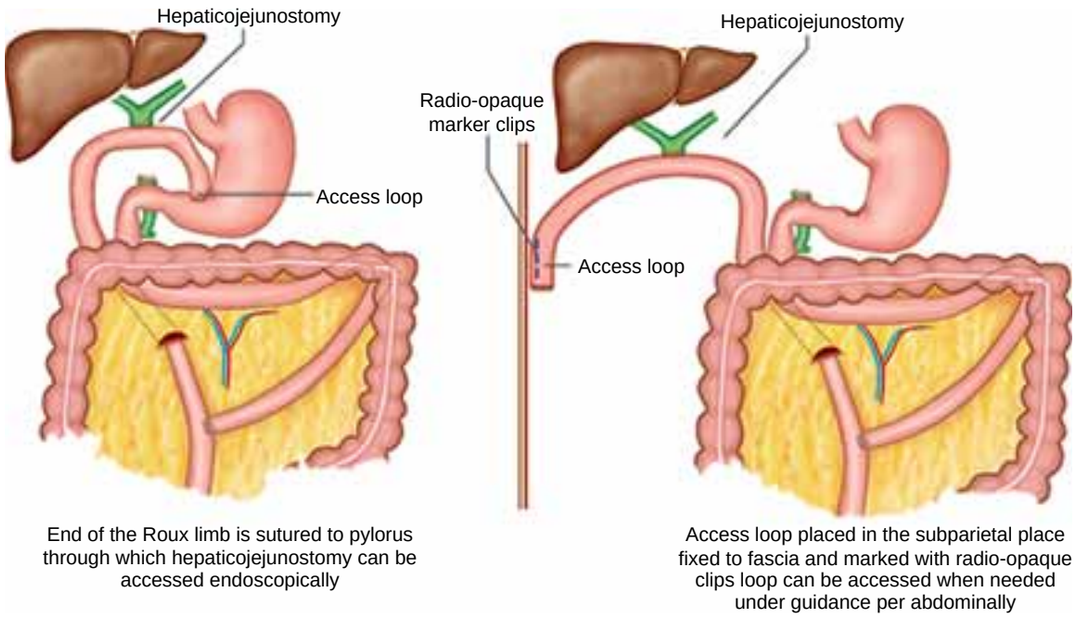

Hepaticojejunostomy
Access loop
Hepaticojejunostomy
Radio-opaque
marker clips
Access loop
End of the Roux limb is sutured to pylorus through which hepaticojejunostomy can be accessed endoscopically
Access loop placed in the subparietal place fixed to fascia and marked with radio-opaque clips loop can be accessed when needed under guidance per abdominally

Fig. 22-132: Hepaticojejunostomy access loop – two approaches.

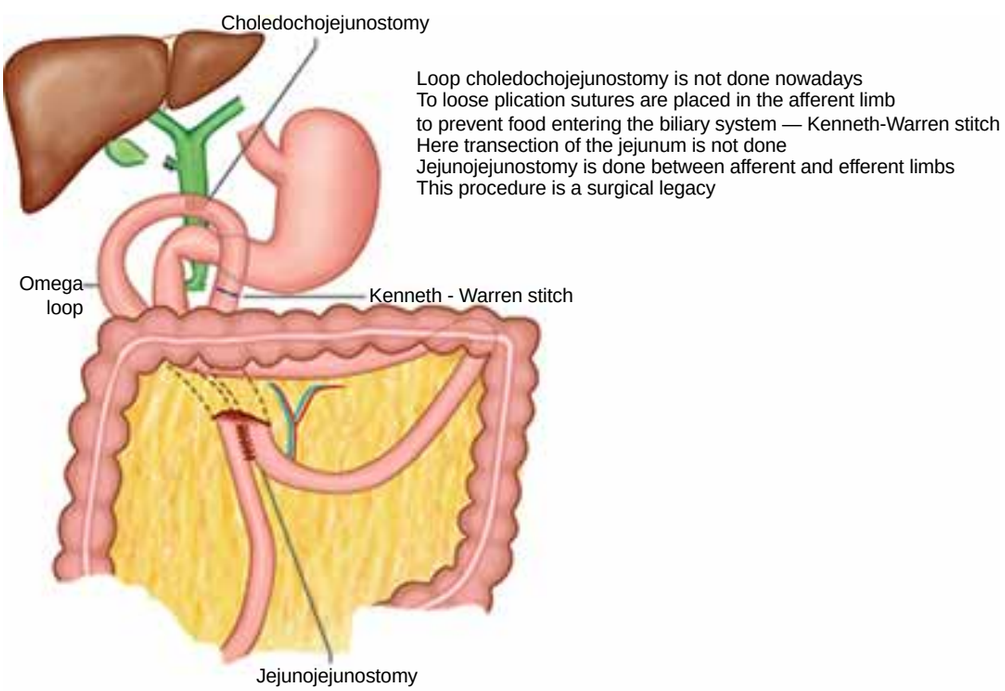

Choledochojejunostomy
Loop choledochojejunostomy is not done nowadays
To loose plication sutures are placed in the afferent limb
to prevent food entering the biliary system — Kenneth-Warren stitch
Here transection of the jejunum is not done
Jejunojejunostomy is done between afferent and efferent limbs
This procedure is a surgical legacy
Omega
loop
Kenneth - Warren stitch
Jejunojejunostomy

Fig. 22-133: Loop choledochojejunostomy with enteroenterostomy. It is not advocated commonly now.

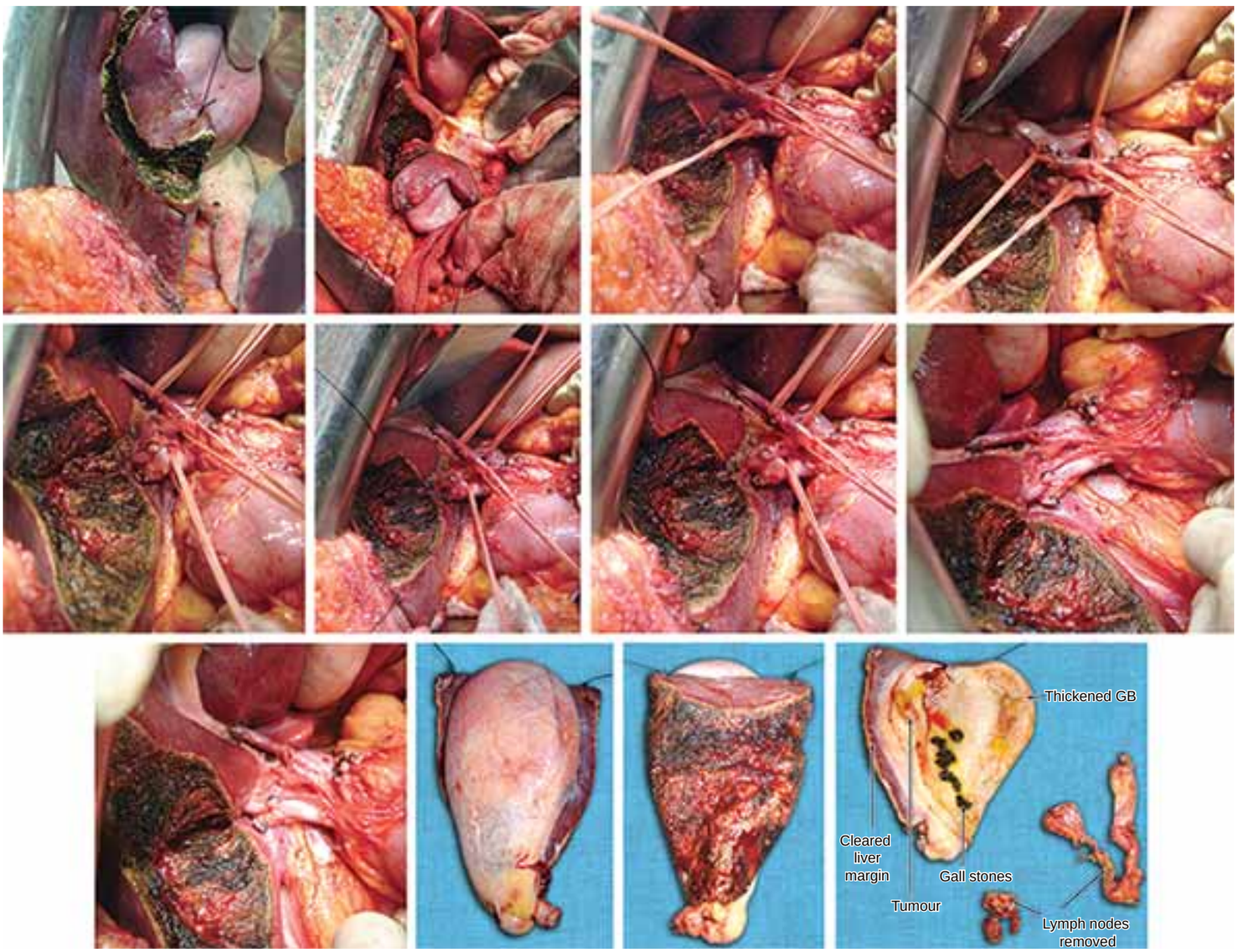
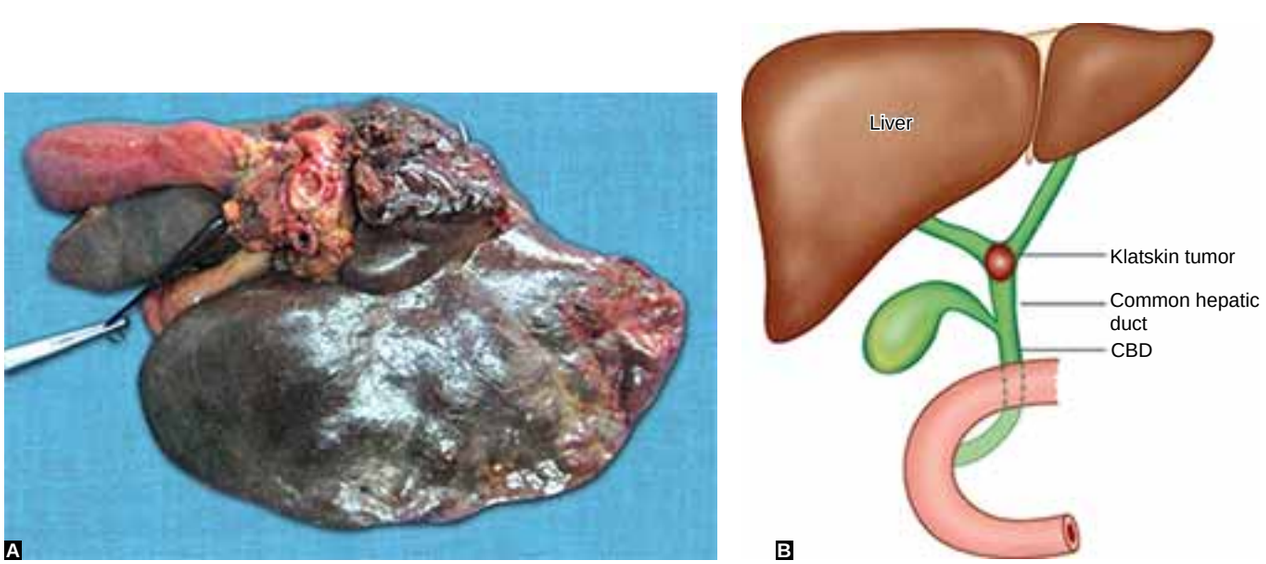


Fig. 22-134: Extended cholecystectomy for gallbladder carcinoma. (By Dr Arunkumar, Mch GI surgeon).



Figs 22-135A and B: Klatskin tumour; its location (A), and resected specimen (B).

Classifications

Strasberg classification

- Class A: Bile leak from the cystic duct or an accessory duct showing continuity with the common bile duct.
- Class B: Section/injury of an accessory duct/sectorial ducts/aberrant right hepatic duct with no continuity with the common bile duct with occlusion.
- Class C: Leak/open drainage from a sectorial duct/aberrant right hepatic duct with no continuity with the common bile duct.
- Class D: Partial section/lateral injury of an extrahepatic duct/bile duct with no complete loss of continuity with the rest of the bile duct system.
- Class E: Complete section/circumferential injury of the bile duct with subtypes according to the length of the stump at various levels.
  - E1–Stricture/injury at more than 2 cm distal to bifurcation.
  - E2–Stricture/injury less than 2 cm distal to bifurcation.
  - E3–Stricture/injury at bifurcation.
  - E4–Stricture/injury involving right and left hepatic ducts.
  - E5–Complete obstruction of entire bile duct.

Note: Only right and left partial injuries are not included in this classification

Stewart-Way classification

This classification involves four strata based on the mechanism and anatomy of injury.

- Class I: It refers to the incomplete section of bile duct with no loss of tissue. It has a prevalence rate of 8%.
- Class II: It is a lateral injury of the common hepatic duct that leads to stenosis or bile leak. It is the consequence of thermal damage and clamping the duct with surgical staples. It has a prevalence of 2% with a concomitant hepatic artery injury in 20% of cases. T-tube related injuries are included within this class.
- Class III: It is the most common (60%) represents the complete section of the common hepatic duct. It is subdivided in to type IIIa, remnant common hepatic duct; type IIIb, section at the confluence; type IIIc, loss of confluence; and type IIId, injuries higher than confluence with section of secondary bile ducts. Associated injury of right hepatic artery occurs in 25% of cases.
- Class IV: It is right (65%) and accessory right (25%) hepatic duct injuries with associated injury of the right hepatic artery (60%). Occasionally, it includes the common hepatic duct injury at the confluence (5%) besides the accessory right hepatic duct lesion (prevalence of 10%).

Hannover classification (2007)

It classifies injuries in relationship to the confluence and also includes vascular injuries.

- Type A: It refers to cystic and/or gallbladder bed leaks.
- Type B is a complete or incomplete stenosis caused by a surgical staple.
- Type C represents lateral tangential injuries.
- Type D refers to complete section of the common bile duct emphasizing their distance to the confluence as well as the hepatic artery and portal vein concomitant injuries.
- Type E is late bile duct stenosis at different lengths to the confluence.

Note: *Bismuth classification* (for open surgery/prelaparoscopic era) is discussed in biliary stricture topic earlier.

Presentations

Fever, pain, bile stasis features like cholangitis, jaundice; 10% of laparoscopic bile duct injuries are identified on table; 30% with bile leak; 25% with obstructive jaundice; 30% with cholangitis. Patients with bile leak present early; with formed biliary stricture presents with jaundice and cholangitis months or years later.

Problems

Biliary fistula with electrolyte imbalance; biliary peritonitis, septicaemia; subphrenic abscess formation; *Biloma* formation; severe malnutrition, deficiencies; late - biliary cirrhosis, portal hypertension.

Investigations

LFT, coagulation profile; US abdomen, fistulogram; Dynamic CT scan will delineate the anatomy of injury; ERCP is useful if injury is only partial where stenting can also be done. PTC is the *investigation of choice* to identify site, nature, extent of stricture. It also facilitates drainage and stenting. Hepatobiliary scintigraphy may be useful. MRCP may be useful to identify ductal anatomy. CT arteriography is useful to identify associated hepatic artery or portal vein injury which is 20% in association with CBD injury.

Management

General: Antibiotics, nutrition, TPN.
Conservative: Small partial injury to CBD may resolve spontaneously or with the help of ERCP, sphincterotomy and stenting.

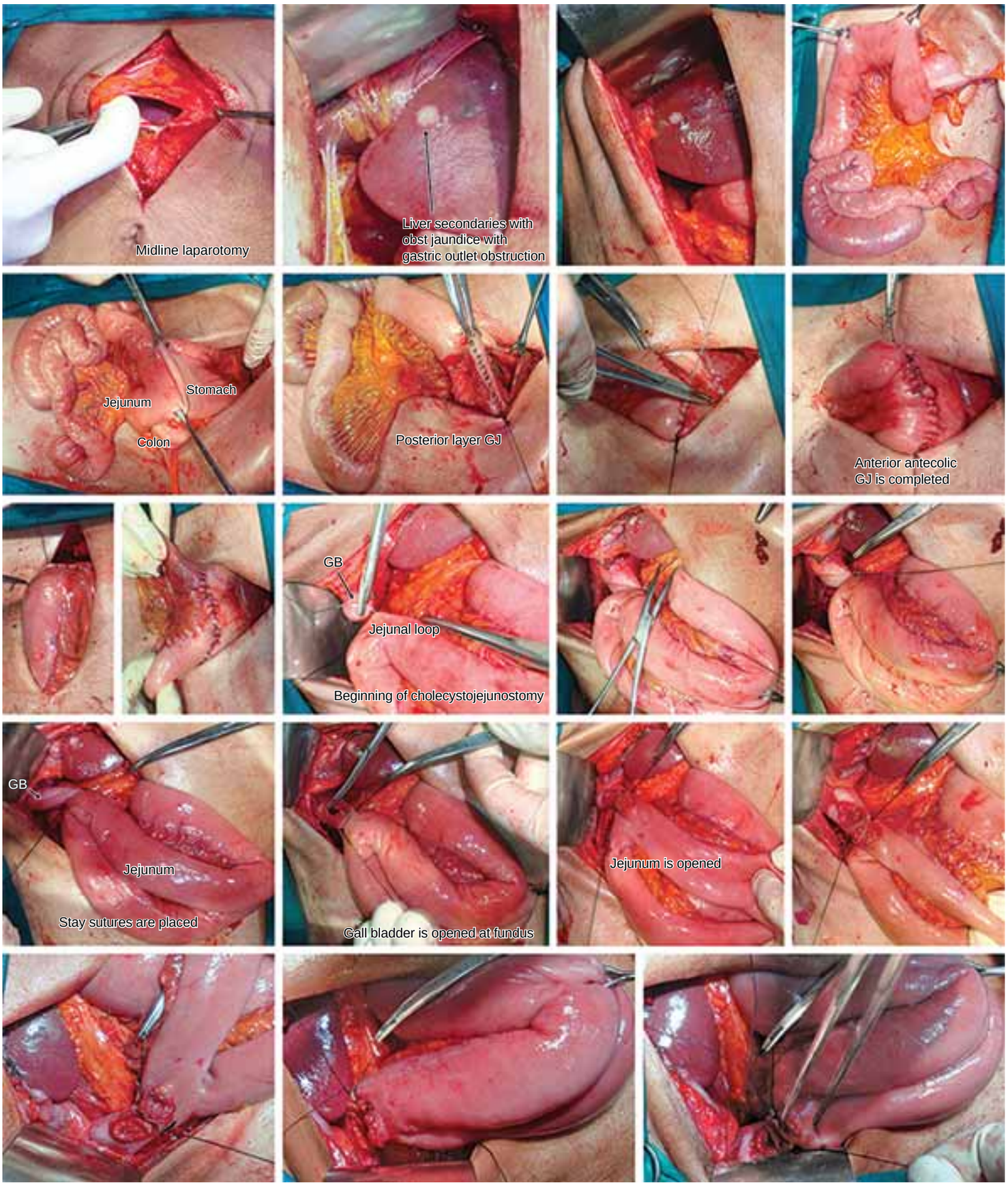
Management of biliary duct injury on table (during ***laparoscopic cholecystectomy***/open): Conversion into open with a lengthy subcostal/bucket handle incision. Intraoperative cholangiogram should be done. Partial injury of CBD less than 30% of circumference is treated with primary repair with a T-tube in place. Extensive injury more than 30% of the circumference or cautery injury or complete CBD transection should be treated with Roux-en-Y choledochojejunostomy. Isolated hepatic duct injury less than 3 mm in size should be ligated. More than 3 mm in size should be reimplanted or Roux-en-Y hepaticojejunostomy should be done. If facility for surgical repair is available, patient should be sent to a higher centre after placing a drain with abdomen closure.

Management of bile duct injury identified at a later period: In such situation it is better to wait for 6 weeks to subside inflammation which facilitates easier proximal CBD identification. After proper assessment of injury, Roux-en-Y choledochjojejunostomy or *Roux en Y hepaticojejunostomy* is done.

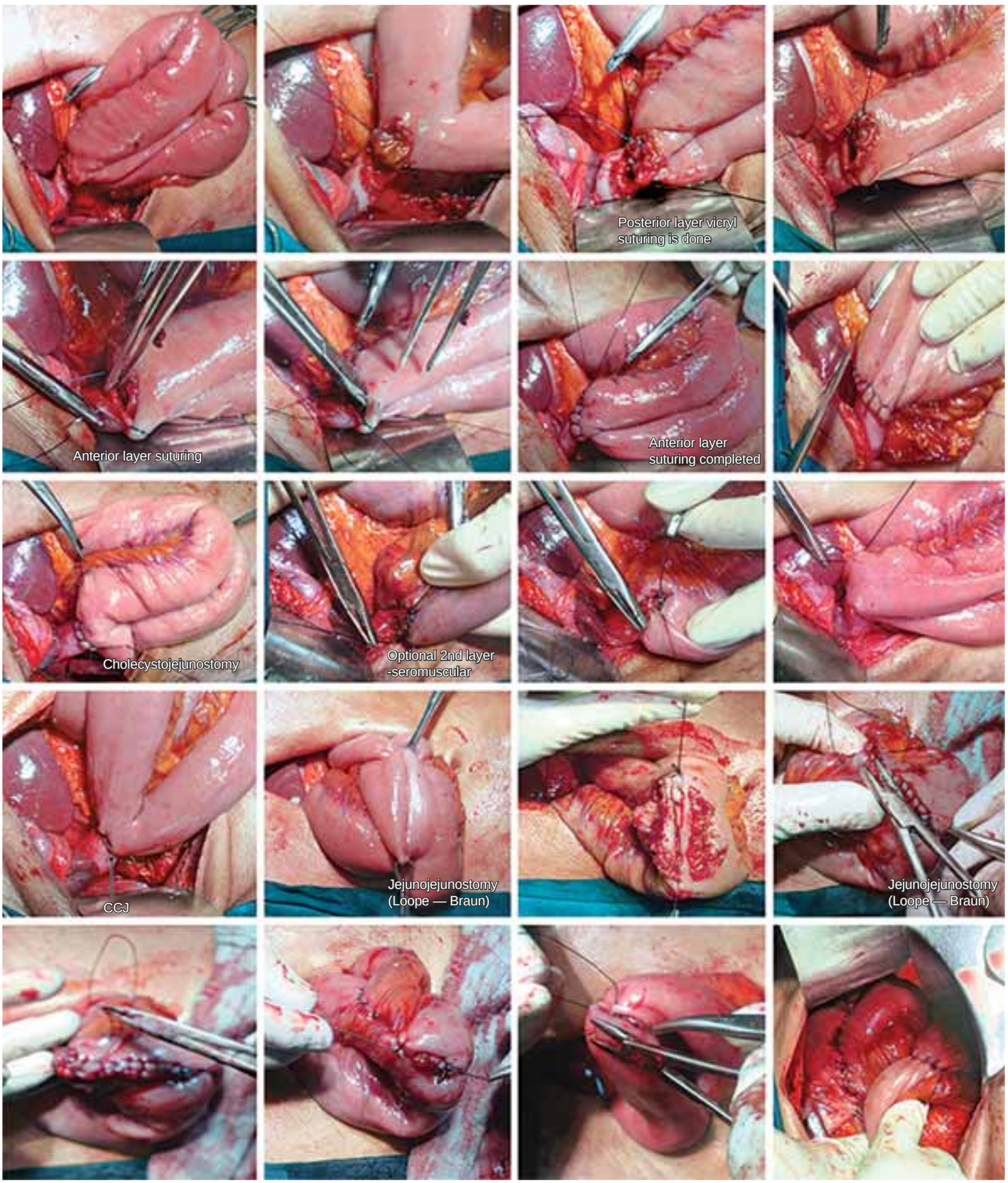
Hepp–Couinaud approach: Here hilar plate is meticulously dissected; left hepatic duct is anastomosed to Roux jejunal loop to create hepaticojejunostomy often with creation of proximal 'access loop' for future endoscopic approach. Complications are—recurrent cholangitis, bile leak from stoma, haemobilia, stenosis of biliary enteric anastomotic site (10%; occurs often after many years).

CHOLECYSTOJEJUNOSTOMY

It is not commonly advocated now. It is indicated in advanced pancreatic malignancy as a bypass as life expectancy in these patients is short. It is often combined with gastrojejunostomy whenever there is duodenal obstruction. It is a palliative procedure in obstructive jaundice due to advanced malignancy in head of pancreas or periampullary carcinoma. It is not done in benign disease and in conditions where long-term results are anticipated. It is possible to do only if there is patency of cystic duct and the common bile duct so that obstructive jaundice is relieved through patent cystic duct into jejunum. Additional enteroenterostomy is also done (Braun) **(Fig. 22-136)**.


Midline laparotomy
Liver secondaries with obst jaundice with gastric outlet obstruction
Jejunum
Stomach
Colon
Posterior layer GJ
Anterior antecolic GJ is completed
GB
Jejunal loop
Beginning of cholecystojejunostomy
GB
Jejunum
Stay sutures are placed
Gall bladder is opened at fundus
Jejunum is opened

Figs 22-136(1)



Figs 22-136(2)

Figs 22-136(1 and 2): Technique of palliative gastrojejunostomy and loop cholecystojejunostomy with jejunojejunostomy (Braun) as a palliative procedure. Patient has got liver metastasis.

Technique: Midline laparotomy is sufficient. First antecolic gastrojejunostomy is done to anterior wall of the stomach. Then next jejunal loop is selected for anastomosing into the fundus of the gallbladder. Gallbladder is aspirated to confirm presence of bile. Preoperative CT may be useful to assess cystic duct patency. It also can be confirmed by on table dye study. Stay sutures are placed between fundus of gallbladder and jejunal loop. Fundus is opened horizontally; jejunum is opened on its antimesenteric border little lesser size than that of fundus of gallbladder. Usually single layer is sufficient. However, if two layer anastomosis is planned, posterior seromuscular layer is placed using interrupted silk or vicryl sutures. Full thickness posterior seromucosal 2nd layer is sutured using continuous or interrupted 3-0 vicryl. Third layer full thickness anterior seromucosal layer is placed similarly; finally anterior seromuscular interrupted sutures are placed. Between afferent and efferent limb of the anastomosis enteroenterostomy is done using single layer continuous vicryl suture. Abdomen is closed in layers without drain. Nasogastric tube is removed after 72 hours. Jaundice will reduce in 10 days; patient can eat food as palliation.

Complications: Cystic duct may get blocked and jaundice will reappear. Severe cholangitis may develop.

TREATMENT OF CHOLEDOCHAL CYST

Types of choledochal cysts (Todani modification of Alonso-Lej classification) **(Fig. 22-137)**.
Type I: Dilatation of extrahepatic biliary tree (60%).
Type Ia—Cystic.
Type Ib—Focal segmental (saccular).
Type Ic—Fusiform.
Type II: Diverticulum of extrahepatic biliary tree (5%).
Type III: Choledochocoele—cystic dilatation of intraduodenal part of CBD (5%).
Type IV: Dilatation of extra- and intrahepatic or multiple parts of extrahepatic biliary tree (30%).
Type IVa: Dilatation of extrahepatic and intrahepatic biliary tree. It is 2nd most common.
Type IVb: Dilatation of multiple sections of the extrahepatic bile duct.
Type V: Dilatation of the only intrahepatic biliary tree (*Caroli's disease*) **(Figs 22-138 and 22-139)**.

Treatment

Choledochal cyst should be treated to avoid possible late complications of the cyst—cirrhosis, portal hypertension, abscess formation, malignant changes (cholangiocarcinoma).

Resection of extrahepatic biliary tree with removal of choledochal cyst along with cholecystectomy and Roux-en-Y hepaticojejunostomy is the ideal treatment for choledochal cyst especially types I, II and IVb. In Type I—excision of cyst with its mucosa and reconstruction by Roux-en-Y hepaticojejunostomy is done. In Type II—excision of the diverticulum and suturing of the CBD wall is done. In type III—endoscopic sphincterotomy is done. Excision is also often needed. Intrahepatic dilatation is difficult to treat. If it is localised, hepatectomy is sufficient, but if it is diffuse, liver transplantation may be required. In type IV if cyst is adherent to portal vein posteriorly, that part of the cyst wall over the portal vein is left behind. But mucosa of the part should be removed (*Lily's operation*). Liver resection is often necessary

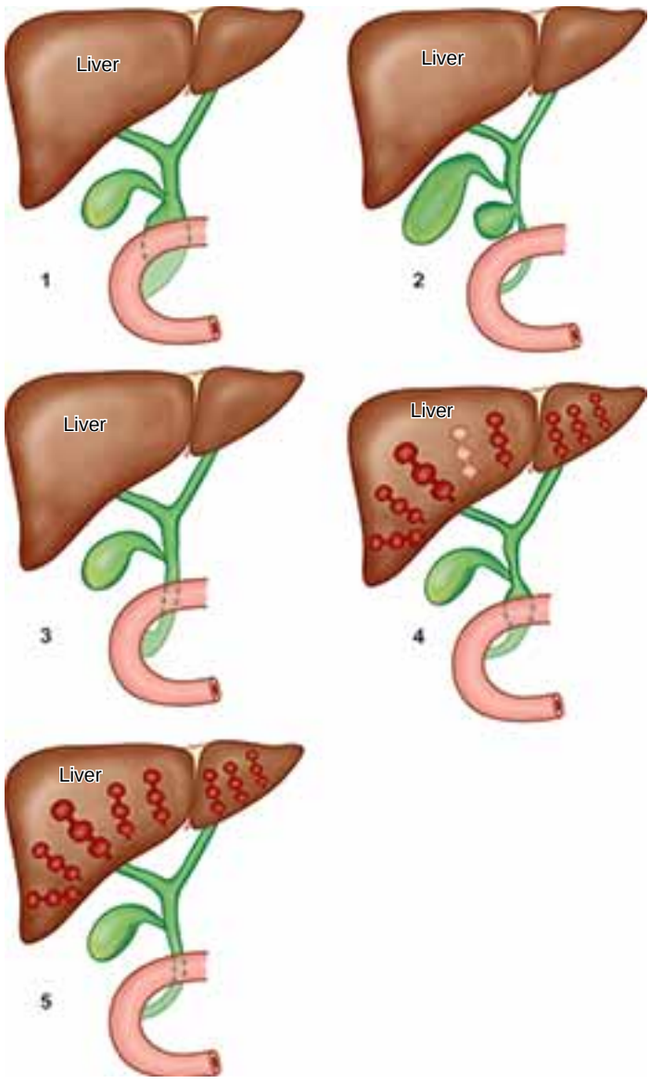


Fig. 22-137: Different types of choledochal cysts—(1) Fusiform type, (2) Saccular type, (3) Choledochocoele, (4) Fusiform + Intrahepatic type, (5) Intrahepatic type.

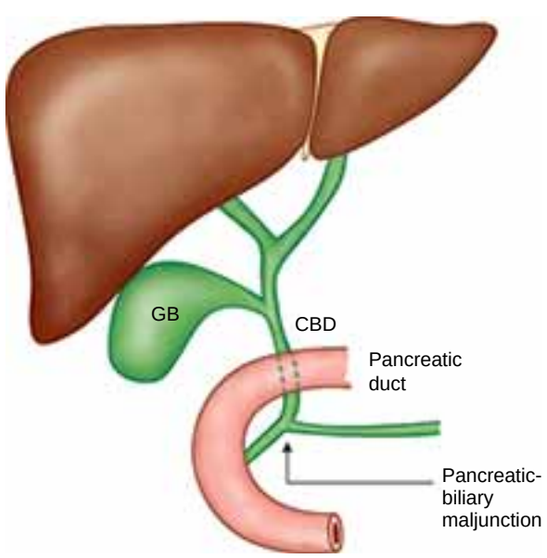


Fig. 22-138: Pancreaticobiliary maljunction. Here pancreatic duct joins CBD more proximally than normal causing reflux of pancreatic enzymes into the CBD. It leads into weakening, dilatation and choledochal cyst.

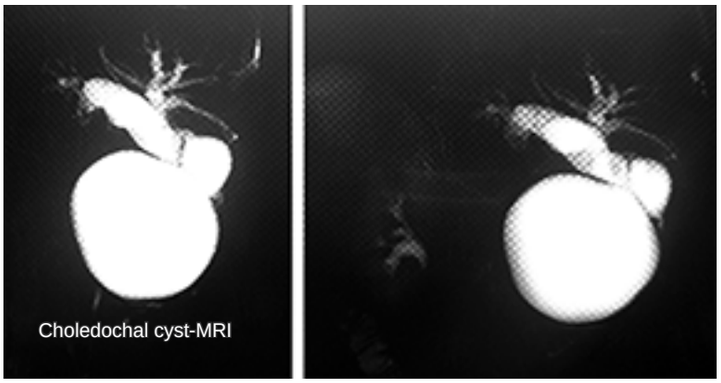


Fig. 22-139: MRI of choledochal cyst.

in type IV. Frozen section biopsy of the choledochal cyst should be done for possible chances of existing cholangiocarcinoma; if biopsy becomes positive then hepatic resection along with bile duct resection is needed. Caroli's disease needs liver transplantation.

When CBD excision with cholecystectomy is done; distal CBD is washed using cystoscope to remove all stones, debris. Level I excision will retain cyst mucosa; level II will be adequate; level III is likely to damage the pancreatic duct as there will be biliopancreatic malposition with pancreatic duct joining he bile duct much more proximally than normal **(Figs 22-140 and 22-141)**.

Note: Cystoenterostomy should not be done for choledochal cyst.

Complications of Surgery

Ascending cholangitis; formation of intrahepatic biliary stones; pancreatic stones formation; malignancy—cholangiocarcinoma; pancreatitis; liver disease and failure.

BILIARY ATRESIA—TREATMENT

Classification

Correctable—10%; Noncorrectable—90%.

Biliary Atresia

Type I: Atretic CBD—10%
Type II: Atretic CBD and common hepatic duct
Type III: Atretic CBD, common hepatic duct and right and left hepatic ducts—88% **(Fig. 22-142)**

Biliary atresia can be:

Perinatal acquired (70%) type is not associated with congenital anomalies. *Fetal/embryonic* (30%) is associated with congenital anomalies. It may be associated with other congenital anomalies (20%) of the GIT—(malrotation, annular pancreas duodenal atresia) and congenital heart diseases, polysplenia, situs inversus, absent vena cava, preduodenal portal vein.

Treatment

In correctable cases: Roux-en-Y jejunal anastomosis is done; In non-correctable cases, he aticoportojejunostomy (*Kasai's operation*). Liver transplantation is becoming more popular in biliary atresia—ideal.

Presently *Kasai (1974) hepatoportoenterostomy* (Kasai and Susuki, 1959) is done (in 8 weeks) as a preliminary procedure followed by liver transplantation eventually. After opening the abdomen, gallbladder is cannulated and on table cholangiogram is done to confirm atretic segment. Liver biopsy should also be done at the same time **(Fig. 22-143)**.

If biliary patency is found procedure is abandoned. In atretic biliary tree, gallbladder is dissected off the liver and by applying traction to it; fibrotic atretic biliary tree is felt and dissected up to intrahepatic segment (up to the segmental branches of portal vein). Atretic extrahepatic tissue is removed to open up the microscopic ductules. Portal plate (edge of the dissected fibrous mass in portal plate)/hepatic hilum is anastomosed to Roux-en-Y part of the small bowel. Postoperatively, antibiotics, intravenous corticosteroids initially, later orally (for 6-12 weeks), ursodeoxycholic acid (for 1year), nutrition, medium chain and essential fatty acids, essential elements supplementation is given. Success of procedure depends on age of the patient; presence of cholangitis; ductule size (more than 200 μm is better); bridging fibrosis; type of atresia; bilirubin level. Eventually cholangitis, portal hypertension, variceal bleeding will develop.

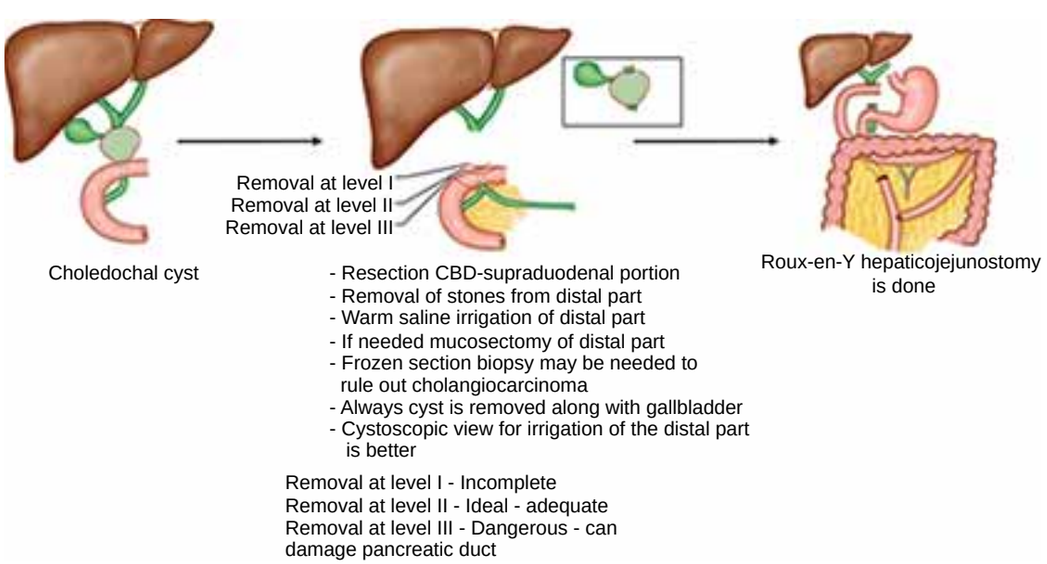

Removal at level I
Removal at level II
Removal at level III
Choledochal cyst
- Resection CBD-supraduodenal portion
- Removal of stones from distal part
- Warm saline irrigation of distal part
- If needed mucosectomy of distal part
- Frozen section biopsy may be needed to rule out cholangiocarcinoma
- Always cyst is removed along with gallbladder
- Cystoscopic view for irrigation of the distal part is better
Roux-en-Y hepaticojejunostomy is done
Removal at level I - Incomplete
Removal at level II - Ideal - adequate
Removal at level III - Dangerous - can damage pancreatic duct

Fig. 22-140: Surgical technique for choledochal cyst.

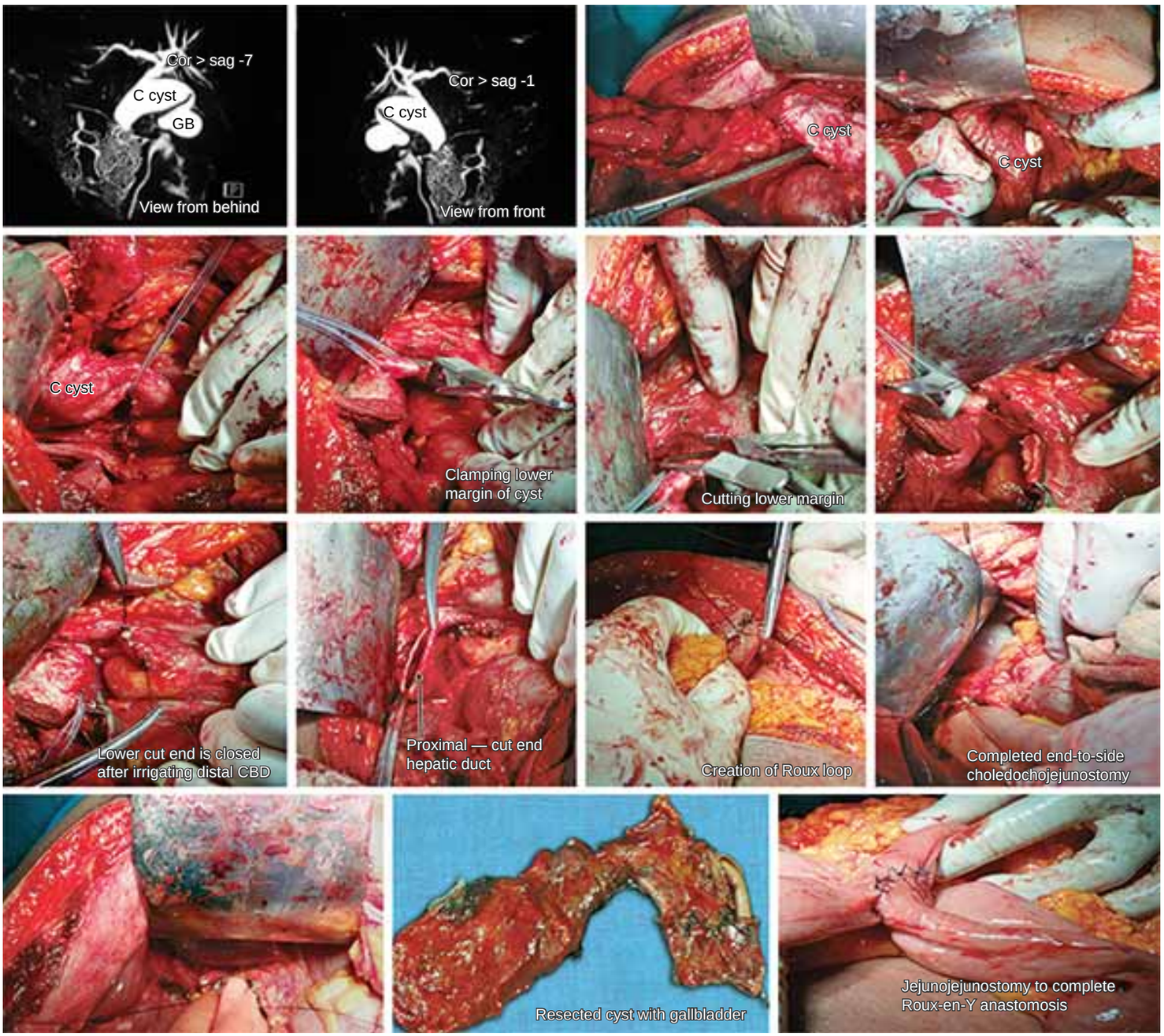


Fig. 22-141: Operative technique of choledochal cyst excision.

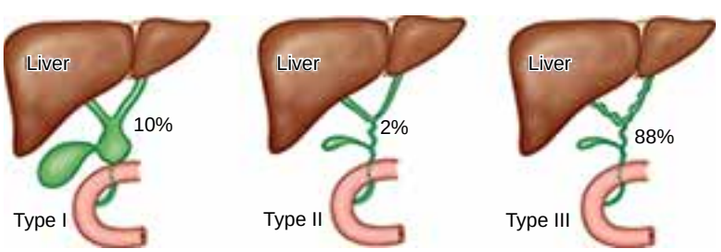


Fig. 22-142: Biliary atresia—types.

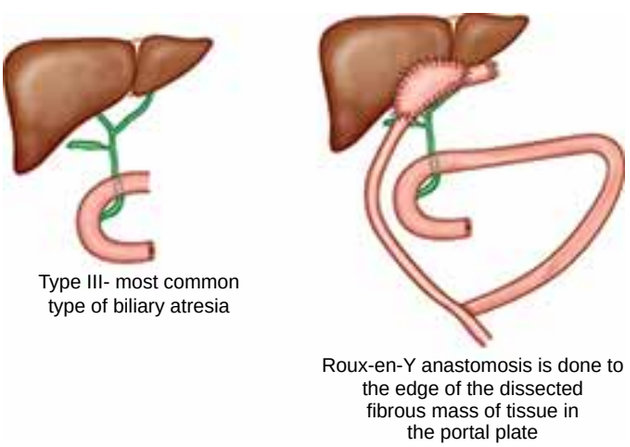

Type III- most common type of biliary atresia
Roux-en-Y anastomosis is done to the edge of the dissected fibrous mass of tissue in the portal plate

Fig. 22-143: Kasai hepatoportoenterostomy.

Chapter

23

Surgeries of Pancreas and Spleen

THE PANCREAS

SURGICAL ANATOMY

It was Rufus of Ephesus who named the organ 'pancreas', which in Greek means Pan—all; Kreas—flesh/meat. Homer used the word 'sweetbread' to describe it as animal flesh; but the fact is that it becomes bitter to the surgeons and not sweet when it develops major disease like pancreatitis. Moynihan described pancreas as an 'abdominal tiger'. The pancreas is a gland located deep in the abdomen between the stomach and the spine (2nd and 3rd lumbar vertebrae). The liver, intestine and other organs surround the pancreas. It extends on the right side from duodenum towards spleen on the left side.

The pancreas lies in the retroperitoneum within the anterior pararenal space. The head is the portion of the gland lying within the C-loop curve of the duodenum. The head is prolonged inferiorly and medially to extend behind the superior mesenteric vein. The uncinate process usually stops short at the level of the right renal hilum inferiorly.

The neck of the gland is the constricted segment of the gland lying anterior to the superior mesenteric vessels. The body is a horizontal segment of the gland lying behind the lesser sac and stomach. Dorsal to the body runs the splenic vein. The tail of pancreas may be inclined slightly cephalic to the level of the head. It follows the splenic vessels into the splenic hilum **(Fig. 23-1)**.

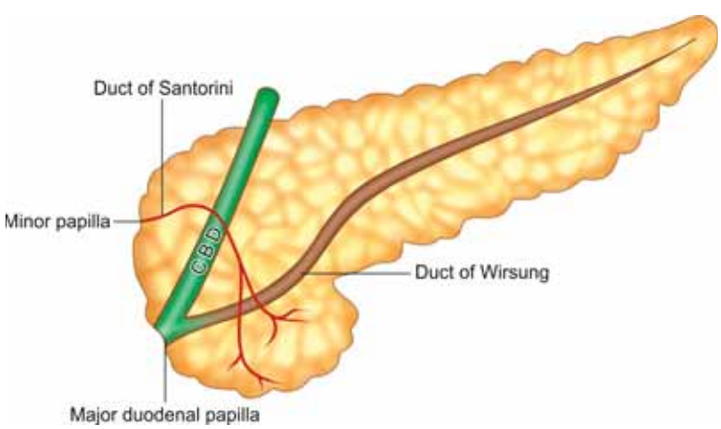


Fig. 23-1: Ductal parts of the pancreas.

The pancreas is about 15 cm long, 3 cm broad and 1.5 cm thick and is flat pear/retort shaped. It weighs around 100 g. The widest part of the pancreas is the head, the middle section is the body, and the thinnest part is the tail. Pancreas is a fixed organ. Omental bursa is above; transverse mesocolon is in front; greater sac is below the pancreas. Above it is related to 1st part of the duodenum, pylorus, stomach, liver and spleen. Below it is related to 3rd part of the duodenum, jejunum, transverse colon and spleen. Inner part of the 1st, 2nd and 3rd parts of the duodenum is closely adherent to the corresponding parts of pancreas and duodenum here is not having peritoneal coverage and is called as bare area of duodenum. Posteriorly pancreas extends from hilum of kidney to hilum of spleen. It is related behind to hilum of kidney, IVC, superior mesenteric vein and portal vein, aorta, left kidney and hilum of spleen **(Fig. 23-2)**.

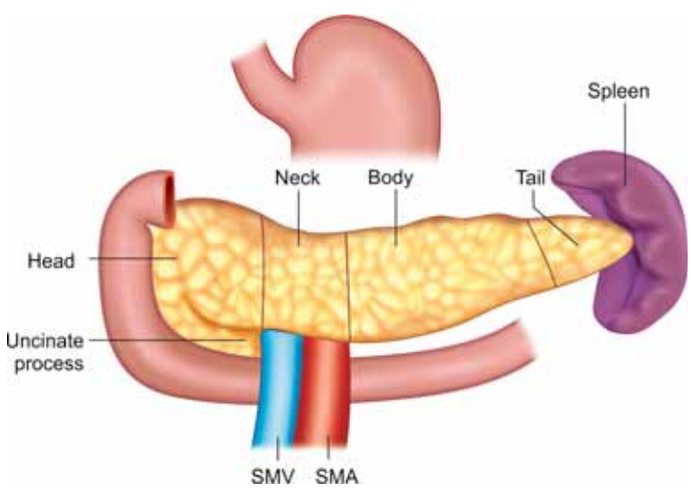


Fig. 23-2: Parts of the pancreas.

Head lies to the right of the superior mesenteric vessels. It is adherent to the inner part of the C-loop of the duodenum. Posteriorly it is related to the hilum and adjacent right kidney, right renal vessels, IVC, left renal vein entering IVC, right crus of the diaphragm, posterior pancreaticoduodenal arcade, right gonadal vein and distal CBD.

Neck is 1.5 cm in length; lies between celiac trunk above and superior mesenteric vessels below. Its junction with the head is at an imaginary line from the portal vein to the superior mesenteric vessels below. Anterior superior pancraticoduodenal artery originates

from the gastroduodenal artery near the upper part of the neck of the pancreas at this junction. Behind the superior mesenteric vein joins the splenic vein to form portal vein. Small veins may enter the portal vein and the superior mesenteric vein directly from the neck of the pancreas. Short and often stout lateral veins may enter it from its lateral part to portal vein; left gastric, splenic and rarely inferior mesenteric vein may enter the portal vein from the left side.

Lower posterior part of the head of the pancreas extends behind the superior mesenteric vessels and in front of IVC and aorta is known as ***uncinate process***. It gets blood supply from the superior mesenteric vessels through very short vessels. One should ligate these vessels carefully while dissecting the uncinate process, otherwise tear of these vessels may lead into torrential bleeding. Occasionally this process may be absent or encircle superior mesenteric vessels completely. Left renal vein is above it; duodenum is below it. An anomalous right hepatic artery may pass through the uncinate process after originating from the superior mesenteric artery.

Pancreas lying towards the left of the neck/superior mesenteric vein is known as ***body of pancreas***. It is related to the 4th part of the duodenum, suspensory ligament of Treitz, first part of jejunum, left side transverse colon. Superior mesenteric vein and artery run between head and uncinate process to run in front of the duodenum. Vein is towards the right of the artery. Above body of the pancreas is related to celiac axis, common hepatic artery and splenic vessels from right to left. In front, it is covered by posterior wall of the omental bursa which has got two layers of the peritoneum. Stomach covers in front of it. Transverse colon with its two leaves is also in front of it. Middle colic vessels are connected here. Middle colic artery after originating from superior mesenteric artery runs between two leaves of mesocolon. Inferior mesenteric vein runs close to inferior border of the distal part of the body of pancreas to join splenic vein. Posteriorly it is devoid of peritoneum and is related to aorta, origin of superior mesenteric artery, left crus of diaphragm, left suprarenal gland, left kidney, left renal vessels and splenic vein **(Fig. 23-3)**.

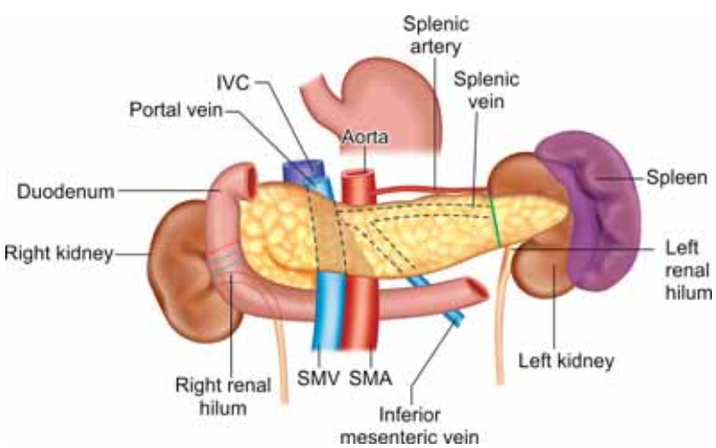


Fig. 23-3: Posterior relations of the pancreas.

Tail of the pancreas is the distal most part of the pancreas; its tip is related to spleen; it is enveloped within two layers of splenorenal ligament along with the splenic vessels. Tail of the pancreas may be mobile.

Pancreas is long, flat and irregularly prismatic in shape; its right extremity, being broad, is called the head, and is connected to the main portion of the organ, or body, by a slight constriction, the neck; while its left extremity gradually tapers to form the tail. It is situated transversely across the posterior wall of the abdomen, at the back of the epigastric and left hypochondriac regions. Conventionally it shows two segments; cephalocervical right segment is supplied by gastroduodenal and superior mesenteric arteries. Left-sided corporocaudate segment is supplied by splenic and dorsal pancreatic arteries. Junction of two segments is relatively avascular.

The main pancreatic duct (duct of Wirsung) opens at the major duodenal papilla, measuring 3-4 mm in diameter in adults. It enlarges slightly with advancing age. The diameter of the duct tapers to 1-2 mm toward the tail. A slight narrowing at the head and body of the pancreas is a normal variation. The accessory pancreatic duct (duct of Santorini) opens at the minor duodenal papilla, proximal to the major duodenal papilla. Both bile and pancreatic ducts open into the duodenum in 60% of individuals; in 30%, duct of Santorini ends blindly and duct of Wirsung carries the secretion; in 10%, duct of Wirsung may be small or absent and duct of Santorini secretes entirely.

On cross-sectional images, the measurements of normal pancreas diameters generally are as follows: head of the pancreas, 3 cm; neck and body of the pancreas, 2.5 cm; and tail, as long as 2 cm.

The position, size and shape of the pancreas vary among patients. The pancreas gradually diminishes with advancing age, sometimes becoming more marked beyond the seventh decade. The surface of the pancreas is smooth in 80% of patients and lobulated in approximately 20%. Ampulla of Vater is situated on the posteromedial wall of the 2nd part of the duodenum; right of 2nd and 3rd lumbar vertebrae (commonly at the level of spine of 2nd lumbar vertebra). Muscular sphincteric complex (Sphincter of Oddi, 1887; sphincter of Boyden) is obliquely placed of 6-30 mm in length, contains four separate sphincters—superior bile duct sphincter, inferior submucosal bile duct sphincter, pancreatic sphincter and ampullary sphincter. Papilla is found in the mucosa (on endoscopy) where longitudinal mucosal fold meets the transverse fold like a 'T'. Papilla is nipple-like projection of duodenal mucosa; major duodenal papilla is located on the posteromedial wall of the 2nd part of the duodenum 10 cm from pylorus (but may vary); minor duodenal papilla is located 2 cm proximal to major papilla **(Figs 23-4 and 23-5)**.

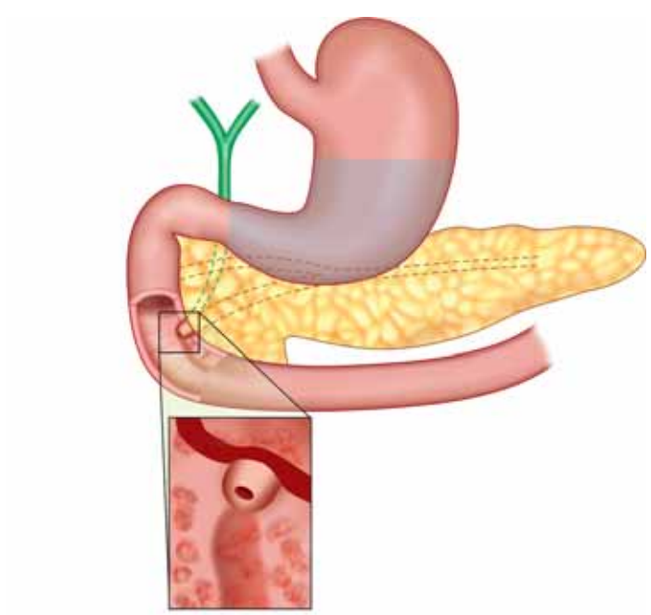


Fig. 23-4: Orifice of ampulla of Vater in the duodenal mucosa.

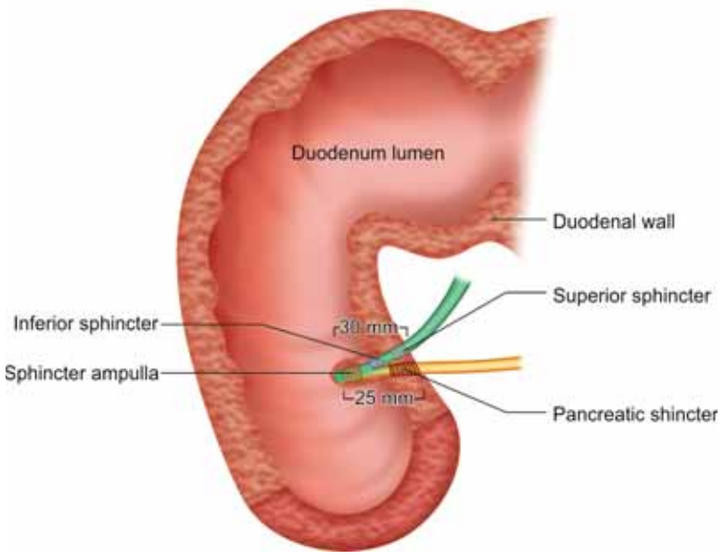


Fig. 23-5: Sphincter complex of Ampulla of Vater.

Ampulla (ampulla of Vater; Abraham Vater, 1684) is slightly widened common pancreaticobiliary channel beyond the septum. Ampulla will not be obvious if septum between bile duct and pancreatic duct extends up to the orifice. Variations are—I: The pancreatic duct joins bile duct at a variable distance; II: The pancreatic and bile ducts open separately on the major duodenal papilla (5%); and III: Both ducts open into the duodenum at separate points (10%) **(Figs 23-6A to C)**.

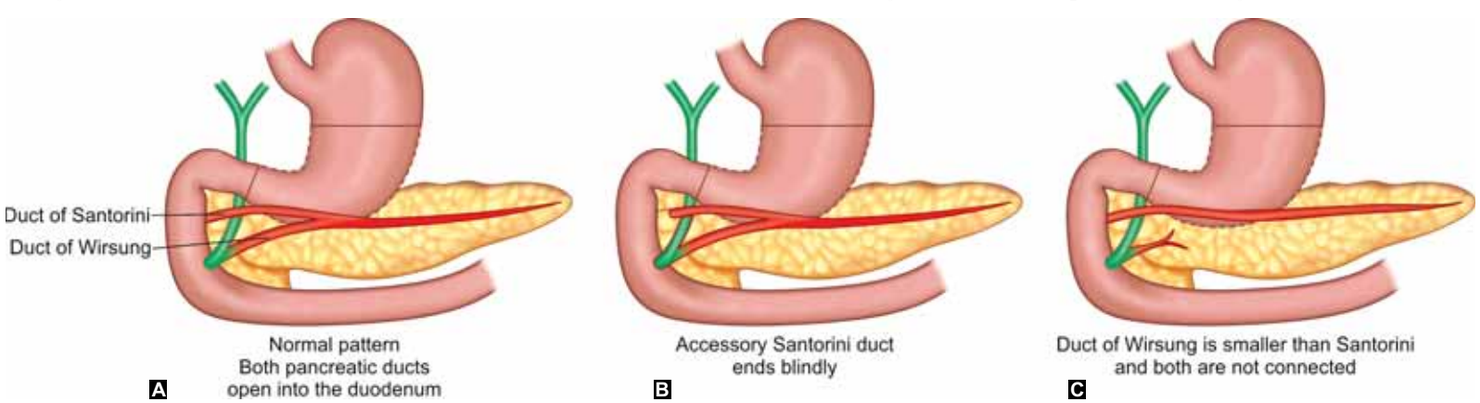
The pancreas produces insulin and other hormones—exocrine and endocrine both. The pancreas also produces pancreatic enzymes that help to digest food. The pancreas releases the juices into a system of ducts leading to the common bile duct. The common bile duct empties into the second part of the duodenum through the ampulla of Vater.

Blood Supply

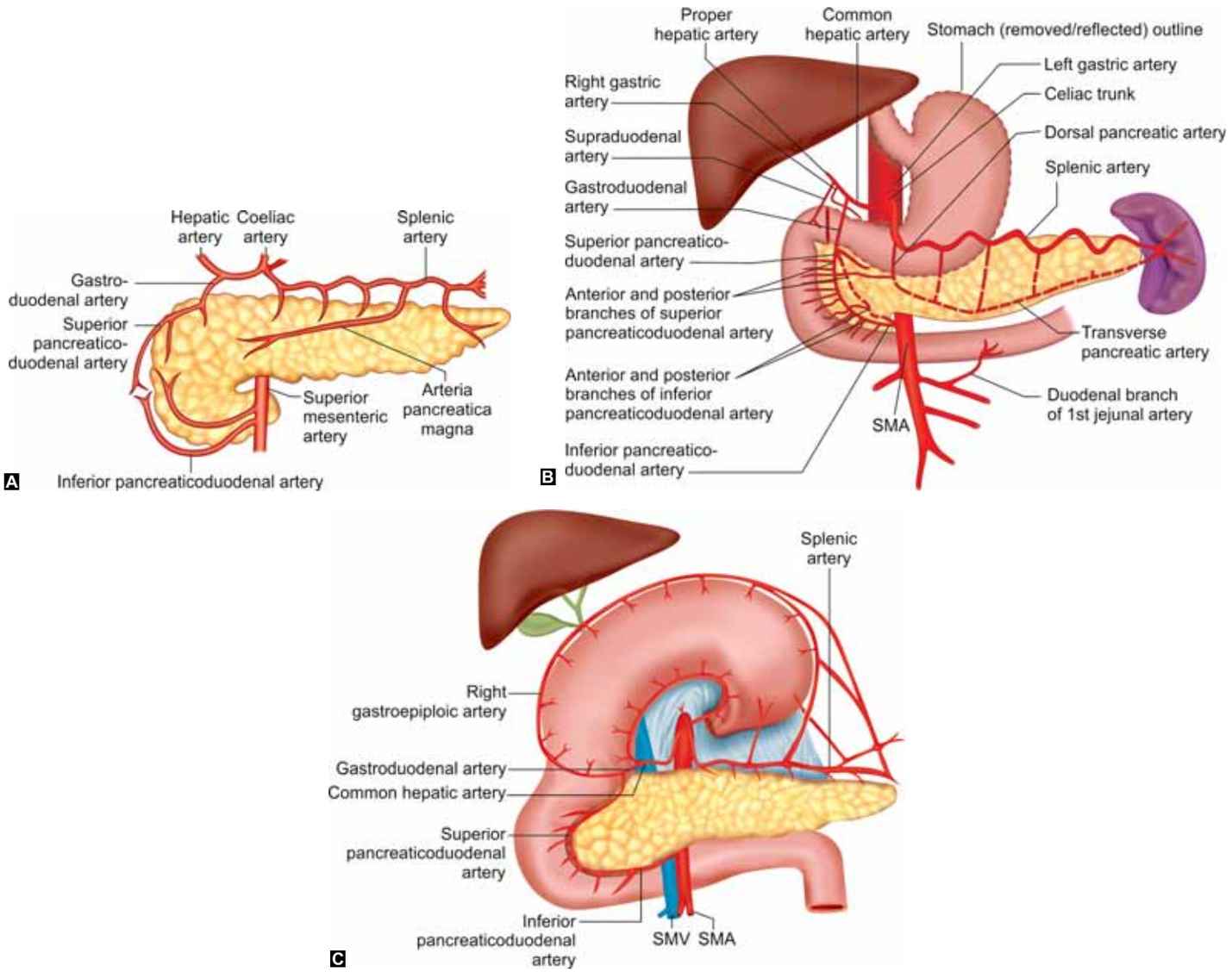
Arterial Supply

The gastroduodenal artery is the descending branch of common hepatic artery which courses in front of the portal vein. The first branch of this artery is the superior posterior pancreaticoduodenal artery which descends posteriorly along the common hepatic duct to anastamose with posterior branch of inferior pancreaticoduodenal artery forming the posterior arch. The superior anterior pancreaticoduodenal artery runs in the curve of the duodenum down to anastomose with anterior branch of inferior pancreaticoduodenal artery to form the anterior arch. The inferior pancreaticoduodenal artery begins behind the uncinate process of the pancreas as the first right branch of the **superior mesenteric artery** and divides after a short distance into an anterior and a posterior branch. Arteria pancreatica magna takes off from the splenic artery and joins into the glandular parenchyma at the level of the passage from the middle part to the left third of the tail of the pancreas. The artery of the tail of the pancreas is represented by four arterial trunks which surround the pancreatic tail. They originate from the left gastroepiploic artery or from the so-called main inferior trunk of the splenic artery. Dorsal pancreatic artery arises from splenic artery at the neck of the pancreas close to its origin from celiac trunk. Right branch of dorsal pancreatic artery supplies head of pancreas after joining posterior superior pancreatic arcade; its left branch runs in a groove on the inferior margin of the pancreas known as transverse or inferior pancreatic artery which supplies body and tail of the pancreas. Dorsal pancreatic artery may arise from the celiac trunk or common hepatic artery. Major arteries of pancreas lie posterior to pancreatic duct. Splenic artery runs tortuously towards left along the upper and posterior surface of the body and tail of the pancreas. Splenic artery gives branches which communicate with inferior pancreatic artery. Arteria pancreatica magna is also known as great pancreatic artery after originating from splenic artery anastomoses with inferior pancreatic artery **(Figs 23-7A to C)**.

Caudal pancreatic artery is often present; originating from splenic artery or left gastroepiploic artery (is a branch of splenic artery); it communicates with transverse pancreatic artery and arteria pancreatica magna. It also supplies accessory spleen when present. Anomalous right hepatic artery is a common variation observed which arises from SMA which runs behind the CBD or portal vein; it may be accessory to normally existing right hepatic artery (a branch of common hepatic artery) or replacing the right hepatic artery, in which case it is the only supply to the right liver. Occasionally aberrant left hepatic artery may arise from SMA or gastroduodenal artery. These variations are important while doing Whipple's pancreaticoduodenectomy or total pancreatectomy. Middle colic artery may arise from dorsal pancreatic or inferior pancreaticoduodenal arteries instead of SMA. Middle colic artery is usually close to uncinate process but it may pass through the head of pancreas or run close to the 2nd part of the duodenum as variation in pathway. Body and tail of pancreas usually derive their arterial supply from branches of both splenic artery and dorsal pancreatic artery (50%); but dorsal pancreatic artery may be entirely absent and body and tail of pancreas are exclusively supplied by splenic artery (25%); or there may not be any branches from the splenic artery to the body and tail of the pancreas and blood supply is exclusively from the dorsal pancreatic artery (25%).



Figs 23-6A to C: Different duct patterns in pancreas.



Figs 23-7A to C: Arterial supply of the pancreas.

Ampulla is supplied by posterosuperior pancreaticoduodenal artery through epicholedochal plexus. Anterosuperior pancreaticoduodenal artery may get injured in pancreaticojejunostomy as drainage procedure for chronic pancreatitis.

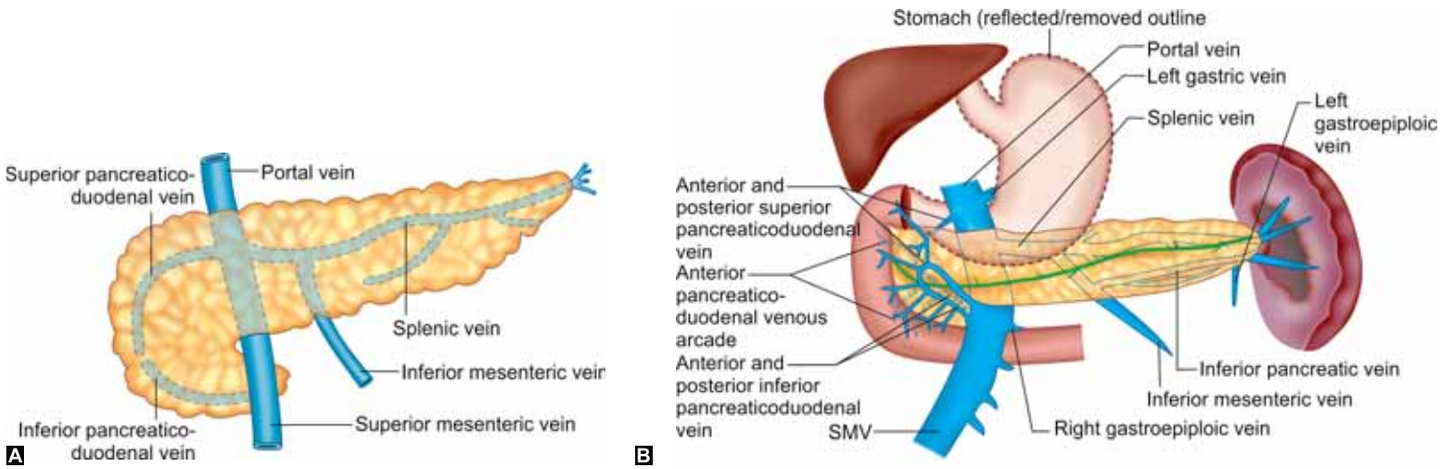
Venous Drainage

The venous drainage from the head of the pancreas drains into the portal vein via pancreaticoduodenal veins and several small veins which drain directly into the portal vein in the medial and inferior aspect. The inferior pancreatic vein courses along the inferior margin of the pancreas and receives different small veins. It flows into the inferior or the superior mesenteric vein. Veins are superficial to arteries; both arteries and veins are deep to the pancreatic duct system. Duct → veins → arteries—is the pattern from front to back. Anterior superior pancreaticoduodenal vein and/or right gastroepiploic vein may join with a colic vein to form a common short gastrocolic trunk which joins the SMV on its right side. This trunk should be ligated in pancreatic resections. Posterior superior pancreaticoduodenal vein joins portal vein on the upper margin of the pancreas **(Fig. 23-8)**.

Posterior inferior pancreaticoduodenal vein joins SMV. Small branches enter the right side of the SMV and portal vein from head of the pancreas which should be ligated in Whipple's operation. Usually there are no branches in front of the SMV and portal vein underneath the neck of the pancreas, but as a variation, veins can be present. SMV joins splenic vein behind the neck of the pancreas to form portal vein. Inferior mesenteric vein usually joins splenic vein but may join portal vein or SMV directly. CBD is on the right side of the portal vein; common hepatic artery on the left side and IVC behind it. Right gastric vein joins portal vein above the joining of the left gastric (coronary vein); left gastric vein may join portal or splenic vein.

Lymphatic Drainage

The lymphatic ducts which drain the pancreas course towards the lymph nodes situated near the gland following the artery. The first tier of lymph nodes are situated on the surface of the pancreas and the second tier of lymph nodes are situated along the gastroduodenal and hepatic vessels near the head and along the splenic artery in the region of the body and tail of the pancreas. Drainage is centrifugal.



Figs 23-8A and B: Venous drainage of pancreas.

Cubilla et al. classified lymphatic drainage nodes into 5 groups—superior, anterior and posterior part of superior part of head, body, gastric → superior nodes drain into the suprapancreatic lymph nodes along the upper border of the pancreas; *inferior*—anterior and posterior parts of inferior part of head, body → inferior nodes drain into the inferior pancreatic group of lymph nodes which drain into the superior mesenteric nodes, left lateral aortic lymph nodes and may reach lumbar lymphatic trunk through a collecting duct; *anterior*—anterior pancreaticoduodenal, pyloric and mesenteric—drains anterior part of both superior and inferior portions of the head of pancreas—anterior nodes → 2 collecting ducts → infrapyloric and anterior pancreaticoduodenal nodes → nodes in the root of the mesentery; *posterior*—posterior pancreaticoduodenal, along common bile duct—drains from posterior surface of the superior and inferior parts of the head of the pancreas → reaches right lateral aortic nodes and nodes at origin of the superior mesenteric artery and lymphatics from bile duct and ampulla reaches to posterior pancreaticoduodenal lymph nodes; *splenic*—along its hilum and tail of the pancreas. Lymph flow is from pancreas to duodenum **(Fig. 23-9)**.

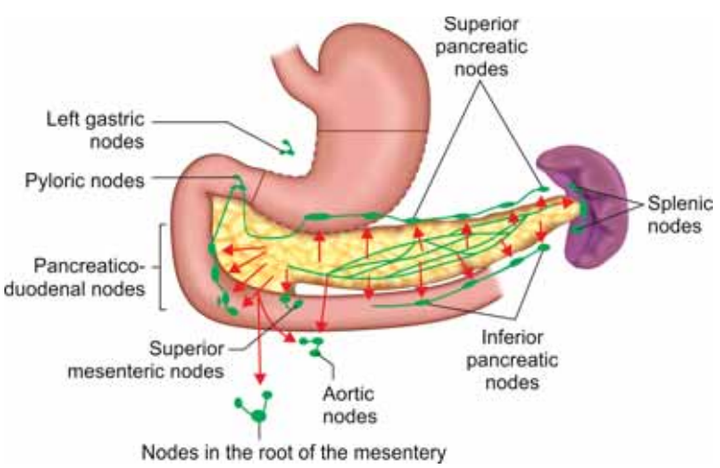


Fig. 23-9: Lymphatic drainage of pancreas.

There are no lymphatic communications between pancreatic nodes and gastric nodes. So, omentectomy is not necessary in pancreatic resections for malignancies. Lymphatics from head of the pancreas may reach hepatic nodes along the bile duct and common hepatic artery. Lymphatics of the head finally drain into nodes right of the celiac and superior mesenteric arteries. Lymphatics from the body and tail drain to the nodes left of the celiac and superior mesenteric arteries. Lymphatics from the head usually will not travel towards the body and tail. All drain finally towards the aortic nodes. Proper Whipple's pancreaticoduodenectomy should include removal of 35 nodes; total pancreatectomy should include 70 nodes. For adequate staging of pancreatic cancer, 15 nodes are needed.

Nerve Supply

Preganglionic sympathetic supply is derived from preganglionic efferent fibers of 5th to 9th thoracic segments to form greater splanchnic nerve. Fibers from 10th and 11th segments form lesser splanchnic nerve. Occasionally some fibers form the least splanchnic nerves. These nerves pass across the crura of diaphragm to supply celiac and superior mesenteric ganglia. Postganglionic branches from these ganglia reach the pancreas through its arterial branches. Cell bodies of efferent fibers are interconnected with the cell bodies of the dorsal root ganglia of spinal nerve of the same level; hence pancreatic pain refers to the abdominal wall. Parasympathetic supply is by celiac division of the posterior vagus. Efferent fibers from the brain reach celiac ganglion and then reach ganglion cells in the pancreas; their postganglionic fibers supply islet of Langerhan cells. Surgical significance of celiac ganglion is for managing the pancreatic pain by celiac plexus block, splanchnicectomy, and guided celiac injection, etc. Pain in chronic and relapsing pancreatitis is due to raised intraductal pressure (ductal hypertension), fibrosis of pancreas, multiple strictures, pancreatic ischaemia, multiple pseudocysts and pancreatic neuropathy. Pancreatic neuropathy is due to neural and perineural inflammation of intrapancreatic nerves with infiltration of immune cells. In carcinoma pancreas, initially tumour is painless but once perineural invasion by tumour cells occurs, then typical pain develops.

GENERAL PRINCIPLES IN PANCREATIC SURGERIES

Pancreas is an organ located deep in the retroperitoneum extending from right to left side. Its clear anatomy, vasculature and relations are to be known while doing pancreatic surgery. Variations and major

vessels should be tackled carefully. 60% of the gland is in the body and tail of the pancreas. Only 40% of the gland will be removed in Whipple's operation.

Preservation of duodenum in surgeries of pancreatic head is difficult due to strong attachment of pancreas and vascular arcade. Preoperative imaging is essential. Helical CT scan with contrast to arterial and portal venous phase is needed. ERCP, endoultrasound (EUS), MRI may be needed in selected patients. Liver function tests, prothrombin time, coagulation profile, adequate hydration is needed preoperatively. Laparoscopic assessment prior to opening the abdomen is better to assess the final operability **(Fig. 23-10)**.

Pancreas is reached by dividing gastrocolic ligament (greater omentum). It can be reached through hepatogastric ligament (lesser omentum) also. Vagus is usually preserved.

Hepatic flexure is better to be mobilised to reach and expose the head of pancreas adequately—**Cattell-Braasch** manoeuvre; ***Kocherisation of the duodenum*** is a must in all pancreatic surgeries in relation to head. In Whipple's operation and total pancreatectomy, extended Kocherisation is needed wherein 2nd part of the duodenum is mobilized beyond the left, margin of the aorta. Peritoneum lateral to the 2nd part of the duodenum is incised above and below; posteriorly IVC with its fascial covering is seen; plane is loose areolar and is relatively avascular; left index and middle fingers are placed behind the duodenum through the incision; left thumb is placed in front; it allows proper palpation of head of the pancreas to assess the size and possible operability. But this will not clearly indicate the portal vein invasion.

Left hand index finger is passed from above underneath the neck gently downwards in front of the portal vein; right hand index finger is passed similarly in front of SMV from below upwards to reach the opposite finger. Care should be taken to keep the fingers strictly in front which is usually avascular (laterally draining veins enter SMV and portal vein and so finger should not pass laterally). Even though it is crude it reasonably confirms the operability. But better is always preoperative dynamic imaging with arterial phase to confirm the operability. Gastrocolic omentum and splenic flexure should be mobilised downwards adequately to expose the body and tail of the pancreas.

It is the invasion or encasement of the SMA or celiac trunk precludes the resection in malignancy. Portal vein / SMV invasion is not considered as unresectable. It is still resectable with resection of segment of vein with placement of patch graft over it. These invasions can be assessed properly by endoultrasound, MRI, arteriogram or venous and arterial phase in CT.

Once operability is confirmed in Whipple's operation, then only superior and inferior pancreaticoduodenal arteries should be ligated; as their ligation causes duodenal and pancreatic head necrosis.

In pancreaticoduodenectomy, bile duct is usually resected above the level of cystic duct, and cystic duct and hepatic duct margins should be sent for frozen section biopsy **(Fig. 23-11)**.

Presently pylorus preserving pancreaticoduodenectomy is favoured. Duodenum is transected just distal to the pylorus. But cut margin should be sent for frozen section biopsy prior to proceeding with the further steps of pylorus preserving pancreaticoduodenectomy **(Figs 23-12 and 23-13)**.

In distal pancreatectomy, ligation of splenic artery and vein leads into splenectomy. If short gastric vessels are preserved, spleen can be salvaged even though splenic vessels are ligated; it is called as ***Warshaw procedure***; but late development of splenic congestion and gastric varices can occur.

Portal vein anomaly and right hepatic artery anomalies should be remembered while doing pancreatic resection.

Secure anastomosis, patience and postoperative care are needed in all patients. Sepsis, bile and pancreatic leak, pancreatic pseudoaneurysm, renal failure, liver failure, disseminated intravascular coagulation, postoperative haemorrhages are the possible different complications which can occur in pancreatic surgeries. Daily monitoring, clinically, biochemically, often imaging are needed during postoperative care **(Fig. 23-14)**.

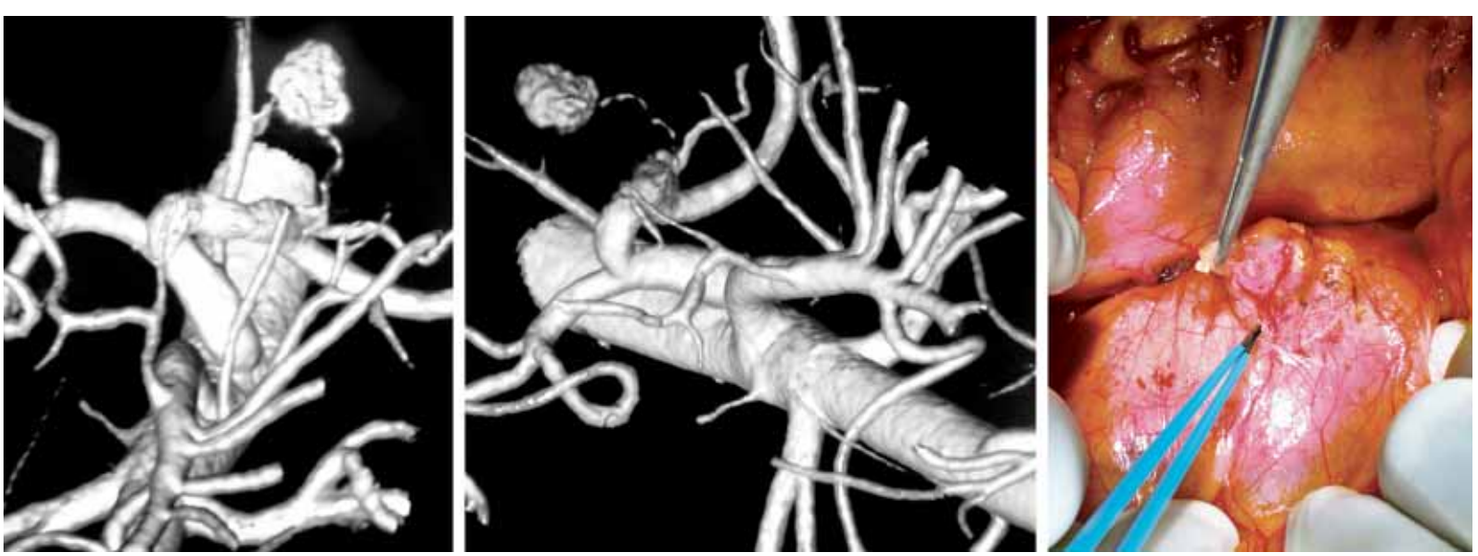


Fig. 23-10: Insulinoma in the body of pancreas. Enucleation can be done; but if multiple in the body and tail of the pancreas, distal pancreatectomy is needed.

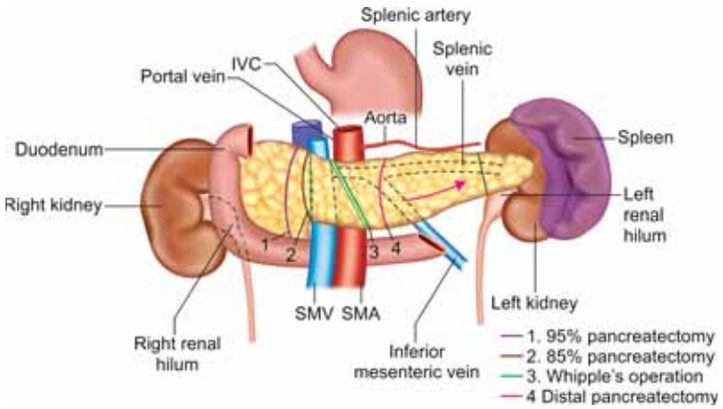


Fig. 23-11: Partial pancreatectomies—types—95% subtotal; 85% subtotal; Whipple's; distal.

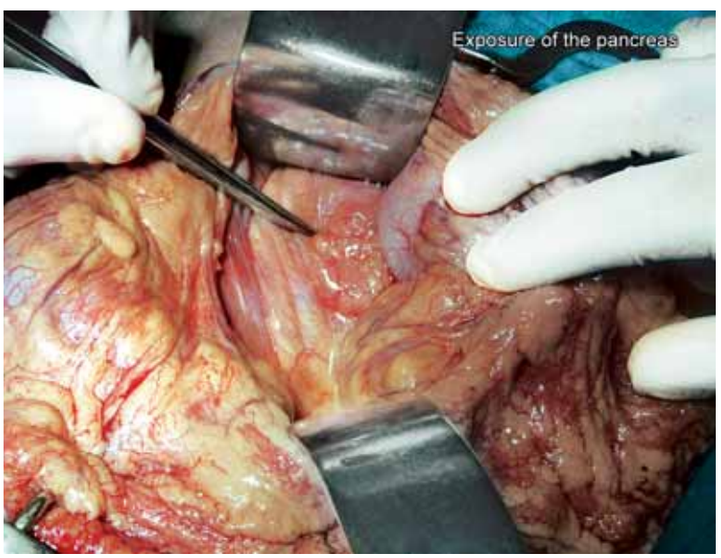


Fig. 23-12: Exposure of the pancreas. It needs mobilisation of the right flexure of colon and transverse colon, often leaves flexure also.

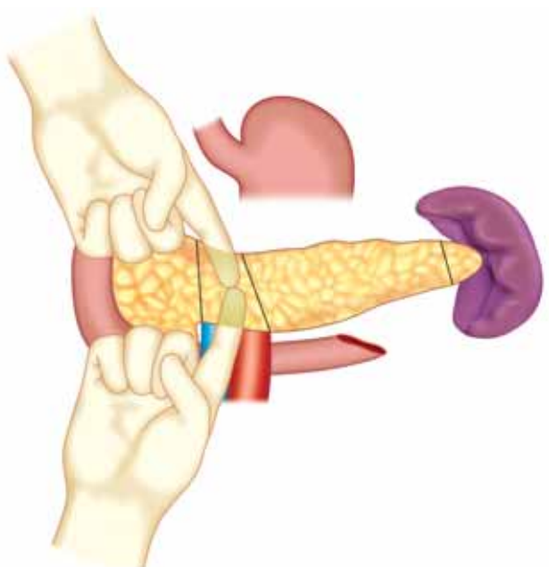


Fig. 23-13: In pancreaticoduodenectomy, whether portal vein and SMV are free of tumour (not adherent to portal vein) is assessed by placing left index finger between neck of pancreas and portal vein; right index finger between neck and SMV; both fingertips if felt easily and freely to be in contact with each other, then portal invasion/adhesion is not present.

SURGICAL TREATMENT FOR CHRONIC PANCREATITIS

Indications for Surgery

Persisting pain is the main indication; severe malabsorption; suspicion of malignant transformation; multiple relapses; complications like pseudocyst, segmental portal hypertension; biliary obstruction (*Wadsworth syndrome*); pseudocyst; pancreatic ductal dilatation > 5 mm; pancreatic ascites/fistula; pancreatic ductal stenosis.

Objectives of Surgery

Pain relief when endotherapy has failed; management of complications; procedure is selected which shows less morbidity and mortality; Quality of life (QOL) should be preserved.

Problems and Limitations of Surgery

Disease is irreversible parenchymal and ductal damage and so surgery *cannot cure* or reverse completely. Disease progression cannot be prevented or arrested by surgery. Risk of development of cancer continues. Complications of surgery are a drawback.

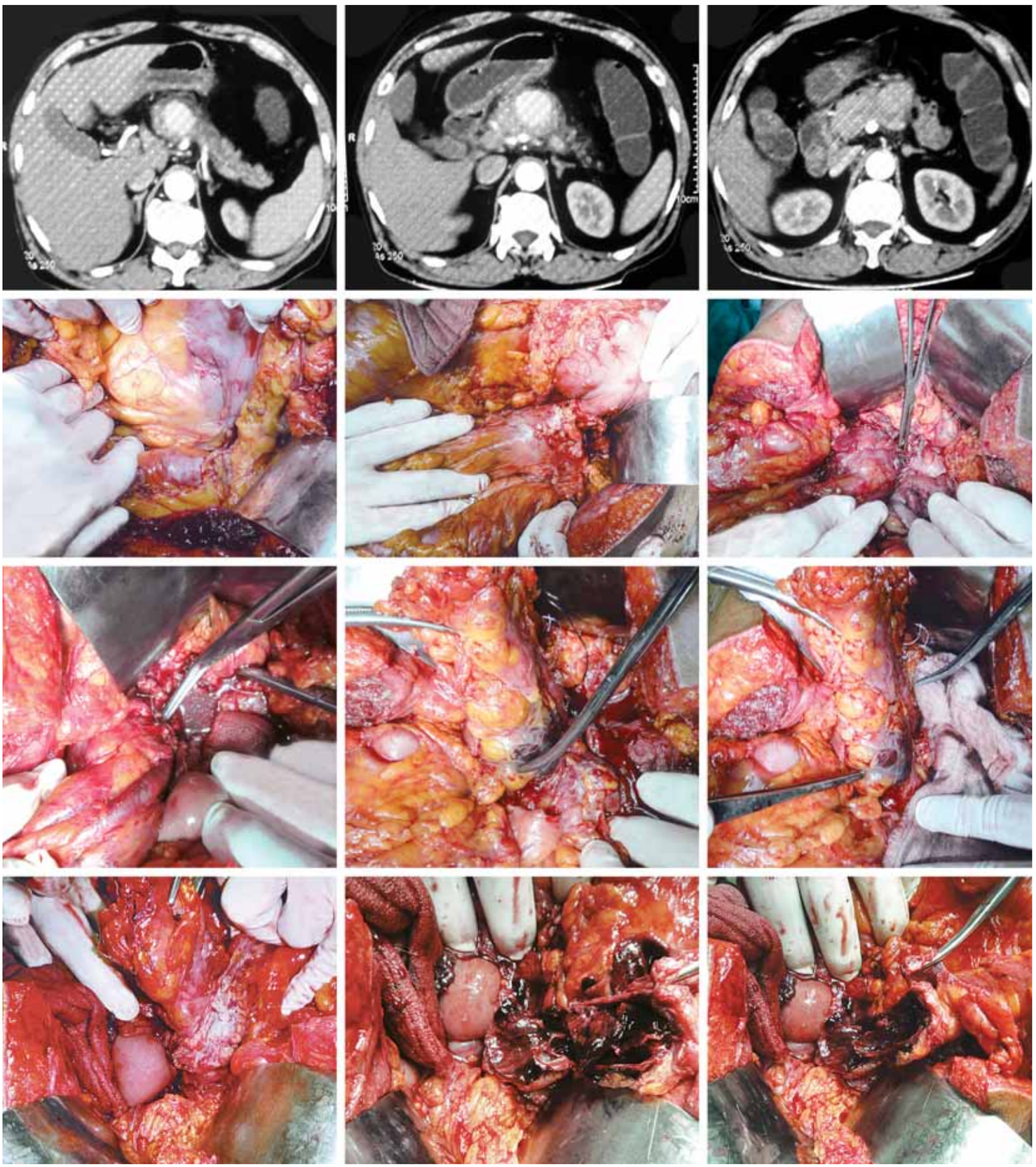
Benefits of Surgery in Relation to Pain Relief and Obstruction

It relieves intraductal, interstitial, intracellular hypertension through drainage procedures. Entrapped nerves are released and reduction in pancreatic enzyme reduces nerve irritation—resectional methods. *Pacemaker*—head of pancreas is removed in head-coring procedure (Frey's) to relieve pain. It is less morbid and acceptable method. Resection is better than the drainage procedure but technically demanding and has got higher mortality.

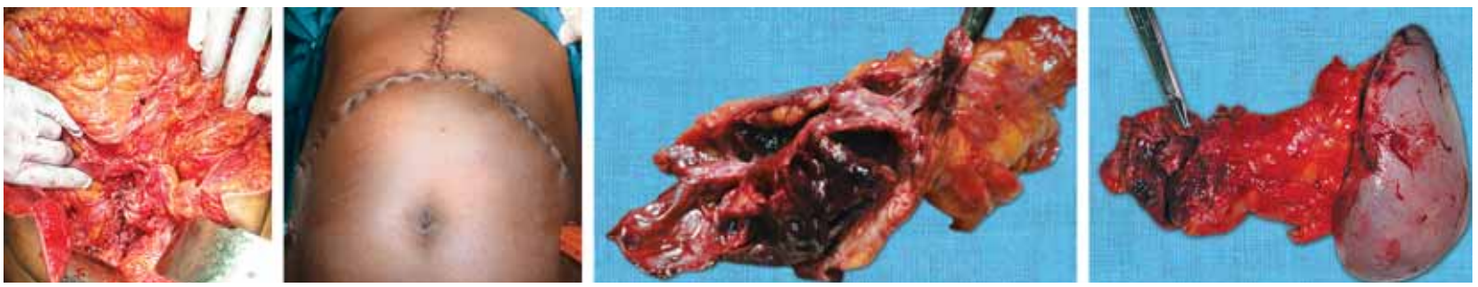
Principles of Surgery

Pancreatic duct decompression (*drainage*) reduces the pain and retains the existing exocrine and endocrine functions. But chances of malignant transformation are still high. In significant number of patients, recurrence of symptoms (50% recurrence of pain in 5 years) and progression of the disease pathology occur and it does not give a complete cure. Normal diameter of pancreatic duct is 4 mm in head; 3 mm in body; 2 mm in tail of the pancreas. *Pancreatic duct diameter more than 5-7 mm is an indication for surgery (pancreaticojejunostomy). Pancreatic resection* (total pancreatectomy) is the actually ideal technique which relieves pain, removes entire diseased tissue. But technical difficulty; high surgical mortality (21%); and severe exocrine and endocrine deficiency (brittle diabetes) are the drawbacks. Head of pancreas is considered as pacemaker and origin of the pancreatitis disease and so pancreaticoduodenectomy (*Whipple's*) is the other option to give adequate relief. It is preferred in patients who are having relatively normal body and tail of the pancreas. Occasionally when the disease is limited to tail and body, then *distal pancreatectomy* with or without splenectomy often with distal pancreaticojejunostomy may be done. But it is not beneficial if disease is extensive and diffuse. Resection is the main method of treatment if ductal dilatation is not adequate. *Combined resection and drainage procedures* are also done. Head is decored at various levels and decompressed duct is anastomosed to jejunum.

Patient should completely stop alcohol and smoking after surgery. Nutrition should be reasonably adequate; serum albumin should



Figs 23-14(1)



Figs 23-14(2)

Figs 23-14(1 and 2): Pancreatic pseudoaneurysm—patient underwent removal of pseudoaneurysm and distal pancreatectomy. Intervention radiology is ideal; but when it fails surgery is the option.

be more than 3g %. Otherwise surgery is done after improvement of nutrition. Proper preoperative evaluation is a must.

Proper preoperative evaluation, assessment of variations in portal vein and arterial pattern, frozen section biopsy are important in all pancreatic surgeries.

Exposure of pancreas needs mobilisation of the right flexure of colon (Cattell-Braasch) transverse colon and often left flexure also; extended Kocherisation (duodenal mobilization), separation of stomach from anterior part of the pancreas, separation of spleen and tail of the pancreas from left adrenal gland, left kidney and left renal vessels.

Meticulous dissection, control of bleeding and using bipolar cautery or other energy sources minimise the bleeding and improve and hasten the dissection.

Anastomosis in pancreatic surgery should be careful, skilled and meticulous as leak from pancreas will be disastrous **(Figs 23-15 to 23-17)**.

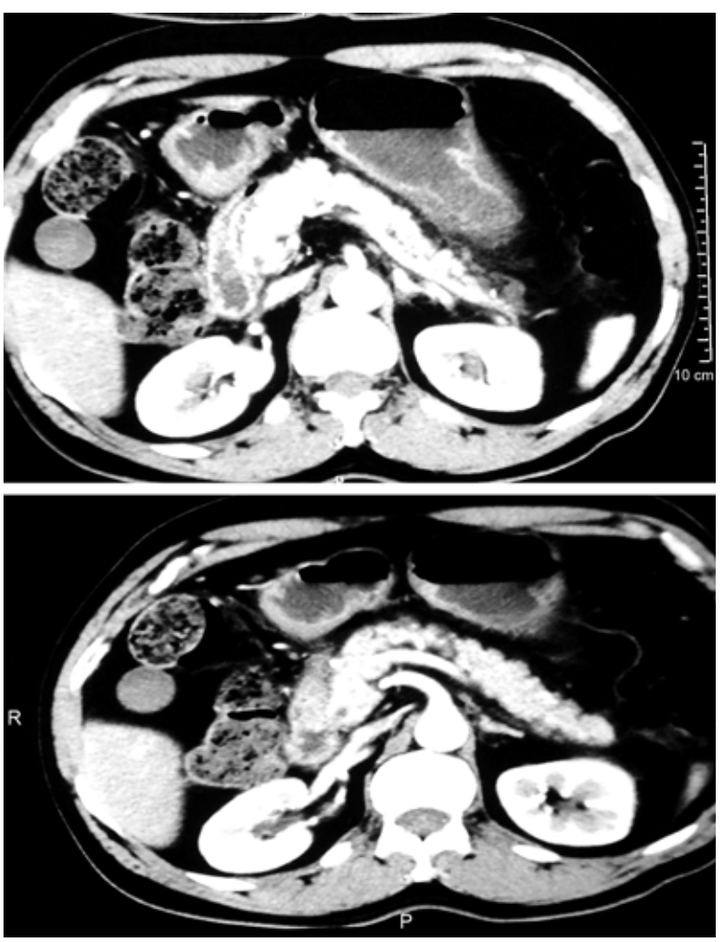


Fig. 23-15: CT scan of chronic pancreatitis.

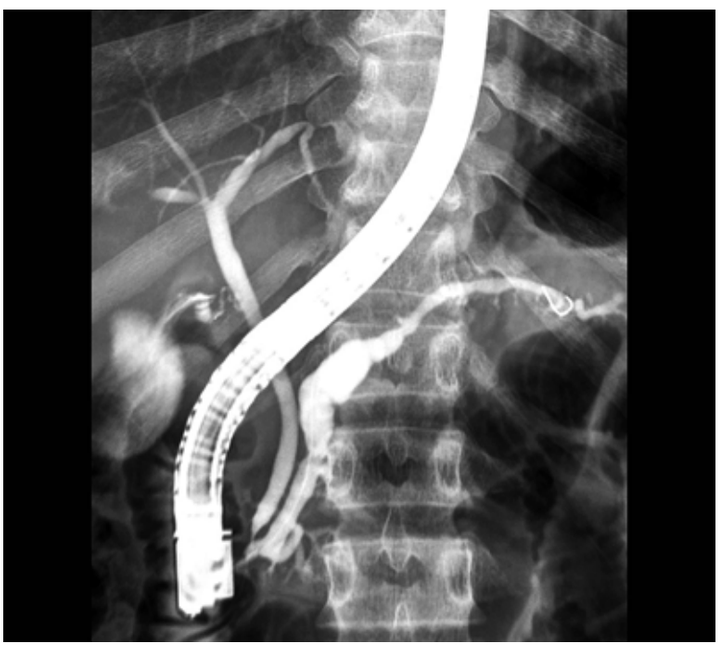


Fig. 23-16: ERCP showing pancreatic duct pathology with strictures.

Fig. 23-17: X-ray showing multiple pancreatic stones.

Surgeries

1. *Puestow's operation* [*Puestow-Gilesby* (1958)]: As the duct is dilated more than 7-8 mm, duct can easily be opened longitudinally. After removing all stones from the duct, it is anastomosed to the jejunum as *Roux-en-Y anastomosis*. In Puestow's operation, spleen is removed **(Fig. 23-18)**.
2. *Partington-Rochelle operation/Modified Puestow's Operation (1960)*: Here longitudinal pancreaticojejunostomy is done using almost entire laid open pancreatic duct. Spleen is retained in this procedure. This is now a commonly done procedure **(Fig. 23-19)**.

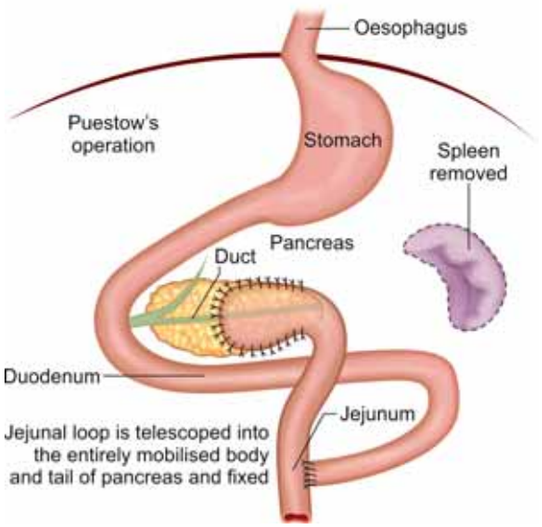


Fig. 23-18: Puestow's pancreaticojejunostomy. Here spleen is removed. Entire length of dilated duct is opened. Distal pancreas is mobilised up to the superior mesenteric vessels. Pancreas with opened duct is telescoped into the Roux loop of jejunum and anastomosed.

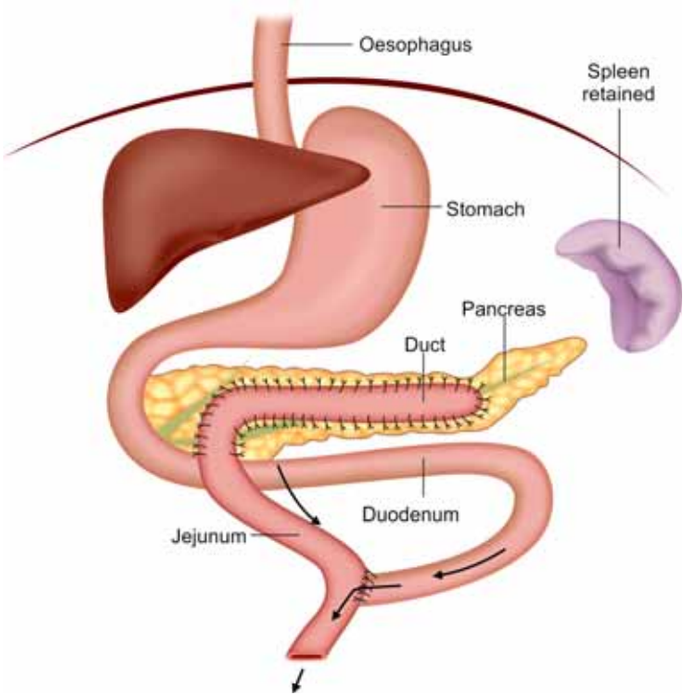


Fig. 23-19: Partington-Rochelle operation. Here spleen is retained and longitudinal pancreaticojejunostomy is done to the opened duct from the front.

3. Duodenal preserving with resection of head of pancreas in front of portal vein with jejunal loop anastomosis to the transected neck of pancreas—*Beger procedure (Hans Beger from Ulm, Germany, 1980)*. Here extensive resection of head (than Frey's) is done. It addresses the inflammatory mass present in the head of pancreas by resecting it but preserving the blood supply of duodenum and bile duct. Here two anastomoses are present; one proximal over the extensive decored area; another on to the distal pancreas to its ductal system. Sleeve of pancreas is left behind with duodenum to preserve the blood supply. It is less radical resection; but it needs transection of the neck of the pancreas and double separate anastomoses; one at the decored transected part of the head; another at distal cut end of the body with laid open duct. Pancreaticojejunostomy is done at two sites of the Roux limb. It is also known as *duodenal preserving pancreatic head resection (DPPHR)*. Pain relief is 94%; insulin secretory capacity and glucose tolerance improve in this **(Figs 23-20 and 23-21)**.
4. *Berne modification of Beger procedure :* This modification spares the dissection of the pancreatic body from the portal vein. After the resection of pancreatic head, a single cavity results which can be anastomosed end to side with a Roux-en–Y jejunal loop. If stenosis of the intrapancreatic part of the common bile duct cannot be resolved by decompression and resection of the surrounding pancreatic tissue, or if the intrapancreatic portion of the common bile duct is opened accidentally during pancreatic head resection, the wall of the opened bile duct is fixed with single stitches to the surrounding tissues and is included in the same anastomosis. Complete transection of the neck is not done here.
5. *Longitudinal pancreaticojejunostomy* after excision of peripancreatic duct tissue: Here superficial part of the head of pancreas is removed to achieve improved drainage—*Frey procedure (Frey and Smith, 1987)*. It is done when ductal dilatation is not adequate; head is more than 4 cm thick. Head coring is done with retaining 5 mm thick tissue in front of veins, close to duodenum. It shows 75% pain relief in 3 years. Here procedure is similar but decoring is done up to duct of Wirsung and Santorini and single longitudinal pancreaticojejunostomy is done **(Fig. 23-22)**.

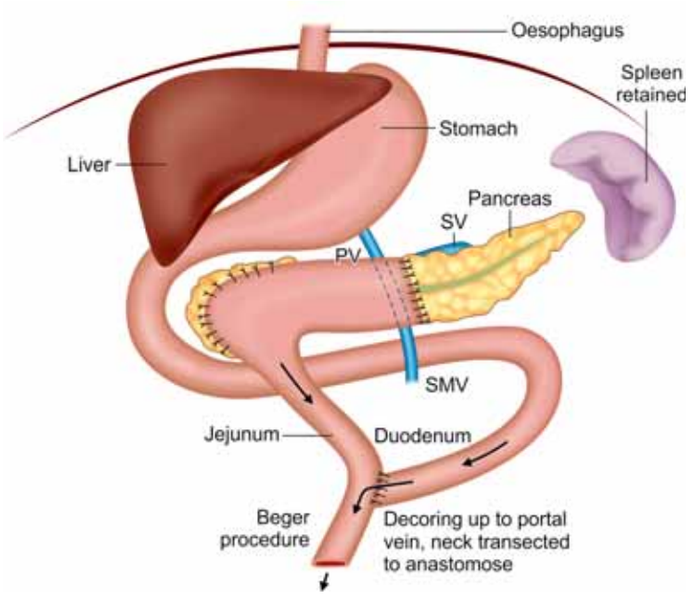
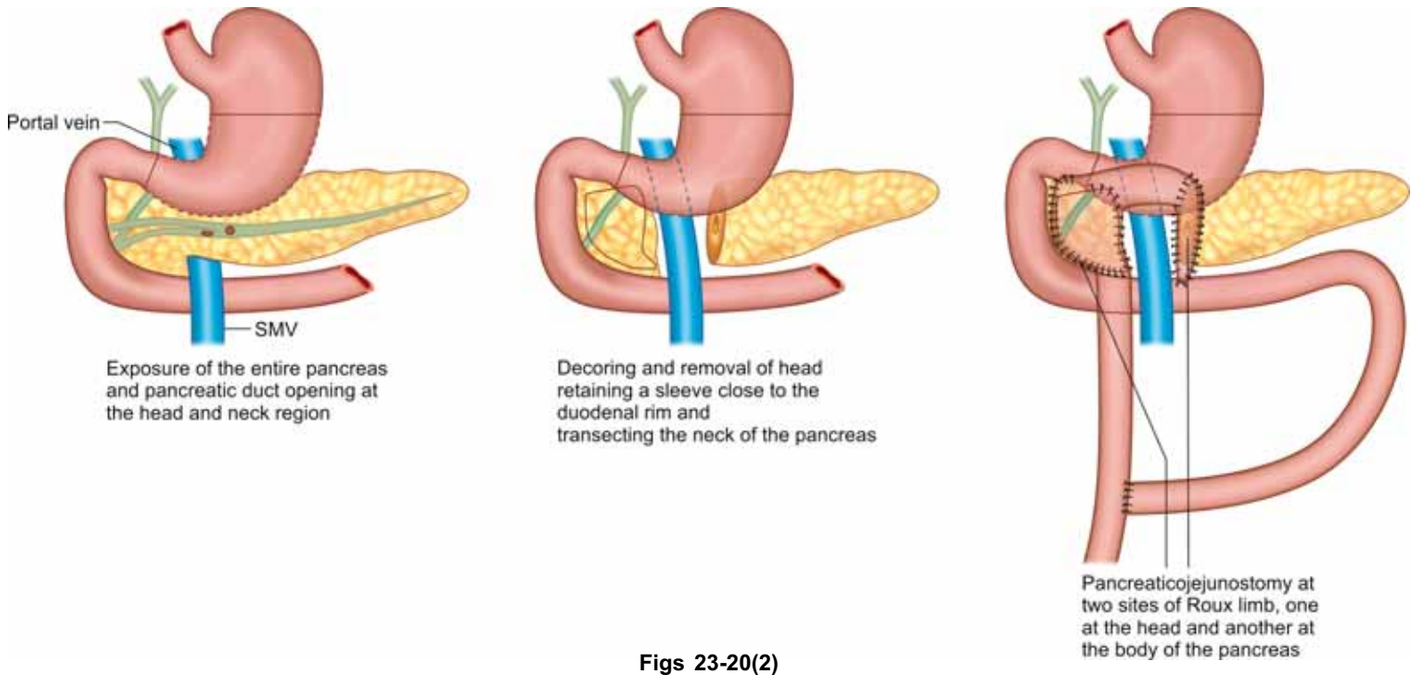


Fig. 23-20(1)


Portal vein
SMV
Exposure of the entire pancreas and pancreatic duct opening at the head and neck region
Decoring and removal of head retaining a sleeve close to the duodenal rim and transecting the neck of the pancreas
Pancreaticojejunostomy at two sites of Roux limb, one at the head and another at the body of the pancreas

Figs 23-20(2)

Figs 23-20(1 and 2): Beger procedure. Here head is decorated up to the visible portal vein. Neck is transected. Distal end of the pancreas with retained part is anastomosed to Roux loop of jejunum.

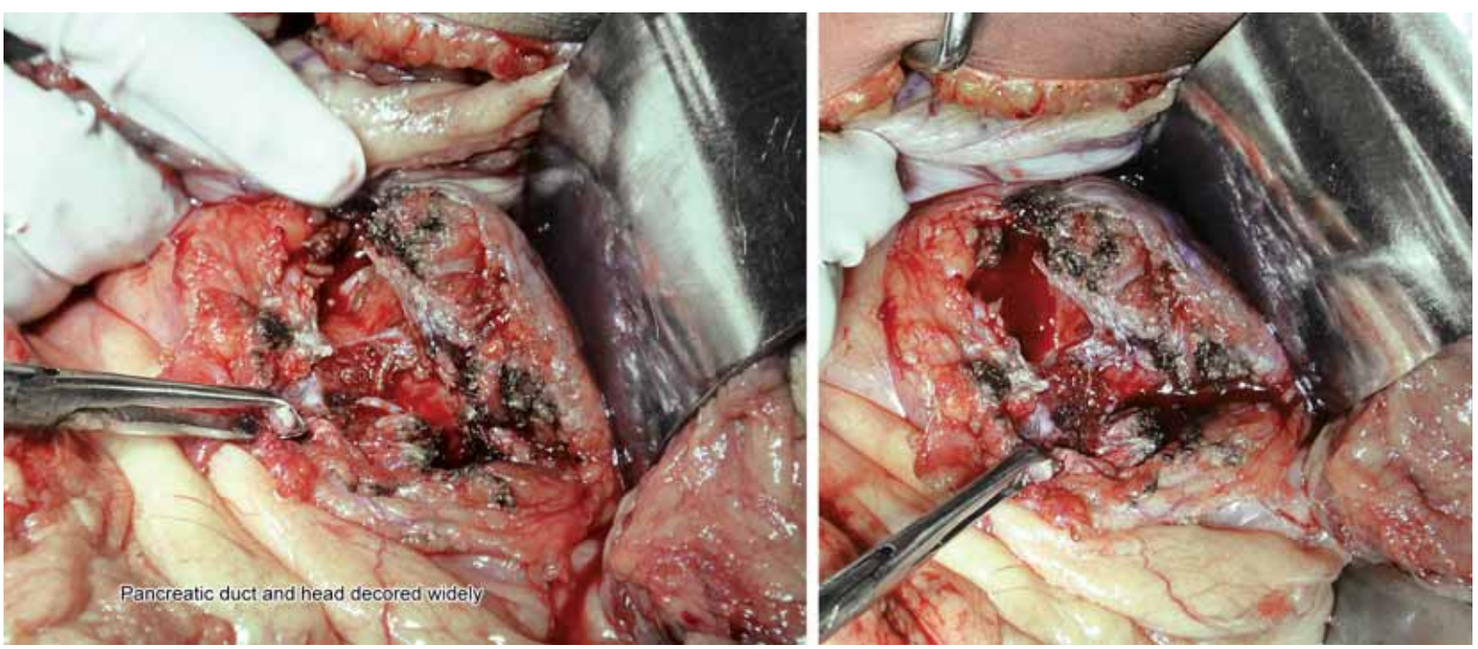


Fig. 23-21: Decoring of the pancreatic duct and head in Beger technique.

6. Resection of tail of pancreas with retrograde Roux-en-Y pancreaticojejunostomy is known as—*Duval procedure (1954)*. It was not very successful in long-term as multiple strictures especially in proximal part are not laid open and addressed. Decompression of the main pancreatic duct is achieved by resection of the pancreatic tail and retrograde drainage of the pancreatic duct via a termino-lateral pancreaticojejunostomy. It may be useful if there is single stricture, which is unlikely **(Fig. 23-23)**.
7. If disease mainly involves head of the pancreas, then pancreaticoduodenectomy can be done—*Whipple's procedure.*
8. *Subtotal pancreatic resection:* Here spleen, body and tail of the pancreas are removed entirely, retaining the head of pancreas.
9. 95% *subtotal pancreatectomy is ideal but technically not feasible and demanding—Child's operation.* It is never recommended and advocated.
10. *Total pancreatectomy* is indicated when the entire gland is diseased. It relieves the pain and also prevents the diseased pancreas from turning into malignancy. Patient has to take insulin and oral pancreatic enzymes permanently (*brittle diabetes*).
11. The cause is treated like cholecystectomy for gallstones. Therapeutic ERCP is useful in removal of stones in dilated duct.
12. When duodenal, biliary and pancreatic obstruction is present—choledochojejunal, pancreaticojejunal and gastrojejunal anastomosis may be needed—*triple anastomosis.*

13. Only biliary stricture which cannot be managed by ERCP needs choledochojejunostomy.

Figs 14.31A and B: *Choledochojejunostomy*. It is Roux-en-Y anastomosis. It is done whenever there is complication of biliary stricture after pancreatitis. Often triple anastomosis may be required—pancreaticojejunostomy, choledochojejunostomy and gastrojejunostomy. It is done whenever there is duodenal obstruction, biliary block and pancreatic duct dilatation (drainage procedure) **(Figs 23-24 and 23-25)**.

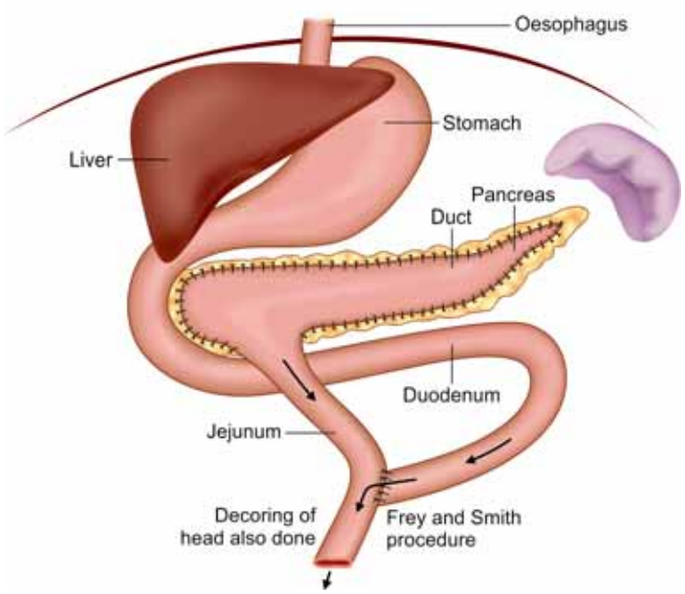


Fig. 23-22: Frey's procedure. Here head of pancreas is decorated and opened duct with decored head is anastomosed to Roux loop of jejunum.

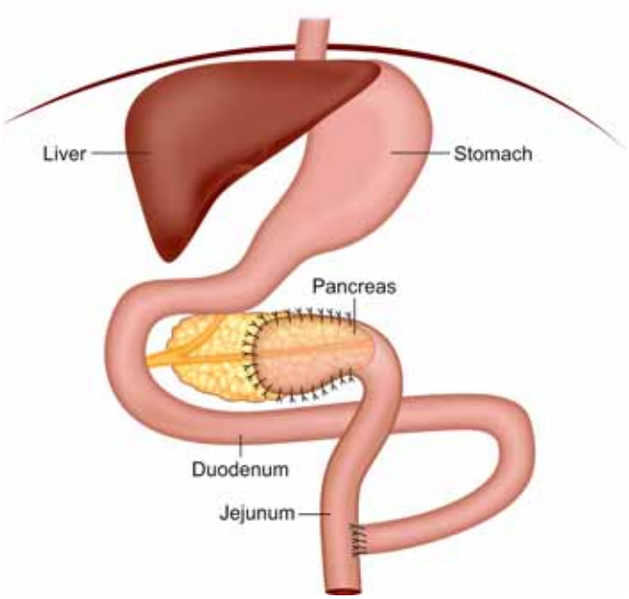


Fig. 23-23: Retrograde pancreaticojejunostomy after resection of the tail of the pancreas (Duval).

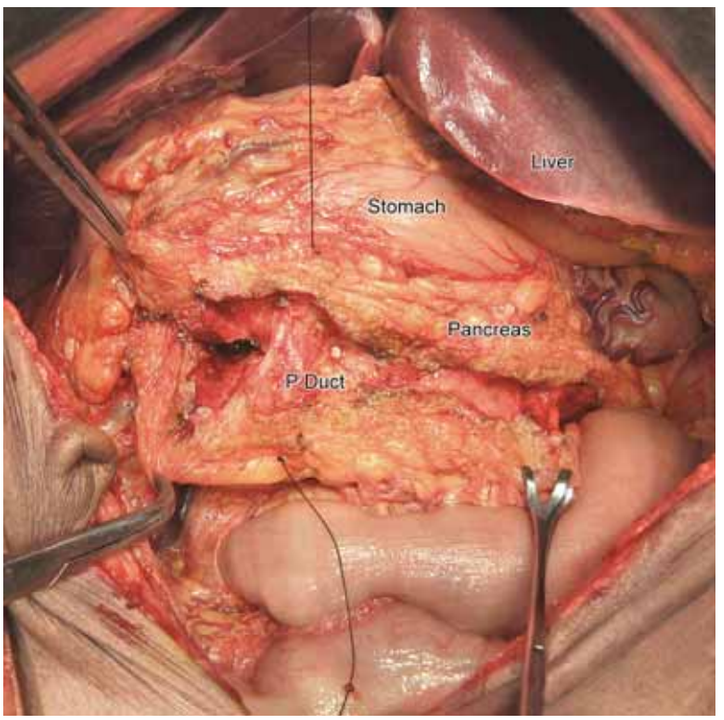


Fig. 23-24: Dilated pancreatic duct is laid open; multiple stones are removed and duct is ready for longitudinal pancreaticojejunostomy (LPJ). (By Dr Arunkumar, MCh, Gastro, Kochin).

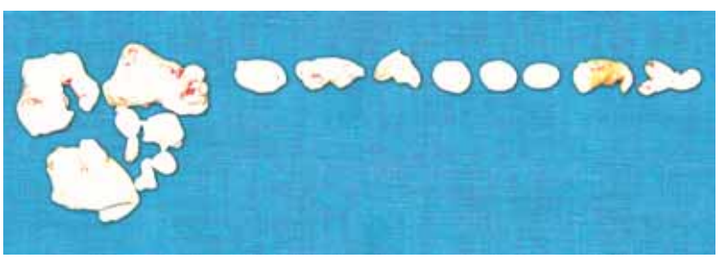


Fig. 23-25: Pancreatic duct stones—removed during pancreaticojejunostomy.

Technique of Longitudinal Pancreaticojejunostomy—(Partington-Rochelle Operation—LPJ)

Longitudinal pancreaticojejunostomy is commonly done as drainage procedure as it is technically easier with reasonable good results with minimum morbidity and mortality. Preoperative CT scan to assess the ductal pattern diameter and splenic vein status is important. Duct dilatation more than 5-7 mm is better for pancreaticojejunostomy to drain the pancreas; it is also now done in non-dilated or less dilated duct system as it acts like a permanent fasciotomy on the pancreas which allows significant decompression. Splenic vein thrombosis when present, patient will have varices which are tortuous and dilated and so during surgery may cause troublesome bleeding. ERCP is a must to assess ductal anatomy, strictures ('chain of lakes' appearance), and stones. Pancreatic malignancy and chronic pancreatitis are difficult to differentiate grossly and on table biopsy is a must. Chronic pancreatitis itself predisposes malignancy **(Fig. 23-26).**

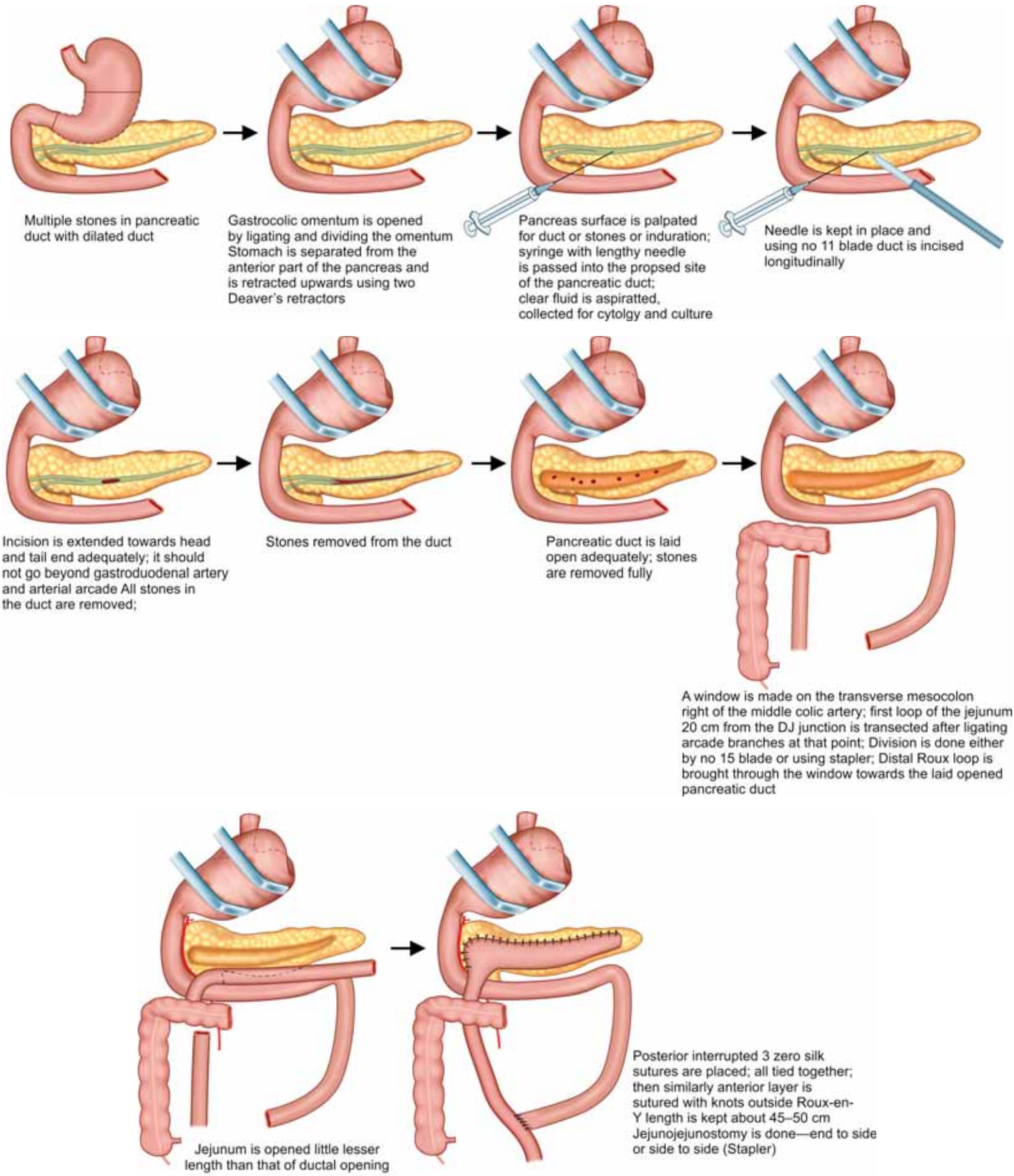

Multiple stones in pancreatic duct with dilated duct
Gastrocolic omentum is opened by ligating and dividing the omentum Stomach is separated from the anterior part of the pancreas and is retracted upwards using two Deaver's retractors
Pancreas surface is palpated for duct or stones or induration; syringe with lengthy needle is passed into the propsed site of the pancreatic duct; clear fluid is aspiratted, collected for cytolgy and culture
Needle is kept in place and using no 11 blade duct is incised longitudinally
Incision is extended towards head and tail end adequately; it should not go beyond gastroduodenal artery and arterial arcade All stones in the duct are removed;
Stones removed from the duct
Pancreatic duct is laid open adequately; stones are removed fully
A window is made on the transverse mesocolon right of the middle colic artery; first loop of the jejunum 20 cm from the DJ junction is transected after ligating arcade branches at that point; Division is done either by no 15 blade or using stapler; Distal Roux loop is brought through the window towards the laid opened pancreatic duct
Jejunum is opened little lesser length than that of ductal opening
Posterior interrupted 3 zero silk sutures are placed; all tied together; then similarly anterior layer is sutured with knots outside Roux-en-Y length is kept about 45–50 cm Jejunojejunostomy is done—end to side or side to side (Stapler)

Fig. 23-26: Technique of longitudinal pancreaticojejunostomy.

Under general anaesthesia, patient is in supine position, lengthy midline incision is placed. In obese patients, bilateral subcostal or upper transverse incision may be needed. After thorough exploration, self-retaining retractor is placed. Usually Kocherisation is not essential but to feel head of pancreas and if decoring is planned, then Kocherisation is done. It is better to release transverse colon on right side and hepatic flexure downwards to expose field adequately.

If gall bladder is not yet removed earlier by laparoscopy or open method, then cholecystectomy should be done.

Gastrocolic ligament is opened and transversely divided to expose the anterior surface of the pancreas. Omentum is held in between clamps, divided and ligated; alternatively harmonic scalpel or ligaseal can be used here to hasten the technique. Stomach is retracted upwards using a wide Deaver retractor. All adhesions between the posterior surface of the stomach and pancreas should be released over the head, uncinate process, body and tail of the pancreas **(Fig. 23-27)**.

Transverse colon and small bowel are retracted downwards. Peritoneal attachment on the front of the pancreas may be incised but not necessary. Entire gland from head to tail is carefully palpated for location of duct, stones and possible site of malignancy.

A 21-gauge needle with syringe is taken; suspected site of the duct usually in lower part of the gland is pricked; by trial and error usually which is dilated duct can be reached; clear pancreatic fluid is aspirated; fluid is collected for culture, analysis and cytology. With the needle in place no. 11 blade is passed adjacent to the needle to enter into the duct. It can be done using a cautery also **(Fig. 23-28)**.

Once duct is visualized, a Bake's dilator or any probe or infant feeding tube is passed to locate the duct direction and stones. If identification of the duct system has failed by repeated needle punctures which is not uncommon, then on table ultrasound is very useful to identify the duct. If it is not available, then carefully millimeter by millimeter pancreatic tissue is cut near the neck of the pancreas towards body side until duct is reached. In olden days tail used to be transected often with splenectomy to identify the duct and proceeded with standard old Puestow Gilesby technique—but nowadays it is not necessary to change to Puestow. Any bleeders in the cut edge of the duct are controlled using bipolar cautery. Duct is incised towards head up to the gastroduodenal artery not beyond; distally it is opened up to the end of the duct as much as possible. All stricture parts should be laid open; all stones should be removed. Minimum 8 cm duct length should be opened. Venous plane is deeper to ductal system. Deep incision across the posterior wall of the duct may injure the splenic vein. In the head, there are chances of injuring anterior pancreaticoduodenal vessels; one should be careful to preserve them. After passing the needle, intraductal pressure can be measured; or another fine needle can be inserted into the parenchyma to measure interstitial pressure of the pancreas. Entire duct of Wirsung, duct of Santorini and duct of uncinate process should be laid open; but should limit within the anterior pancreaticoduodenal arcade **(Fig. 23-29)**.

If Frey's procedure is undertaken, entire pancreatic tissue in front of these ducts should be excised and laid open. It is done by placing series of consecutive stay sutures using silk or vicryl and cutting the pancreatic tissue using tough curved scissor (Pott's scissor or another one). Bleeders are addressed with suture ligation using 3 zero silk or vicryl. Monopolar cautery should not be used. Bipolar cautery is safer.

Roux limb is prepared 20 cm from the ligament of Treitz. Jejunal vessels are ligated. Small bowel is transected between two occlusion clamps; proximal end is left like that to do later end-to-side jejunojejunostomy. Alternatively stapler transection of the jejunum can be done. A window is created in the transverse mesocolon to the

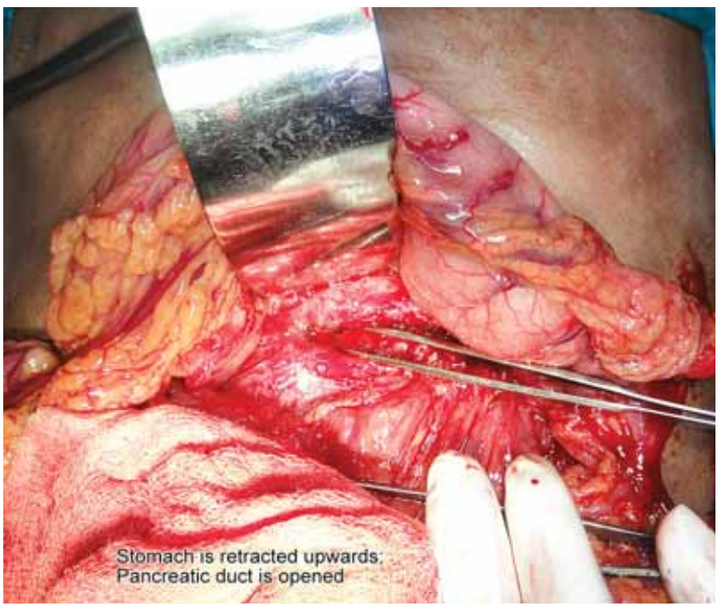


Fig. 23-27: Stomach is retracted upwards.

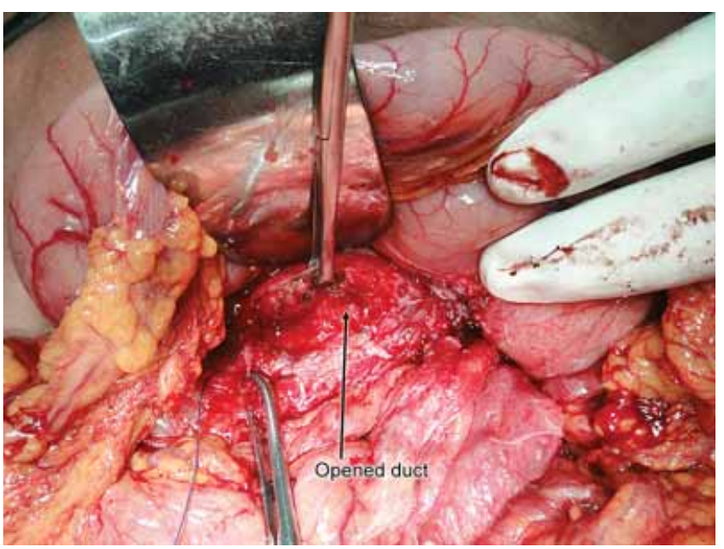
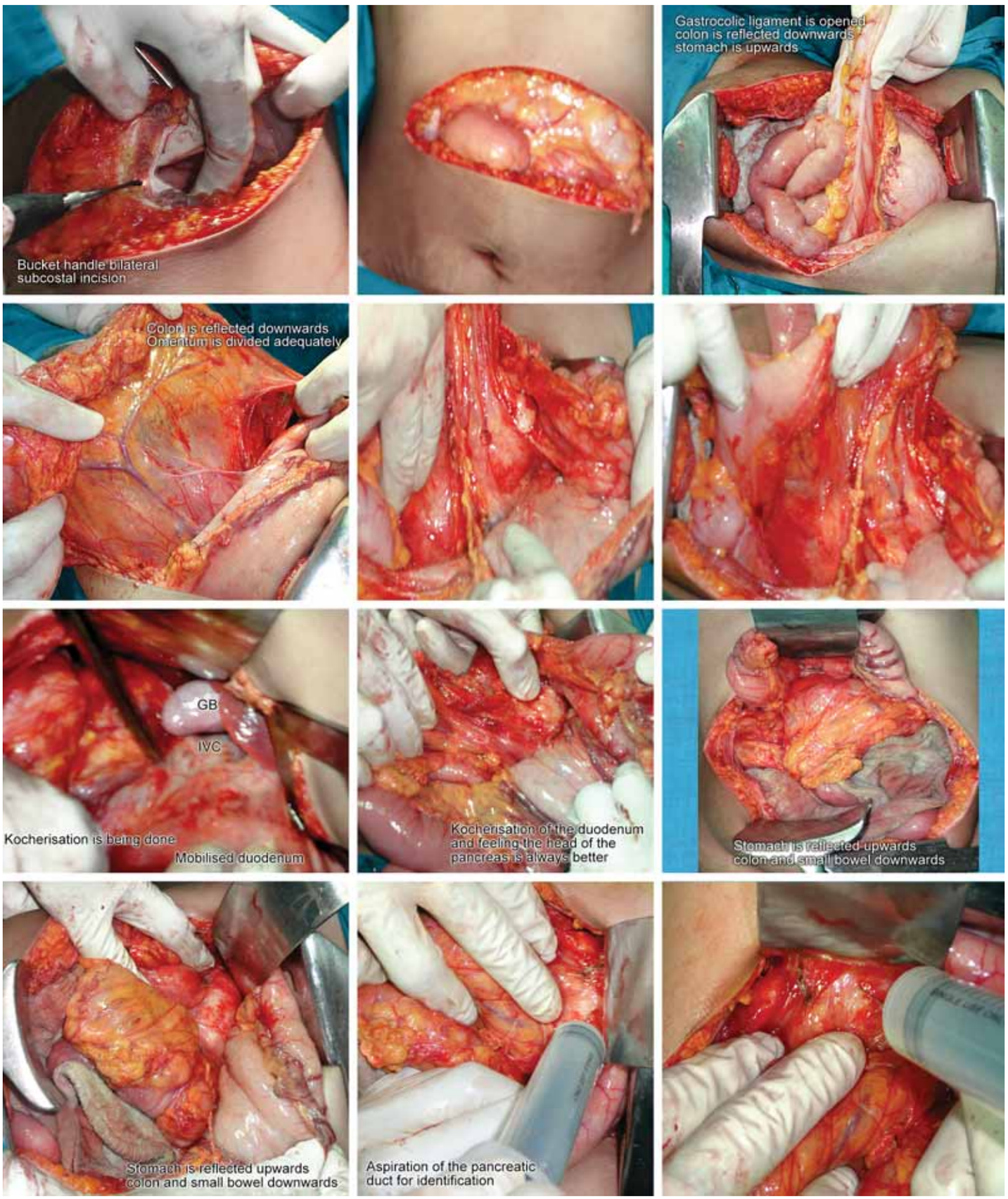


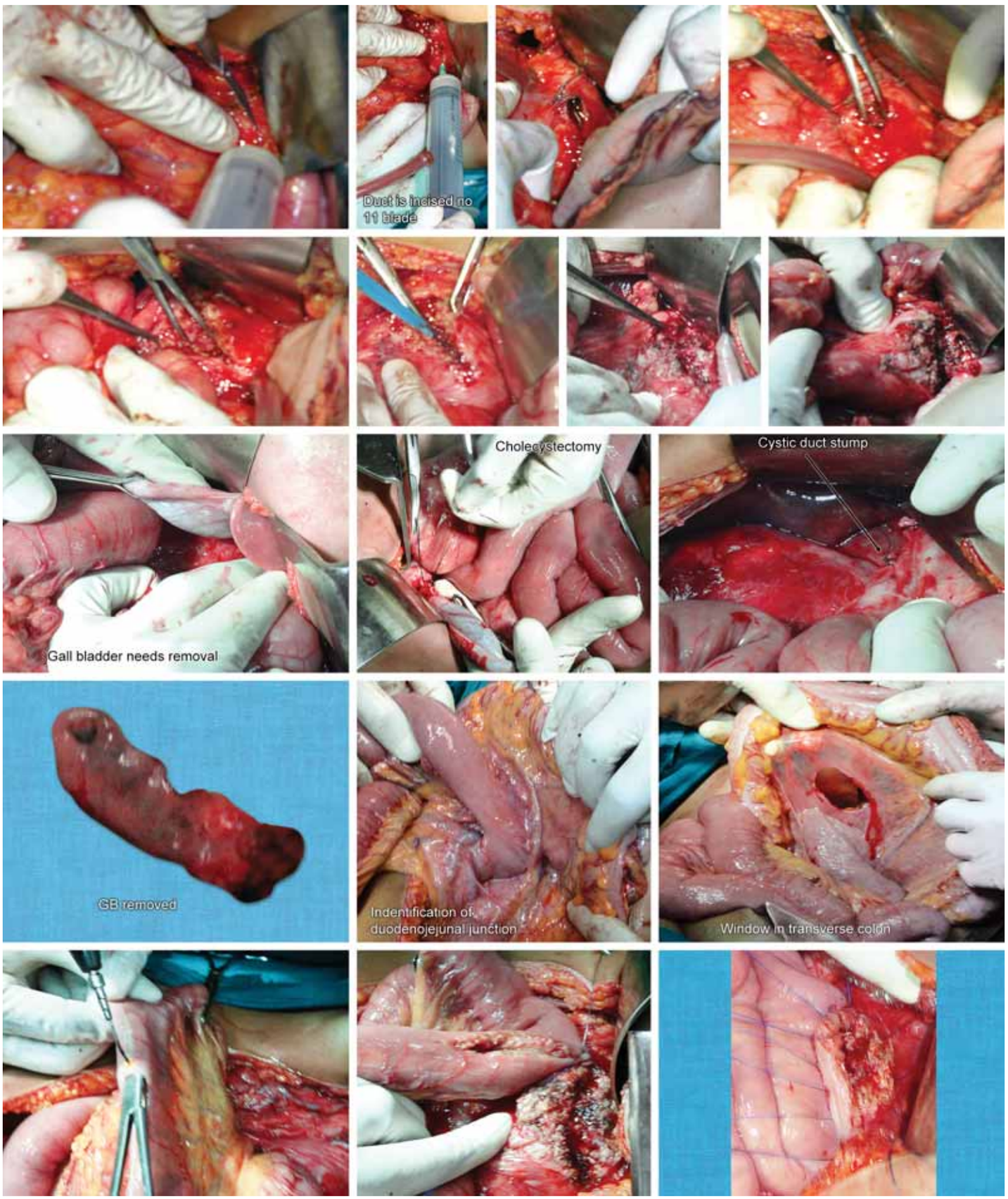
Fig. 23-28: Pancreatic duct is opened for adequate length from head to tail, minimum of 8 cm.

right of the middle colic artery. Distal Roux limb is brought through it to reach supracolic compartment. Loop is brought towards the tail end of the pancreas so that anastomosis becomes isoperistaltic in relation to the ductal drainage. If loop end is brought towards the head part of the pancreas it will become antiperistaltic, still can drain the duct adequately. Usually 45-50 cm Roux loop is sufficient **(Fig. 23-30)**.

Entire pancreatomy on the duct is anastomosed to the jejunum. Jejunotomy/enterotomy is done on the antimesenteric border of the jejunum just 1 cm proximal from the distal end of the Roux loop. Enterotomy should be 5 mm lesser than the ductal opening. Side-to-side pancreaticojejunostomy is done. Posterior layer is sutured first. Interrupted 3 zero silk or vicryl sutures are used. All suture bites should be taken first. While taking bites from pancreatic side full thickness bite including fibrous peripancreatic tissue should be taken. Few advocate that mucosal bite should be avoided. But usually it does not the cause any problem. Continuous suturing should be avoided as it will block endings of the small ducts into the main pancreatic duct. After taking all bites, posterior layer knots are placed one after other. Ties on either side (one on each end) are kept long. Knots are placed inside. It is also

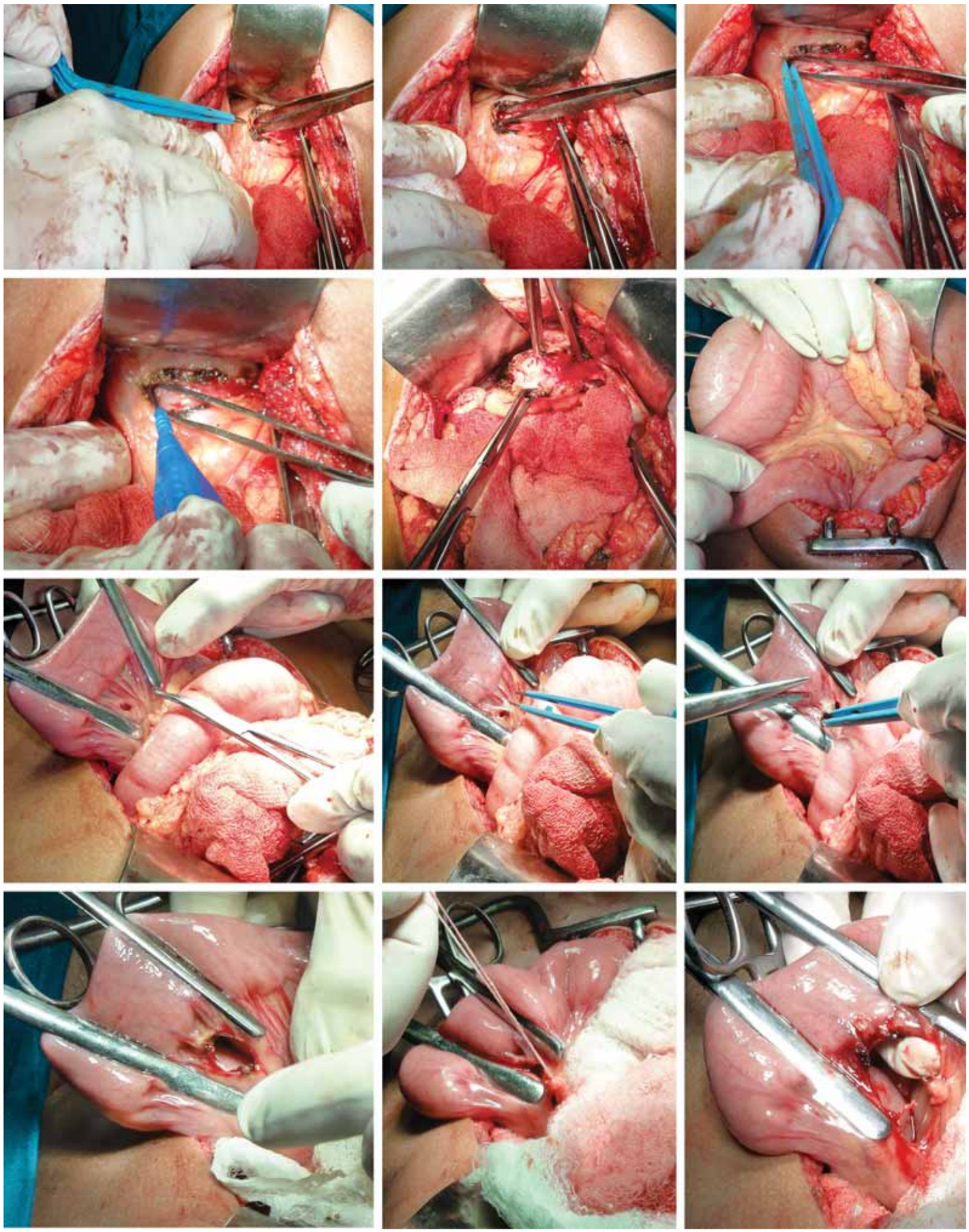

Bucket handle bilateral subcostal incision
Gastrocolic ligament is opened colon is reflected downwards stomach is upwards
Colon is reflected downwards Omentum is divided adequately
GB
IVC
Kocherisation is being done
Mobilised duodenum
Kocherisation of the duodenum and feeling the head of the pancreas is always better
Stomach is reflected upwards colon and small bowel downwards
Stomach is reflected upwards colon and small bowel downwards
Aspiration of the pancreatic duct for identification

Figs 23-29(1)

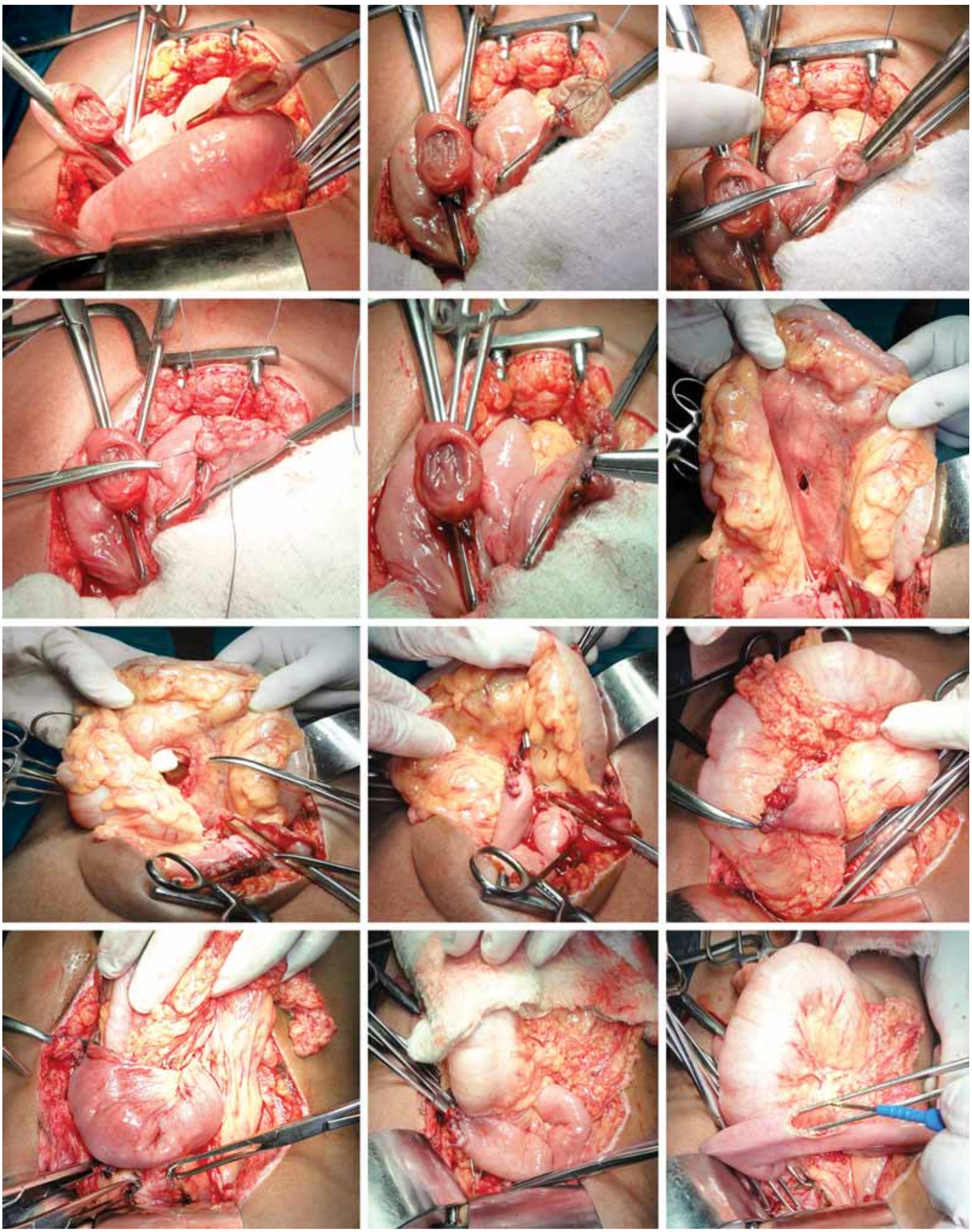


Figs 23-29(2)

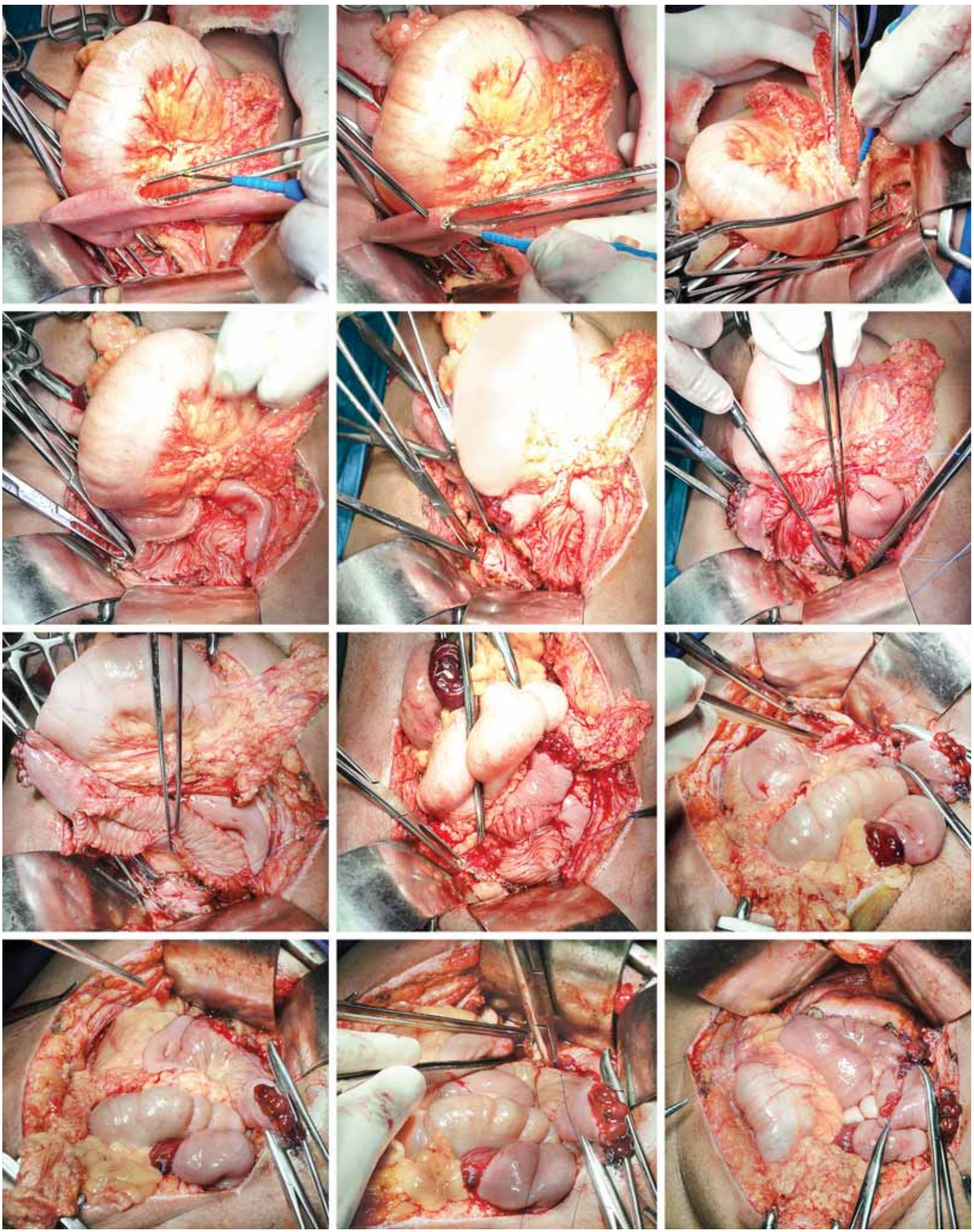
Figs 23-29(1 and 2): Initial steps in longitudinal pancreaticojejunostomy.



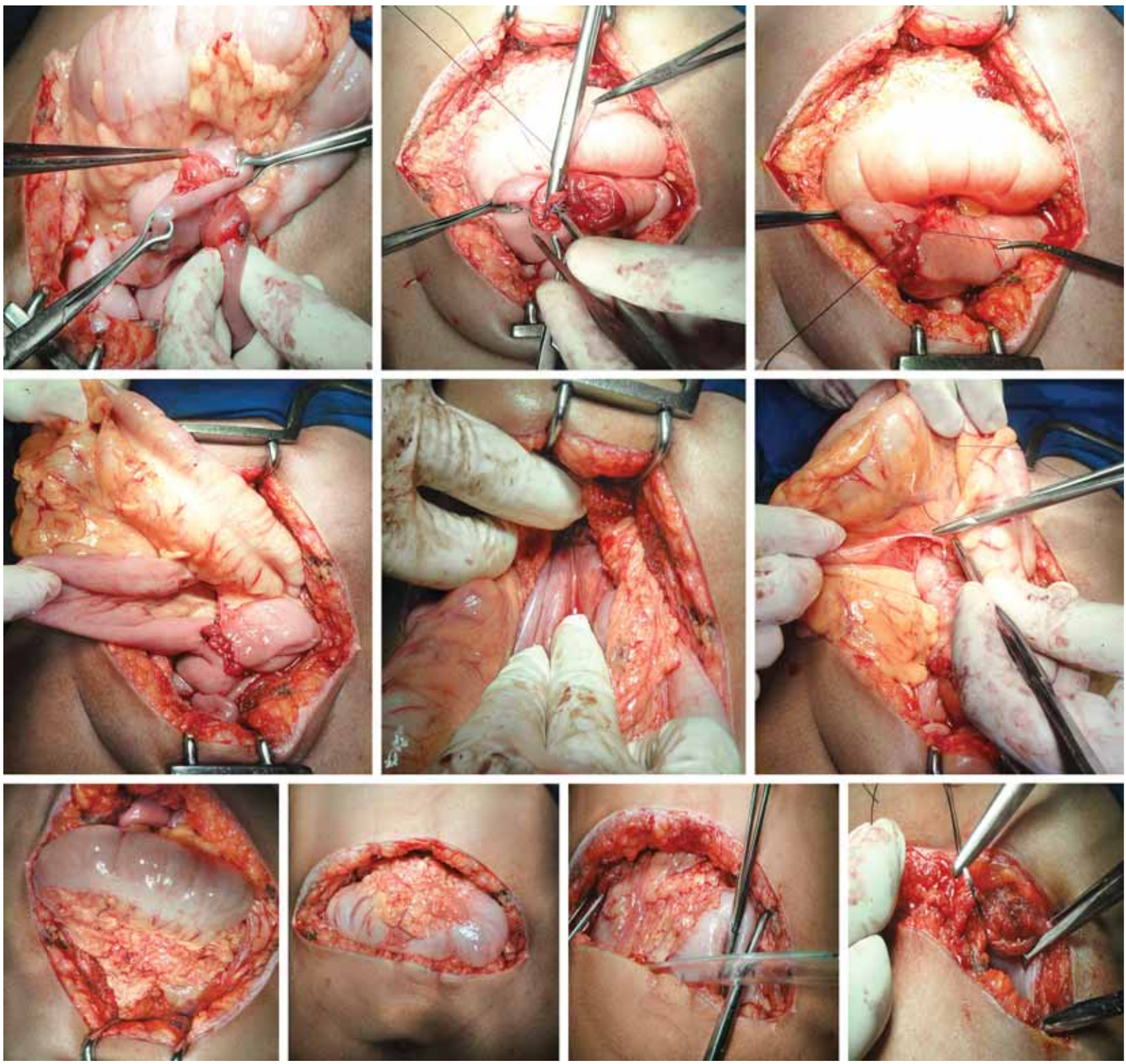
Figs 23-30(1)



Figs 23-30(2)



Figs 23-30(3)



Figs 23-30(4)

Figs 23-30(1 to 4): Longitudinal pancreaticojejunostomy procedure.

often practised that knots are placed outside in posterior layer; if it is so, bites should be taken from outside to inside of the duct and then inside to outside of the jejunum to place the knots at end. Placing knots inside the pancreaticojejunostomy is very well accepted. Anterior layer anastomosis is done by taking series of interrupted bites from anterior edge of the duct opening to anterior edge of the jejunal incision. Here also all bites are taken, tied one by one later and then ends are cut. Knots are placed outside in anterior layer. Single layer is sufficient in pancreaticojejunostomy even though few practice double-layer anastomosis which is technically difficult and not essential as such. Roux limb may be fixed to anterior pancreatic tissue to prevent kinking proximal to lengthy anastomosis **(Fig. 23-31)**.

End-to-side jejunojejunostomy is done to maintain the bowel continuity (45–50 cm from pancreaticojejunostomy site). If stapler transection is done, side-to-side anastomosis can be undertaken. Single layer continuous or interrupted 3 zero vicryl sutures are used for the same. Second layer 3 zero silk interrupted seromuscular sutures can be added **(Fig. 23-32)**.

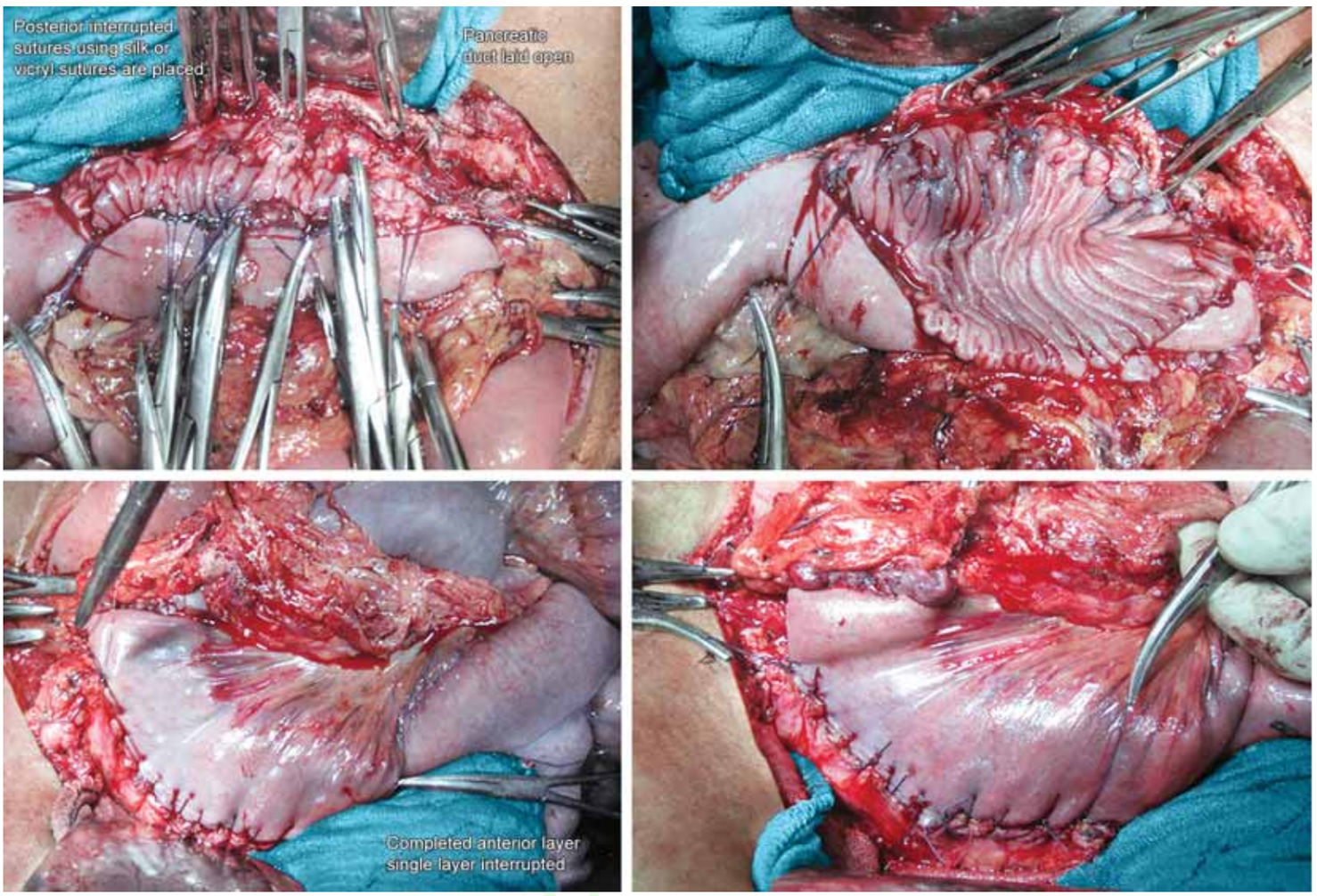

Posterior interrupted sutures using silk or vicryl sutures are placed
Pancreatic duct laid open
Completed anterior layer single layer interrupted

Fig. 23-31: Longitudinal pancreaticojejunostomy.

Fig. 23-32: Jejunojejunostomy in Roux-en-Y pancreaticojejunostomy.

If celiac ganglion block is needed, it can be given on table by direct palpation of aorta. 20 ml of 50% ethanol is injected along each side of the aorta using 21-gauge spinal needle.

Jejunum is fixed to the mesocolon by few interrupted silk sutures to prevent herniation. Jejunostomy, if needed, is done. Drain is placed. Abdomen is closed in layers.

Problem with this procedure (LPJ) is failure to identify the portal hypertension and dilated veins in the pancreas, and possible occult carcinoma of the pancreas.

Complications of Surgery

Pancreatic leak/fistula (10%); infection; bleeding; recurrence; brittle diabetes in total pancreatectomy.

Pain/relief in chronic pancreatitis is achieved by drugs; decompression/drainage surgeries, resection surgeries, epidural analgesia, coeliac ganglion block, operative chemical splanchnicectomy, extra/intraperitoneal right and left splanchnicectomy, transhiatal bilateral splanchnicectomy, thoracoscopic splanchnicectomy. 5-year pain-free period in decompression surgery is 70%.

A. Drainage procedure

- *Partial*: draining the duct partially
  a. Sphincterotomy and sphincteroplasty
  b. Duval procedure
  c. Puestow-Gillesby procedure
  d. Leger's procedure—Here splenectomy; opening of the duct; retrograde loop pancreaticojejunostomy is done instead of Roux-en-Y.
  e. Marcadier procedure—Only duct in the body is drained through a side-to-side loop pancreaticojejunostomy.
- *Complete*: draining the main duct completely

  I. Pancreaticojejunostomy
    a. Partington-Rochelle procedure
    b. Bapat's (India, 1997) modification of Partington's procedure—Here end of Roux loop is not closed but fish mouth is created by giving a cut at antimesenteric border and entire part is anastomosed to side of the duct.
    c. Moreno Gonzales procedure—Pancreatic and bile duct drainage is established into an isolated vascularised loop of jejunum which is then anastomosed to the duodenum.

  II. Pancreaticogastrostomy

  It is technically found easier; however, it is not practised usually. Patients developed steatorrhoea because of the inactivation of the pancreatic enzymes by gastric acid.

B. Resectional procedures

a. Whipple's operation.
b. Traverso-Longmire procedure: Pylorus preserving pancreaticoduodenectomy, 1978.
c. Beger's procedure: Decoring of head with transection of the neck and two anastomoses are done—one at head and another at cut end of the body of pancreas to a single Roux loop. In Berne's modification, head is decored but neck is not transected and a single cavity created is anastomosed to a Roux jejunal loop; CBD when opened here, its edge is also involved in stitches so that bile is also made to drain into the Roux loop.
d. Denervated pancreatic flap: Warrens denervated pancreatic flap: The pancreas is divided over the portal superior mesenteric vein after ligation of the splenic artery and vein. The pancreatic head is excised leaving a thin rim. The remaining pancreas is not drained. Ligation of splenic vein and artery is probably denervate the gland.

   Shires' denervated splenopancreatic flap: Complete mobilization of the pancreas from the retroperitoneum, resection of the head and the uncinate process leaving a thin rim of pancreas adjacent to the duodenum, division of the splenic vein at its junction with the SMV and drainage of the distal pancreatic remnant into a Roux-en-Y limb of jejunum.
e. Subtotal pancreatic resection: Body and tail of pancreas is removed. Disease in the body and the tail is often secondary to disease in the head of the pancreas, thereby limiting its role. This procedure is still indicated when the disease is confined to body and tail, e.g. pseudocyst, failed pancreaticojejunostomy, nondilated duct, pseudoaneurysm and when there is disease beyond the neck of pancreas, and the pancreatic duct is oversewn. A concomitant splenectomy is unavoidable in the majority of patients because of dense fibrosis precluding the isolation of the splenic vessels.
f. Child's procedure: 95% distal pancreatectomy. The spleen, the tail, body and uncinate processes are completely removed. The small cuff of the head that is preserved protects the vascularity and common bile duct during surgery. This procedure is performed when lesser procedures have failed or when the entire pancreas is severely diseased.
g. Total pancreatectomy: With duodenal preservation (Russel, 1987); without duodenal preservation.

C. Extended drainage procedure

a. Rumpf's extended drainage (1983): This is a combination of Partington's procedure with a transduodenal pancreatic sphincteroplasty. It is indicated when there is a prepapillary obstruction to the drainage of pancreatic duct due to stones or stricture.

D. Resection with extended drainage

a. Extended Beger procedure—In addition to the duodenum preserving head resection, a side-to-side lateral pancreaticojejunostomy is performed after slitting open the main pancreatic duct.
b. Frey's procedure.
c. Izbicki V-shaped ventral pancreatic excision. In this procedure, a long V-shaped excision of ventral aspect of the pancreas is done with a lateral pancreaticojejunostomy by a mucosa to capsule anastomosis. This procedure drains the main as well as the second and third order ducts. This is an ideal procedure for small duct disease with a maximum diameter of the Wirsung's duct less than 3 mm.

E. Pancreatic denervation alone

a. Left splanchnicectomy with celiac ganglionectomy: Mallet Guy (1983) advocated an extraperitoneal approach through the 12th rib for left splanchnicectomy with celiac ganglionectomy. This is done after correcting the extrapancreatic pathology.
b. Left splanchnicectomy, celiac ganglionectomy with bilateral vagotomy.
c. Complete pancreatic denervation: Hirokawa described a more extensive denervation procedure, which includes freeing the pancreas from the posterior abdominal wall and resection of all postganglionic pancreatic nerve plexus including those surrounding the common hepatic and splenic arteries (1986).
d. Transthoracic/videothoracoscopic pancreatic denervation: The greater splanchnic nerves are responsible for pain in supramesenteric viscera and the nerve trunks lie above the level of the 10th thoracic vertebra and descend along the spine to end in the celiac plexus, similarly the lesser splanchnic plexus. Transthoracic division of the splanchnic nerves with bilateral vagotomy performed through a left thoracotomy. Procedure can be performed using a videothoracoscopic technique (Makarewicz W et al, 2003).

F. Pancreatic autotransplantation

a. Islet cell transplantation
b. Segmental pancreatic transplantation.

Postoperative Care

Nutrition—TPN/jejunostomy feed; fluid and electrolyte management; prevention/control of sepsis; proper monitoring; Octreotide on table and postoperatively—regular intervals or slow infusion—5 days. Nasogastric tube is removed in 48 hours. Oral fluid is started in 4-5 days. Drain is removed in 5-7 days.

Surgery for Chronic Pancreatitis

Drainage: Technically easier; Less mortality < 2-5%; Adequate pain relief; Recurrence of pain in 5 years—50%. But diseased tissue is left behind; Disease progression and fear of existing occult carcinoma (17%) or later onset.

Resection: Technically demanding; Mortality is 8-21%—very high; Used when carcinoma is suspected or localised disease. Head is the pacemaker of the disease. Whipple's is preferred. Total pancreatectomy causes high mortality, brittle diabetes; though ideal, it is not done commonly.

Islet Cell Auto-transplantation

The Mirkowitch technique: Partially purified islet produce a fairly large volume of minced digested islet cell tissue which is then injected into a portal vein very slowly. But portal pressure is markedly raised several fold. *Let preparation technique (Hinshaw et al)*—5 ml tissue pellet is produced containing 500,000-2000,000 islets for transplantation, portal pressure remained essentially unchanged. Total pancreatectomy and islet autotransplantation are done for chronic pancreatitis with intractable pain when other treatment measures have failed, allowing insulin secretory capacity to be preserved, minimising or preventing diabetes, while at the same time removing the root cause of the pain. Pain relief is obtained in most patients, and insulin independence preserved long-term in about a third, with another third having sufficient beta-cell function so that the surgical diabetes is mild. Islet autotransplantation has been done with partial or total pancreatectomy for benign and premalignant conditions. Islet autotransplantation should be used more widely to preserve beta-cell mass in major pancreatic resections [Blondet JJ, et al. (2007)].

Segmental Pancreatic Transplantation

Auto-transplantation of the resected body and tail of the pancreas is done into the thigh following near total pancreatectomy. The splenic vessels are anastomosed to the femoral vessels. The divided end of the pancreas is closed and the duct is ligated or injected with synthetic polymers (e.g. prolamine or neoprene). Duct obliteration is thought to cause rapid and permanent atrophy of the exocrine pancreas but preserves endocrine function. Still it is found that duct obliteration does not prevent relapse or progression of chronic pancreatitis in the preserved pancreatic segment. Internal drainage of the duct into a Roux-en-Y limb of jejunum has also been reported.

Laparoscopic Pancreatic Resection

Laparoscopic resection of the pancreas is technically quite demanding. It is technically feasible. The benefit of the laparoscopic approach may not be as apparent as that of a less complex laparoscopic procedure. The use of laparoscopy for distal pancreatic resection with splenic preservation is beneficial. Optimal closure of the cut edge of the pancreas and preservation of the spleen and its main vessels are the most important aspects of this operation. Laparoscopic longitudinal pancreaticojejunostomy and laparoscopic Whipple's procedures are done now in specified centers by skilled laparoscopic surgeons with same principles and technique as open surgery.

SURGICAL TREATMENT FOR PSEUDOCYST OF PANCREAS

It is a localized collection of sequestered pancreatic fluid, usually 3 weeks after an attack of acute pancreatitis. It can occur after trauma and recurrent chronic pancreatitis. Collection usually occurs in the lesser sac in relation to stomach, but can occur in relation with duodenum, jejunum, colon and splenic hilum. About 50% of acute pancreatitis leads to pseudocyst formation, but among that 20-40% will resolve spontaneously. **Sites—**Lesser sac—commonest, i.e. between colon and stomach; can occur in relation to duodenum, jejunum, colon and splenic hilum. **Types—**Depending on whether it communicates with pancreatic duct or not is classified as: 1. *Communicating pseudocyst. and* 2. *Noncommunicating pseudocyst. Pseudocyst can also be Acute pseudocyst or Chronic pseudocyst.*

Initially, cyst wall is thin *(unformed),* but later it gets fibrosed and thickened *(formed)* (matured). It is lined by fibrin layer but no endothelium, hence known as pseudocyst. It contains typically brownish fluid with sludge-like necrotic material. It can get infected to form *infected pseudocyst* or *pancreatic abscess.* Amylase level in the cyst fluid is very high (> 5000 units/ml).

Complications of pseudocyst—Rupture—3%—into bowel or peritoneum; bleeding from the splenic vessels—7%; cholangitis; duodenal obstruction; portal/splenic vein thrombosis and segmental portal hypertension; cholestasis due to CBD block.

D'Egidio's classification of pseudocyst

Type I: After an attack of acute pancreatitis; Normal duct anatomy; no fistula/communication.

Type II: After an attack of acute on chronic pancreatitis; Abnormal duct anatomy without stricture; 50% chances of fistula.

Type III: After an attack of chronic pancreatitis, abnormal anatomy with stricture; always communicating. It appears like retention cyst.

Investigations

U/S abdomen (commonly done procedure), U/S reveals the size and thickness of the pseudocyst. Size less than 6 cm indicates that one can wait for spontaneous resolution. US also shows the presence of gall stones. Endosonography (EUS) is very useful. CT scan is ideal and study of choice. It is two times more sensitive than U/S. It demonstrates size, shape, number, wall thickness, contents, pancreatic duct size, and extent of necrosis in pancreas, calcification and atrophy in chronic pancreatitis, regional vessels, pseudoaneurysm, and splenic/portal vein thrombosis. Splenic artery CT angiography is very relevant in suspected cases of pseudoaneurysm. MRCP delineates the ductal anatomy and its abnormality. ERCP can be done to find out the communication **(Fig. 23-33)**.

http://dropeBooks.com

Fig. 23-33: CT scan of pseudocyst of pancreas.

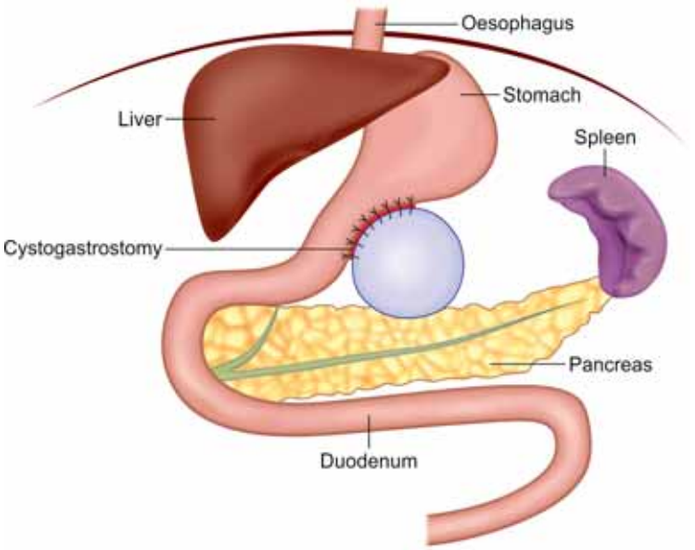
Indications for Surgery/Intervention

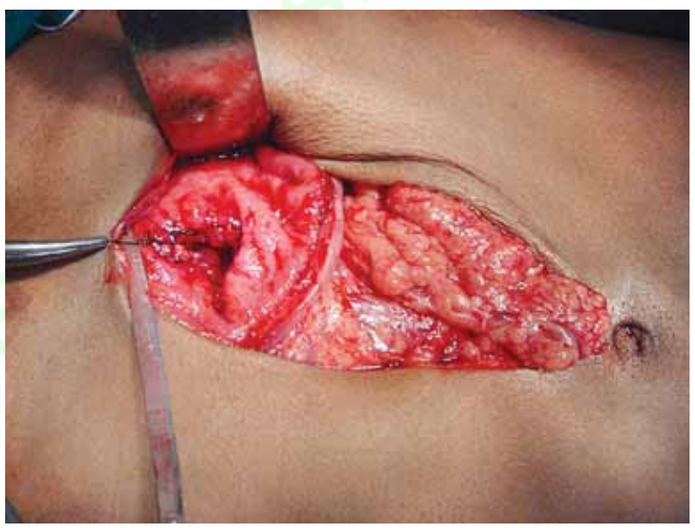
Size more than 6 cm; formed pseudocyst; infected pseudocyst; cyst persisting after 6 weeks/progressive cyst; multiple cysts/cyst due to trauma; communicating cysts/cyst with severe pain; thick-walled pseudocyst.

Cystogastrostomy

Procedure is done under general anaesthesia. Preoperative antibiotics are given. Nasogastric tube is passed. Cyst should be firmly attached to the wall of the stomach to do cystogastrostomy. Cyst wall should be thick to do cystogastrostomy otherwise only external drainage is possible **(Figs 23-34 and 23-35)**.

At laparotomy, cyst is palpated. Any undue pulsation more than usual should indicate a suspicion of pseudoaneurysm. Anterior wall of the stomach is easily exposed. Gastrotomy on the anterior wall of the stomach is made—6-8 cm on its most prominent part. Posterior wall of the stomach is opened after again confirming that cyst wall is adherent to the stomach. Anterior wall is retracted by placing two Deaver's retractors inside anterior wall; or 4 stay sutures can be placed on 4 points. Long needle with syringe is passed into the cyst; brownish coloured fluid is aspirated. If blood is aspirated, pseudoaneurysm is suspected. Fluid is sent for cytology and biochemical assessment (amylase level). Aspiration is often done prior to gastrotomy but usually done after gastrotomy. Posterior wall of the stomach with an elliptical incision is excised along with similar sized anterior cyst wall. This cyst wall is sent for histology. The thick capsule of pseudocyst is opened. All fluid with necrotic material is sucked. Fluid should be sent for cytology, culture and sensitivity and amylase estimation. Cyst wall always should be biopsied—ideally frozen section biopsy. Cyst cavity should be washed with warm normal saline after breaking septae. Cut edge of the stomach is anastomosed to the cut edge of the cyst wall using continuous or interrupted vicryl sutures. This pseudocapsule which is anastomosed to posterior wall of the stomach is known as *Jurasz operation.* Anterior wall gastrotomy is closed with continuous single layer vicryl sutures. Stapler closure also can be done. Usually peritoneal drainage is not necessary. Nasogastric tube is kept for 48 hours. Oral started in 72 hours **(Fig. 23-36)**.





Figs 23-34: Cystogastrostomy.

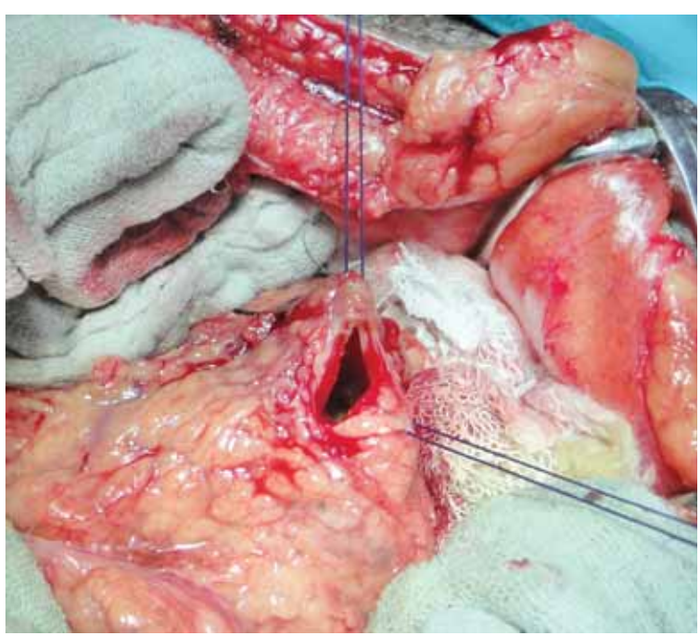


Fig. 23-35: Opened pseudocyst wall. Always collect fluid for amylase which will be very high; and also for CEA; take frozen section biopsy from the edge.

Cyst fluid — note the brownish black colour
Anterior gastrotomy
Posterior wall of stomach with bulging cyst
Posterior wall of stomach and cyst wall are opened
Suturing cyst wall to opened posterior wall of the stomach with continuous vicryl sutures

Fig. 23-36: Pseudocyst with cystogastrostomy.

If stomach is not adherent to cyst wall, then cystojejunostomy is done; if cyst wall is not thick on table, then only external drainage should be done.

If cyst contains pseudoaneurysm, then on table ultrasound should be done; here it is better to do distal pancreatectomy with the removal of cyst and ligation of splenic artery **(Figs 23-37 and 23-38A and B)**.

Note: Feel for pulsation to rule out pseudoaneurysm and needed adhesion between stomach and cyst; aspirate to rule out blood and to confirm brownish black fluid of cyst; do always frozen section biopsy of cyst wall to rule out cystadenocarcinoma. Cyst fluid is sent for amylase and CEA.

Other Procedures

1. ***Cystoduodenostomy:*** It is similar to stomach technically; but duodenum is opened and anastomosis is done. It is commonly not used as duodenum healing is not as good as cystogastrostomy and leak may occur.
2. ***Cystojejunostomy:*** It is done in large cyst and recurrent cyst. Roux-en-Y cystojejunostomy is better with lesser recurrence rate than cystogastrostomy. Upper midline incision is used; laparotomy exploration is done. Cholecystectomy, if needed, is done. Anterior wall of the cyst is exposed by releasing the omental adhesions using sharp and bipolar cautery dissection. Cyst is aspirated in similar way and collected for culture, cytology and biochemical analysis. 4 cm cyst wall is excised elliptically; tissue is sent for frozen section biopsy. Jejunum is transected 20 cm from the ligament of Treitz; distal Roux limb is brought upwards through a created window in the transverse mesocolon. End of the Roux loop is anastomosed to the cyst wall as end-to-end using interrupted 3 zero vicryl or silk sutures. Rent in the mesocolon is sutured to the jejunum. Divided proximal cut end of the jejunum is anastomosed to the antimesenteric side of the Roux limb 50 cm from the cystojejunostomy site. Defect in the jejunal mesentery is closed with interrupted sutures **(Figs 23-39 and 23-40)**.
3. If infected, cystogastrostomy with external drainage is done using Malecot's catheter (*Smith operation)* **(Fig. 23-41)**.
4. ***Laparoscopic cystogastrostomy*** is becoming popular, effective and less invasive.

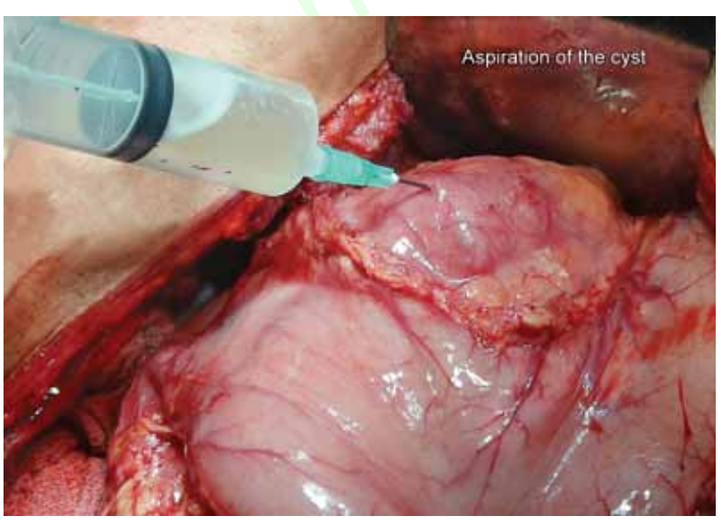
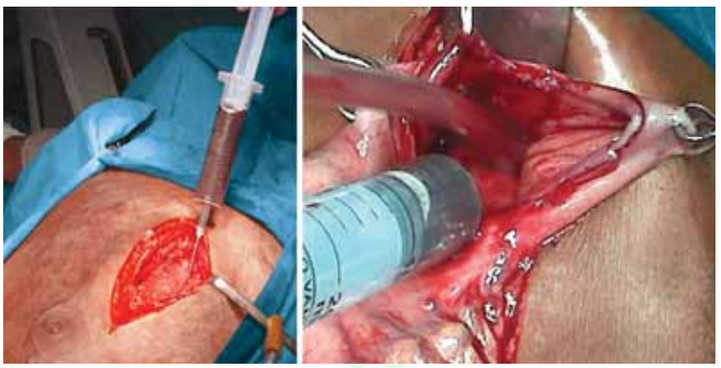


Fig. 23-37: Aspiration of the cyst.

5. ***Distal pancreatectomy*** with pseudocyst removal if cyst is in distal part or if there is a pseudoaneurysm **(Fig. 23-42)**.



Figs 23-38A and B: Aspiration of pseudocyst of the pancreas.

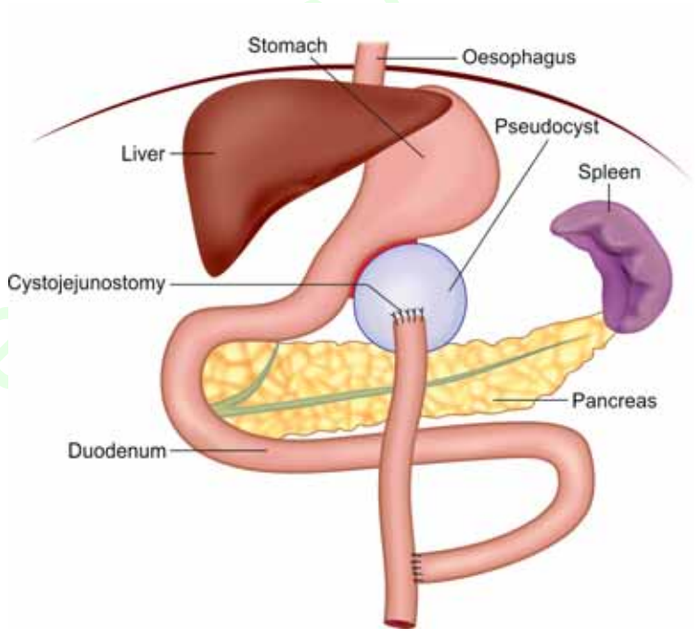


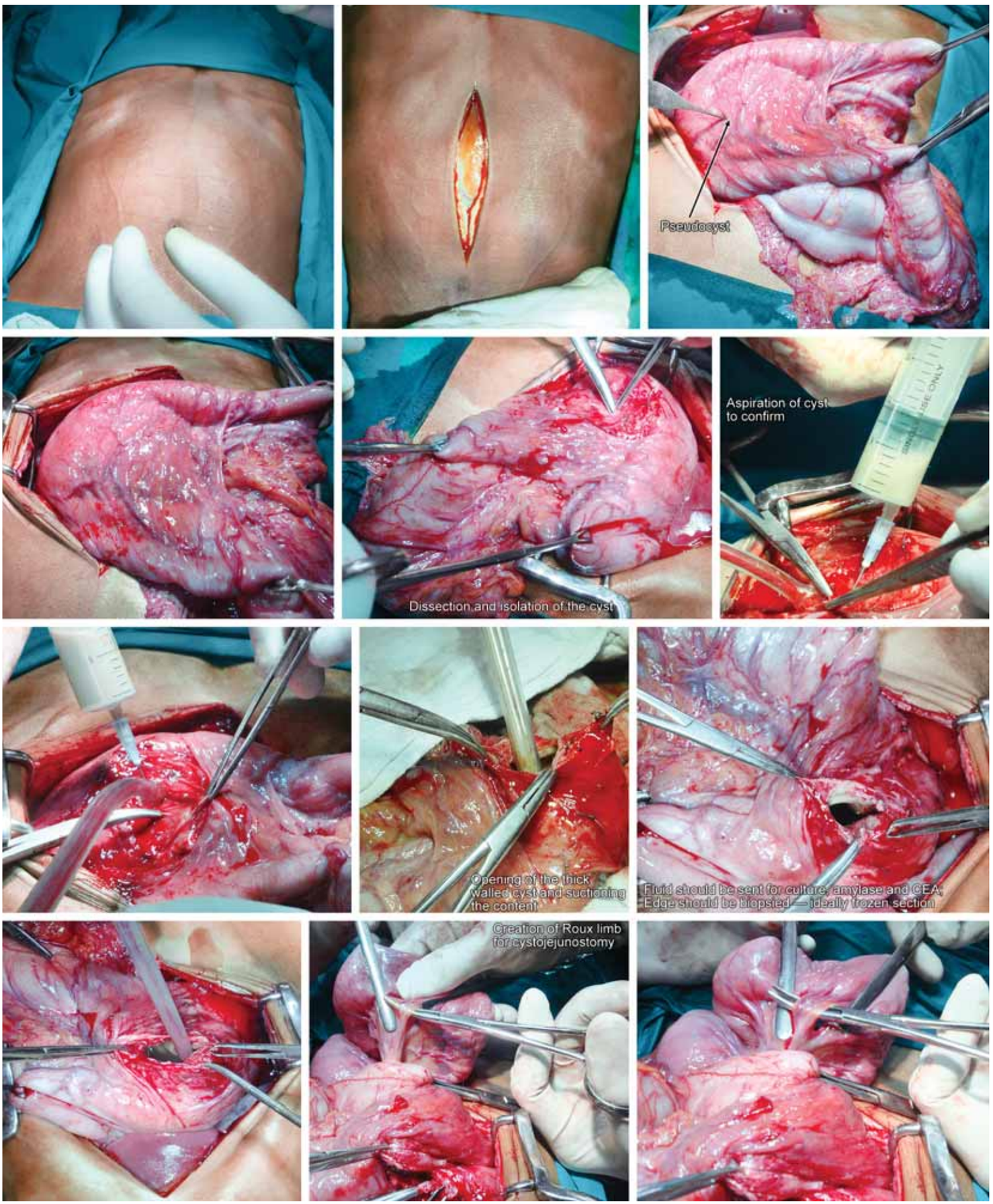
Fig. 23-39: Cystojejunostomy is better. If cyst is not adherent to stomach with thick cyst wall, cystojejunostomy is done.

PANCREATICODUODENECTOMY (WHIPPLE'S OPERATION/PARTIAL PANCREATICODUODENECTOMY)

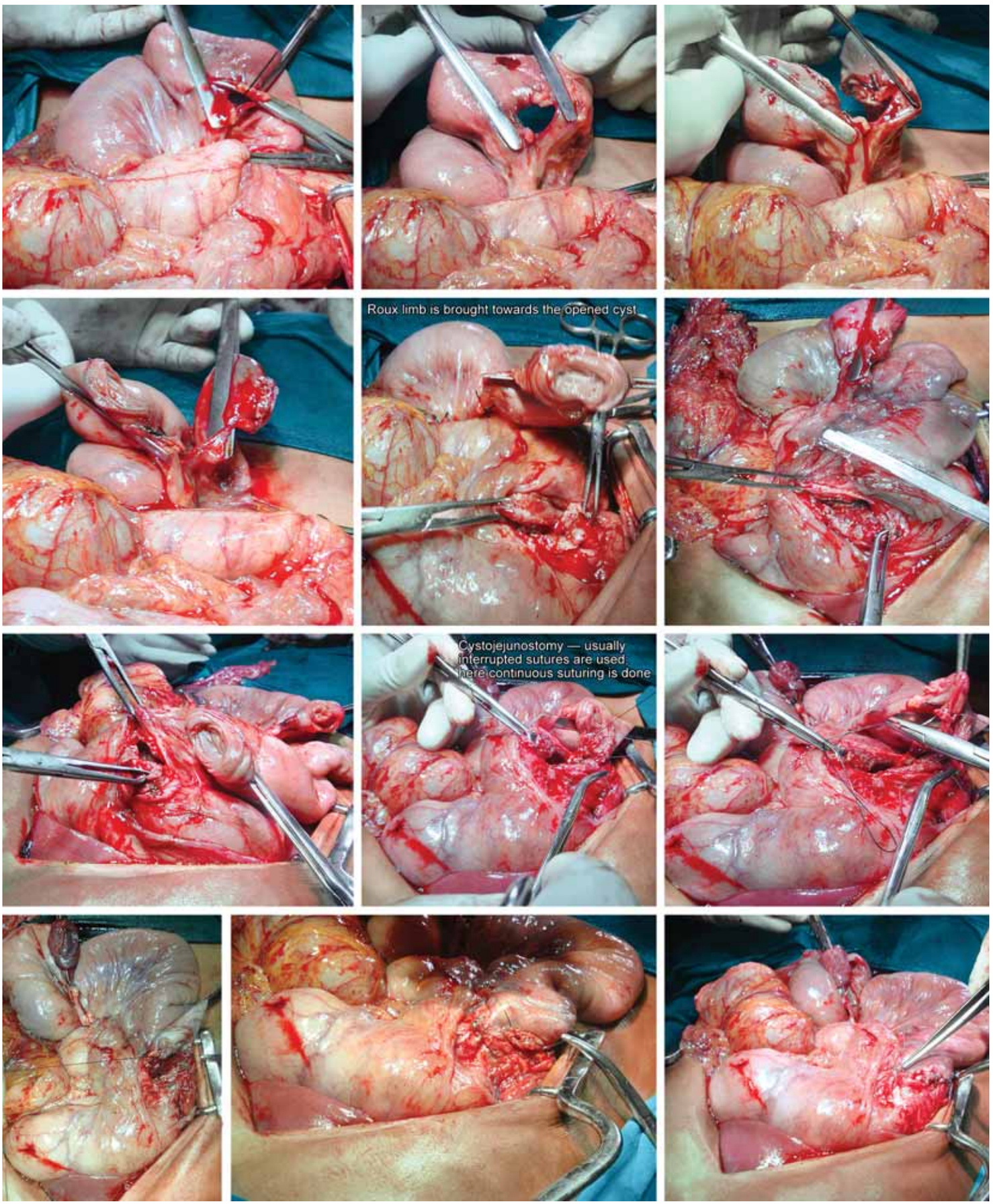
The standard surgical treatment for pancreatic cancer remains the pancreaticoduodenectomy, first described by Whipple (Allen Oldfather Whipple) in 1935. Initially he did two staged procedure and in 1942 he modified into one stage procedure. High operative morbidity and mortality rates led to technical modifications of the operation which, combined with improvement in anesthesia and critical care, have resulted in current perioperative mortality rate of 2% or less **(Fig. 23-43)**.

Indications

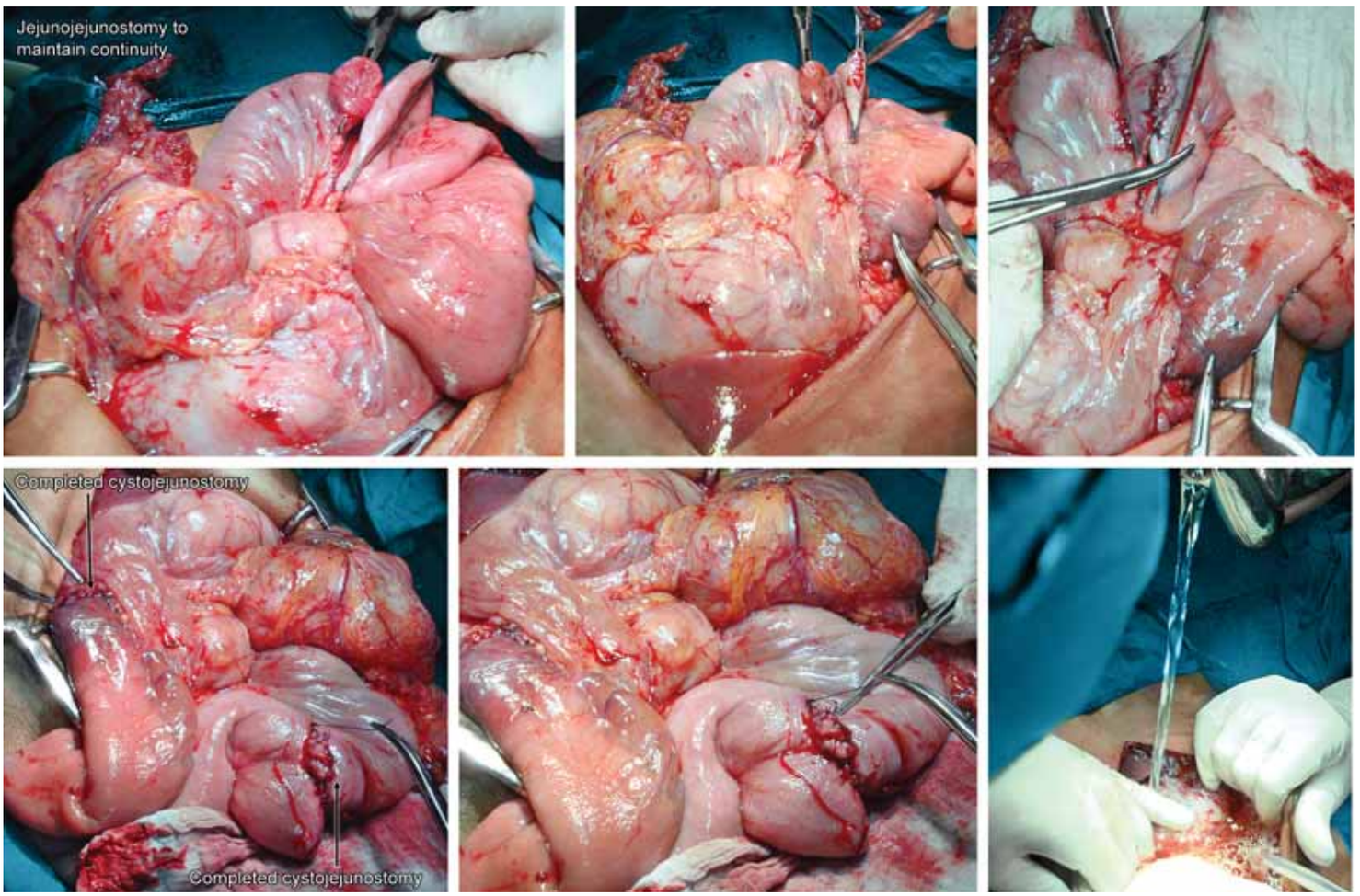
Periampullary carcinoma, carcinoma of 2nd part of the duodenum, ampulla, distal CBD are traditional indications. Chronic pancreatitis with disease involving mainly head of pancreas with severe pain is also an indication **(Fig. 23-44)**.


Pseudocyst
Dissection and isolation of the cyst
Aspiration of cyst to confirm
Opening of the thick walled cyst and suctioning the content
Fluid should be sent for culture, amylase and CEA; Edge should be biopsied — ideally frozen section
Creation of Roux limb for cystojejunostomy

Figs 23-40(1)


Roux limb is brought towards the opened cyst
Cystojejunostomy — usually interrupted sutures are used here continuous suturing is done

Figs 23-40(2)



Figs 23-40(3)

Figs 23-40(1 to 3): Technique of cystojejunostomy for pseudocyst of pancreas.

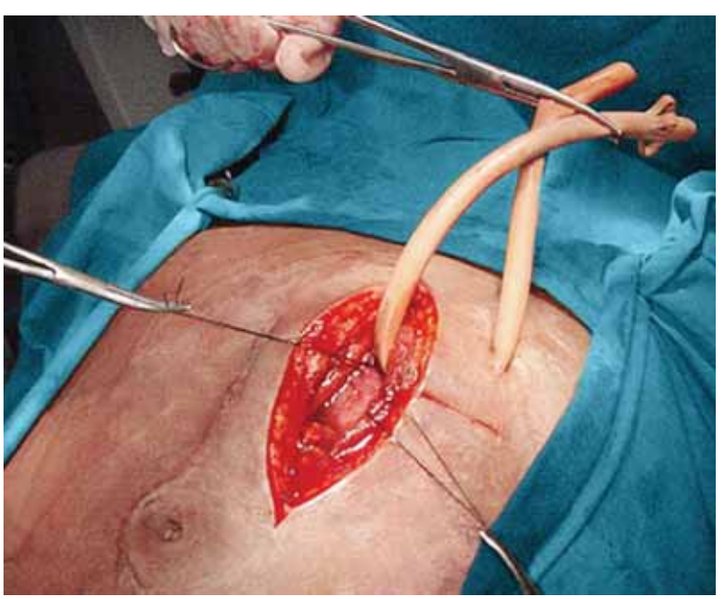


Fig. 23-41: When infected pseudocyst should be drained externally along with internal drainage (Smith).

Fig. 23-42: Laparoscopic cystogastrostomy is a safe and effective method; technique and principles are the same. Intracorporeal suturing is needed.

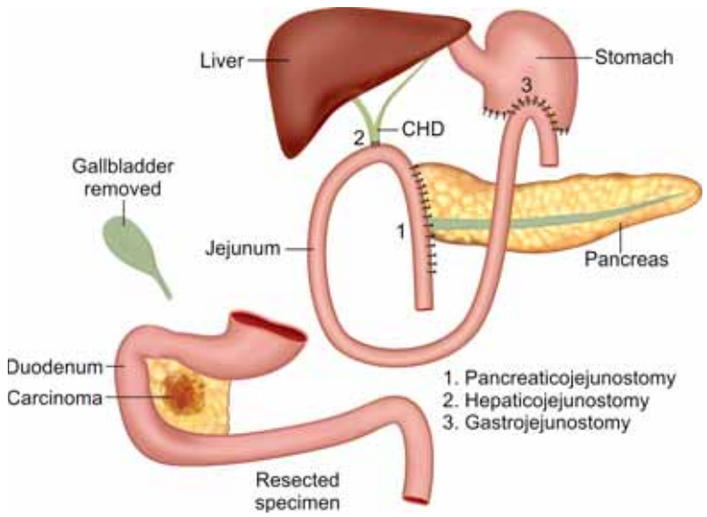


Fig. 23-43: Configuration of Whipple's operation.

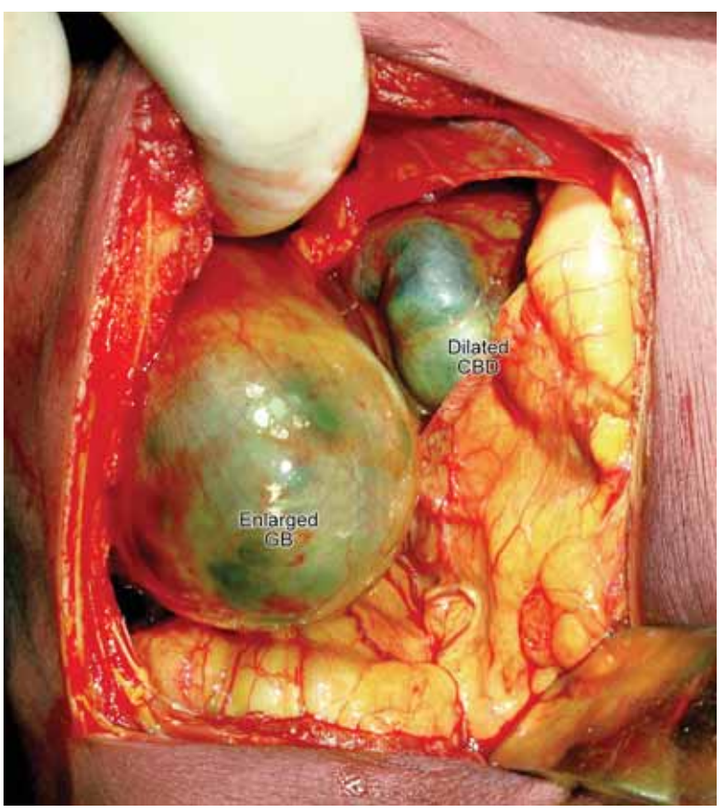


Fig. 23-44: Periampullary carcinoma with dilated CBD and gall bladder.

Contraindications

Liver and peritoneal secondaries; celiac lymph node involvement; involvement of the SMA or root of the mesentery. Significant deep infiltration of portal vein precludes the resection, even though resection of portal vein with graft is done.

Preoperative staging and evaluation with CT, MRI, ERCP, EUS, liver function tests, prothrombin time, and coagulation profile are needed. Adequate hydration in preoperative period is needed. Preoperative antibiotic may be needed if cholangitis is suspected. Malignant obstructive cholangitis, if present, is a high risk, may require an initial decompression by ERCP and then proceed with pancreaticoduodenectomy. However, routine preoperative decompression is not practised nowadays **(Fig. 23-45)**.

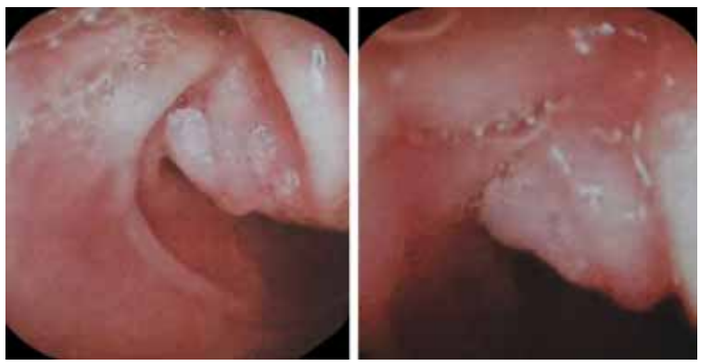


Fig. 23-45: Endoscopic view of periampullary carcinoma.

Risks are—intraoperative bleeding; anomalies of vessels; pancreatic and biliary leak; infection; acute pancreatitis; postoperative bleeding.

Technique of Whipple's Operation

The current practised technique utilizes a *bilateral subcostal incision (Chevron incision)*. The liver and peritoneal surface is carefully examined to exclude the presence of metastatic disease, and intraoperative ultrasonography of liver and pancreas is performed. Random lymph node sampling is not done however; suspicious lymph nodes found during the operation are subjected to frozen section analysis.

In an operable case, it is often practised to go ahead with pancreaticoduodenectomy without biopsy. Ideally on table FNAC of the tumour directly or transduodenal needle tissue biopsy or choledochotomy with choledochoscopic biopsy in case of CBD tumour is preferable; however preoperative endoscopic biopsy of periampullary carcinoma or ERCP biopsy is also commonly advocated.

Adequate exposure is essential for proper Whipple's operation. Good retraction with self-retaining retractor makes assistant's hands free to help the surgeon during surgical procedure. Bipolar cautery, ligaseal, harmonic scalpel are of benefits including staplers to divide stomach and duodenum. Initial mobilization is done by reflecting the hepatic flexure and transverse colon downwards; then extended Kocherisation is done by lateral duodenal ligament which exposes SMV, IVC and aorta partly. Invasion or encasement of these vessels will prevent from proceeding with resection; just essential bypass will be sufficient. Middle colic vein when traced will help in identifying the SMV **(Figs 23-46 and 23-47)**.

Fig. 23-46: Kocher's manoeuvre and Cattell-Braasch manoeuvre to mobilise the duodenum and right-sided colon.

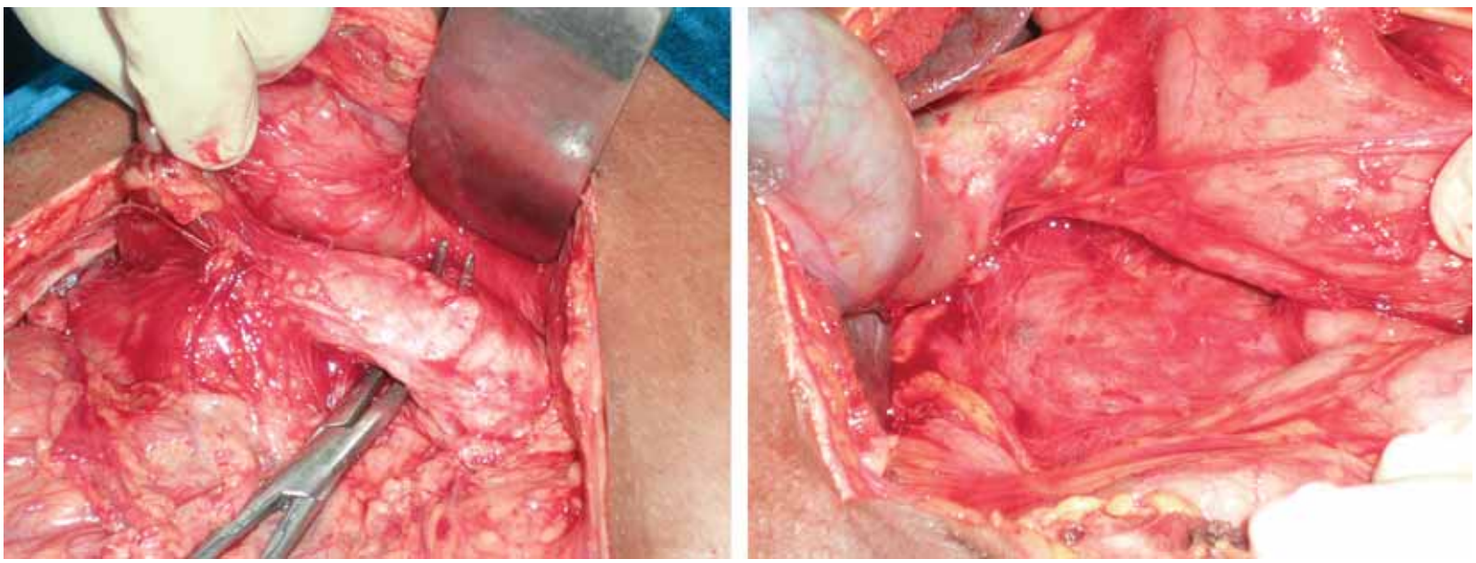


Fig. 23-47: Mobilisation of duodenum and colon in Whiple's operation.

Dissection in this area should be careful and gentle as venous tear causes torrential bleeding and becomes time consuming to control bleeding. Duodenum is freed above up to foramen Winslow. Gastrohepatic ligament is dissected to identify proper hepatic artery after incising the peritoneum over it. Any lymph nodes identified are brought down towards the specimen. Gastroduodenal artery is identified which is a branch of common hepatic artery. It runs downwards under the 1st part of the duodenum on the surface of the head of the pancreas to divide into right gastroepiploic artery and superior pancreaticoduodenal artery. Gastroduodenal artery is divided between double silk ligatures. Once dissection proceeds medially, anterior surface of the portal vein is identified; anterior surface usually being avascular is dissected gently between it and neck of the pancreas downwards; similarly another index finger is passed from below between SMV and neck of the pancreas upwards to feel the other finger from above. But this is not sufficient to confirm the invasion; finger has to be passed under the 2nd part of the Kocherised duodenum with thumb in front to feel for invasion of the uncinate process and posterior wall of the portal vein and superior mesenteric vessels. Right gastric artery is also divided which is much smaller than the gastroduodenal artery. Incision of the peritoneum over the CBD allows clearing the lymph nodes in the porta hepatis. Hepatic artery and CBD should be visualised properly after this part of the dissection. Cholecystectomy is performed. Common hepatic duct (CHD) is transected just above the joining of the cystic duct. CHD is temporarily occluded with a soft camp. It is a routine to do frozen section biopsy of the edge of the CHD and cystic duct in all patients whenever facilities are available. Antrectomy (with vagotomy if desired) is done now **(Figs 23-48 to 23-51)**.

Division of the pancreas can be done now or after the mobilisation of the duodenojejunal loop and bringing the loop towards right underneath the superior mesenteric vessels. Pancreas is carefully mobilised towards the left of the portal vein and SMV at least for 3 cm. Small vessels entering the splenic vein should be carefully divided after ligation. Splenic vein located on undersurface of the distal pancreas should not be injured but should be separated for adequate length so that safe anastomosis of pancreas into the jejunum can be undertaken. Ligation of the superior and inferior pancreatic artery in the pancreas is needed prior to transecting the pancreas. Stapler transection of the

Fig. 23-48: Cholecystectomy is done during portal dissection in Whipple's operation.

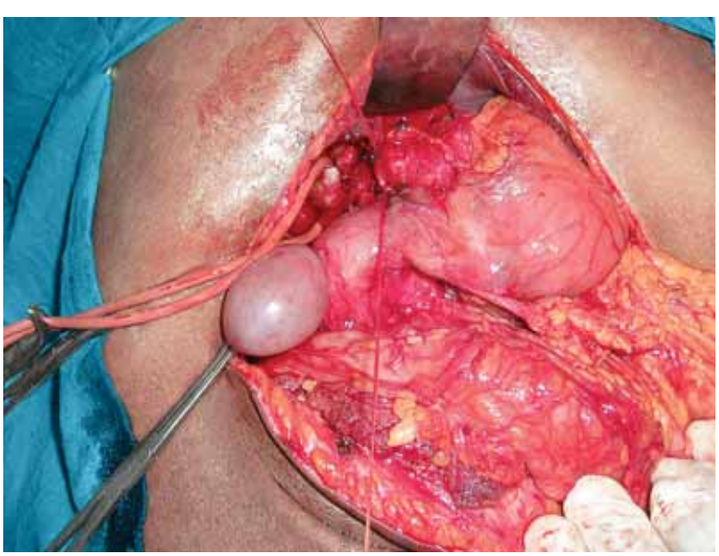


Fig. 23-49: Transection of bile duct and ligation of the gastroduodenal artery in Whipple's operation.

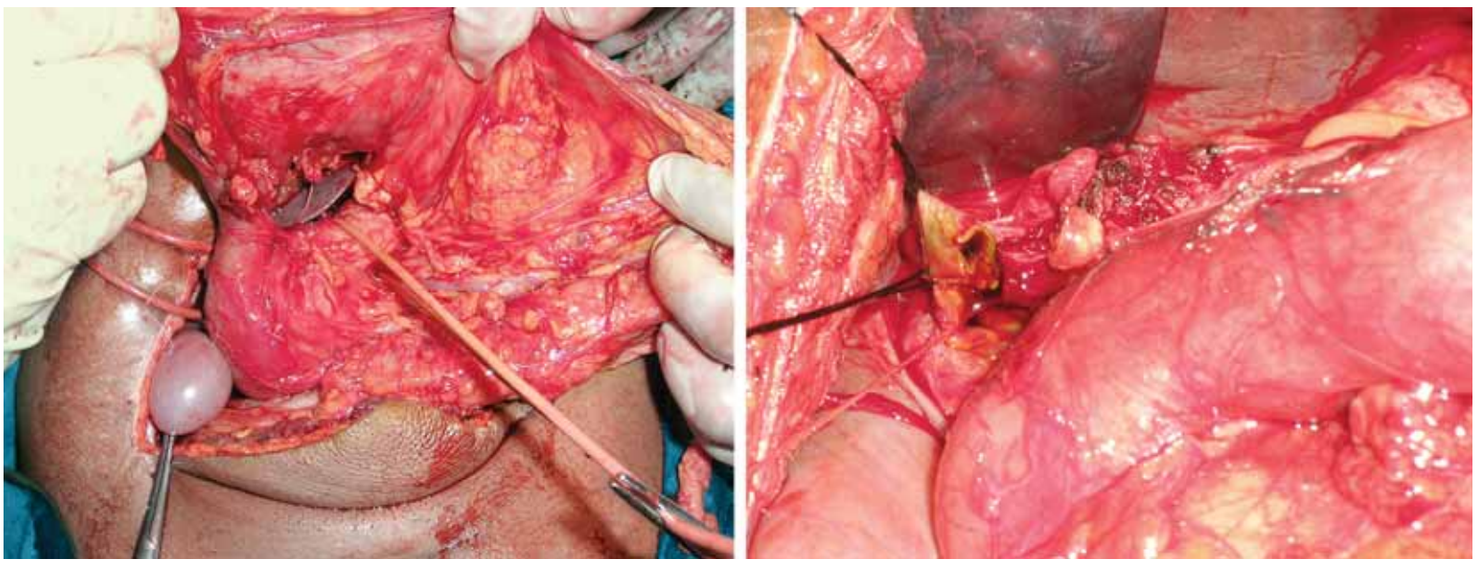


Fig. 23-50: Portal dissection in Whipple's operation.

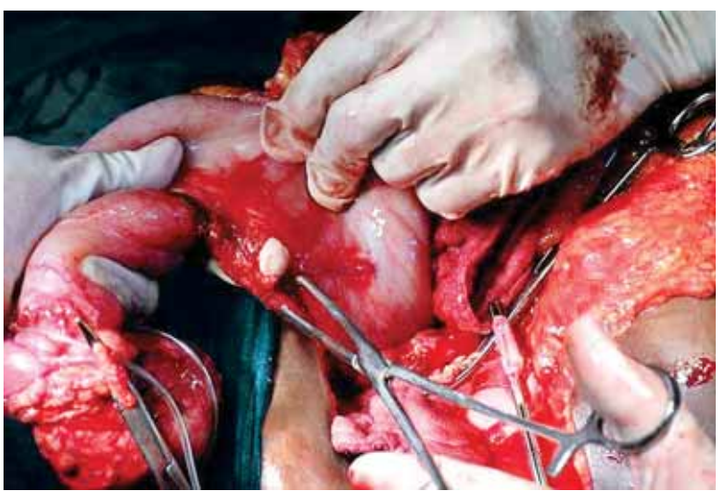


Fig. 23-51: Antrum is transected. Transection can be done using stapler device.

neck of pancreas can be done left of the SMV level; pancreas need to be divided again left of the stapler line to keep the cut distal end open for later anastomosis. Cut margin from left side should be sent for frozen section biopsy. Stapled part will come towards the specimen. Alternatively two stay sutures using 3-zero vicryl is placed on the superior and inferior parts of the neck of the pancreas towards left and held apart and forward; often stay sutures are placed—2 front and 2 behind; flat instrument like scalpel knife is placed underneath to guard the portal vein; neck is transected using no. 15 blade under vision from below upwards; finger guidance underneath is also useful. Duct distally when dilated will be visible and is stented with a fine plastic tube temporarily to prevent it getting entangled with sutures **(Fig. 23-52)**.

Proximal 6 cm of the jejunum is dissected by separating it from jejunal vessels extending proximally along the ligament of Treitz towards the superior mesenteric vessels on the right side; SMV (right) and SMA (left) pass in front of the 3rd part of the duodenum; duodenojejunum is freed by serial clamping, ligating and dividing the vessels of this part; ligaseal or harmonic scalpel saves time if used here. Jejunum is transected with stapler; otherwise divided between clamps and proximal end is closed using 3-zero continuous or interrupted single layer or double layer sutures. 1st jejunal branch arising from the SMA should be ligated prior to sliding the duodenojejunum underneath the superior mesenteric vessels to bring towards right.

Entire specimen with duodenojejunum has come towards right of the portal system. Uncinate process is carefully dissected off from the SMA and SMV. Arterial branches often arise from SMA deep to the SMV to reach head and uncinate process which is carefully dissected, ligated and divided. Uncinate process and pancreas extending behind the portal vein and SMV are serially ligated and divided. Care should be taken not to injure the SMV and portal vein while giving traction to the specimen. Often it is a better practice that a surgeon holds the specimen with his left hand and with his hand, he dissects, allowing the assistant to pass a polypropylene or silk ligature through a right-angled Mixter forceps and ligate it towards left side; opposite specimen side can be divided without ligature as surgeon is holding it firmly. All veins draining from the pancreas towards the right margin of the SMV and portal vein are ligated similarly and divided. Dividing without ligation will end with unnecessary bleeding and as such delays the procedure rather than hastening it. SMV should be retracted using gentle curved vein retractor towards left to visualise the SMA under which uncinate process ends. This dissection is carried out from below upwards. It is again better to do frozen section biopsy of the uncinate process to confirm the adequacy of resection as far as clearance is considered **(Fig. 23-53)**.

Anastomoses Parts

First pancreaticojejunal anastomosis is done usually as end to side; *then* hepaticojejunostomy is done; *later* antecolic gastrojejunostomy is done.

Distal transected jejunal loop is brought through the transverse mesocolon window towards pancreatic region. *Pancreati-*

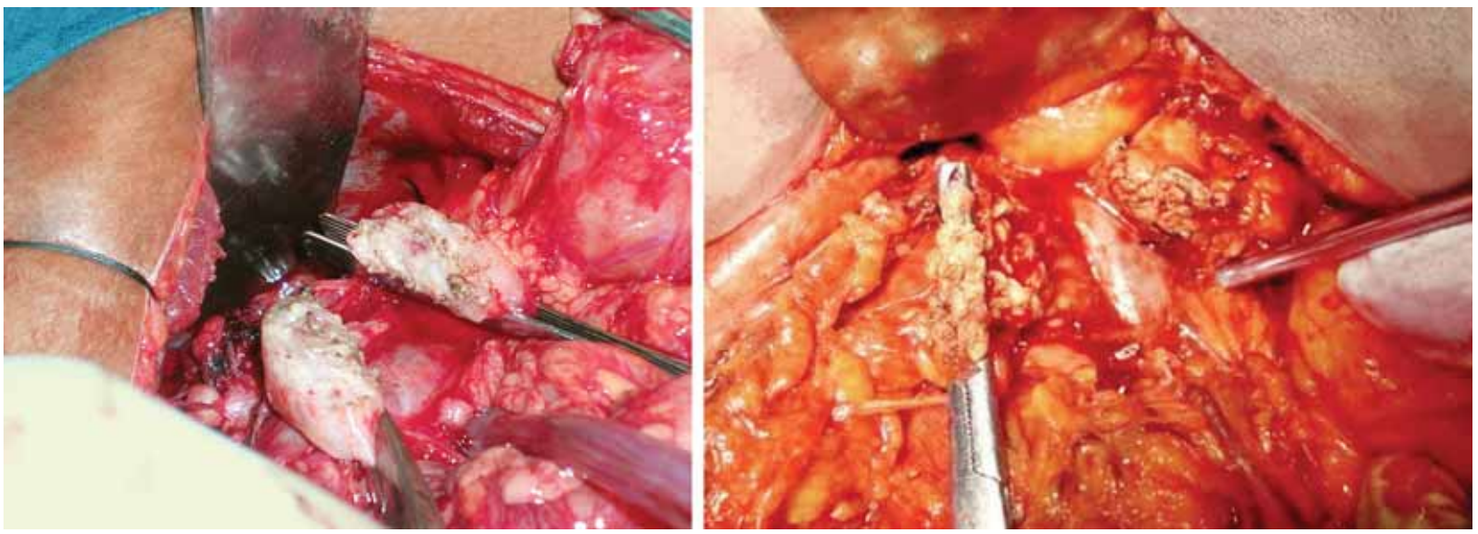
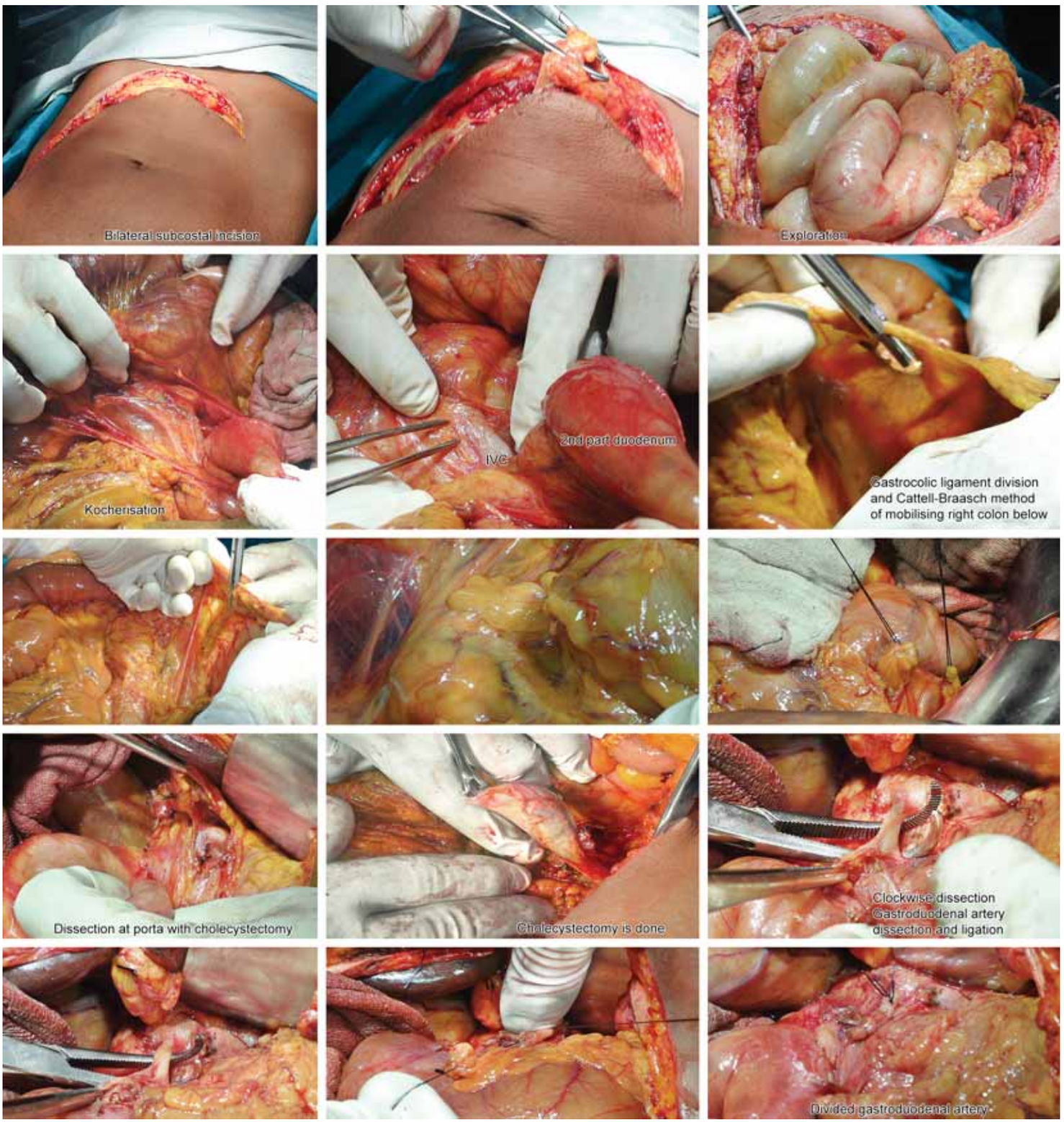


Fig. 23-52: Transection of the neck of pancreas in Whipple's operation.

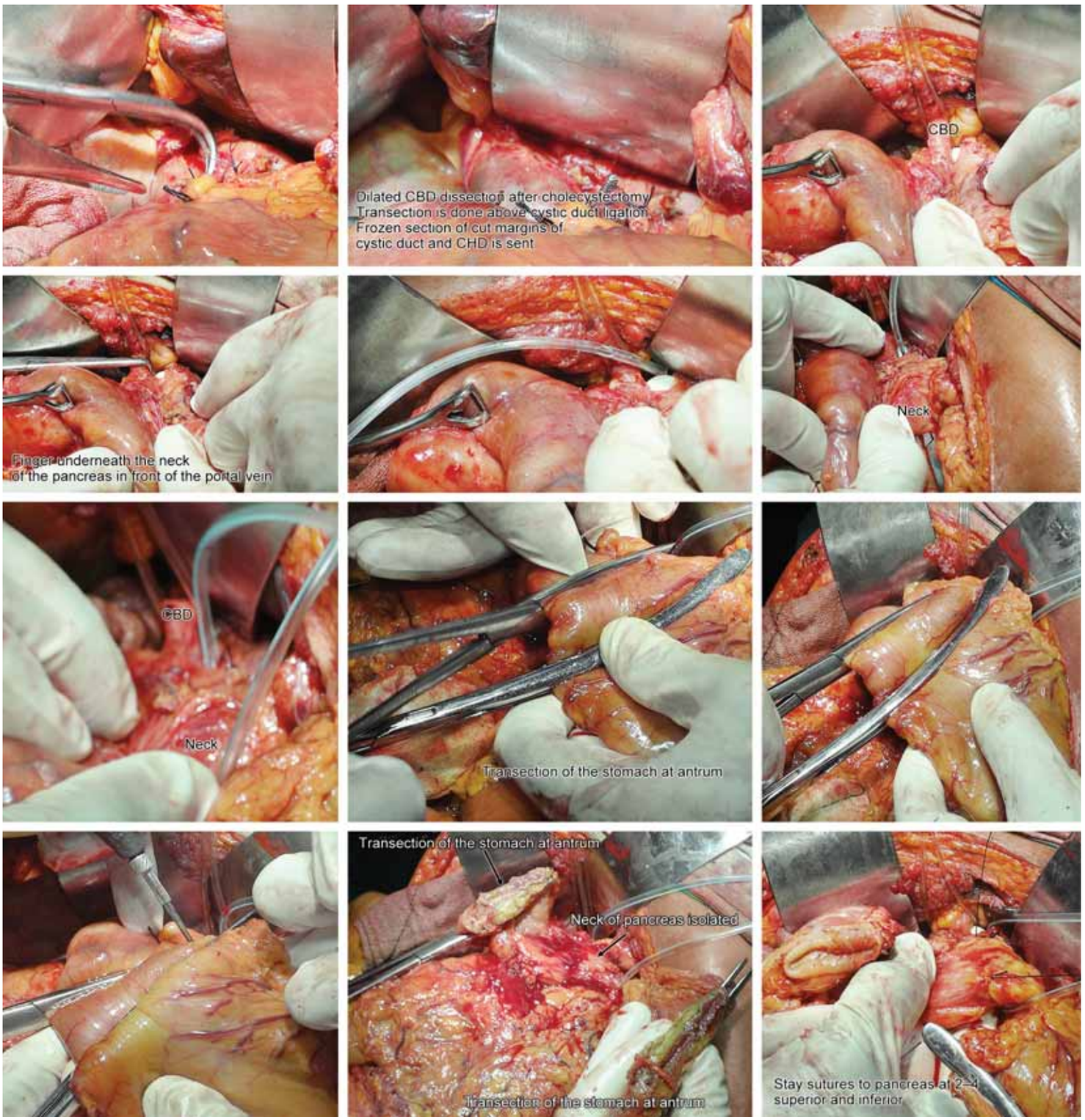
cojejunostomy is done by different methods—(1) When pancreatic duct is dilated duct to mucosa anastomosis is done; 3-5 cm distal to the stapled line along the antimesenteric border, jejunum is opened slightly lengthier than the diameter of the opened pancreatic duct; prior to enterotomy interrupted sutures are placed between the posterior capsule of the pancreas and the seromuscular layer of the posterior part of the proposed enterotomy site on the jejunum (posterior to enterotomy) using 4-zero polypropylene suture material. 5-6 such sutures are needed. Pancreatic duct is sutured to the full thickness jejunum as interrupted sutures using 5 or 6-zero polypropylene or PDS suture material posterior layer. Fine no. 8 infant feeding tube can be passed across the duct; proximal end is brought out through a stab wound 10 cm distal to the anastomotic site and also brought out of the abdominal wall; anterior layer duct mucosa full thickness jejunum anastomosis is done similarly; magnifying lens may be useful for ductal anastomosis. Duct may be fixed to pancreas and jejunal edge by a single 6-zero vicryl. Anterior pancreatic capsules to seromuscular jejunal interrupted sutures are placed. Stenting ductal tube which was brought out is fixed to jejunum with 5-zero vicryl sutures and this jejunal point is fixed to the parietal abdominal wall with 4-zero silk sutures. This stent also can be brought out through the proximal cut end of the jejunal stump through a separate stab incision similarly. End-to-side pancreaticojejunostomy is completed. This method can be used only for end-to-side anastomosis. (2) If duct is not dilated or pancreatic tissue is friable to take suture bites, then entire 2 cm distal cut pancreatic stump is invaginated into the cut end of the jejunal limb. Telescopic sutures are passed from outer part of jejunum 2 cm from the cut edge into its lumen, then from inside to outside of the pancreatic tissue; returning back from outside inside of pancreas and inside out of the jejunum stump. Two such telescopic sutures are placed on both sides. If pancreatic stump is too bulky, injection glucagon 1 mg IV helps to relax and accommodate the stump adequately. Otherwise stump is invaginated to the lateral part of the jejunum 3-5 cm proximal to the jejunal end which is closed; corresponding sized incision is made to accommodate the pancreatic stump. Before telescoping no. 8 infant feeding tube can be placed in the duct if duct is properly identified and brought out in similar way 10 cm proximally. If duct is too small, it is not mandatory to stent or suture the duct as proper telescoping of the pancreas with two layers interrupted, suturing both posteriorly and anteriorly, is sufficient without any problem. When these telescopic sutures are pulled in, pancreatic stump gets invaginated automatically into the jejunum; these telescoping sutures are not tied. Cut edge of the pancreas telescoped inside is sutured again to the bowel wall at 2 cm distance with interrupted polypropylene 4-zero sutures—circumferentially. All sutures round are placed then later tied together. Telescoping sutures are tied now. Next layer of the anastomosis is done between the cut edge of the jejunum as full thickness and the pancreatic capsule as interrupted sutures. This method is used for either side or end of the jejunal limb. (3) Another method is to place the posterior seromuscular layer of the jejunum to the pancreatic capsule 2 cm away from the cut margin; then 2nd posterior full thickness jejunum to the pancreatic cut edge with or without including the posterior edge of the duct; 3rd layer is anterior full thickness bowel wall to the cut edge of the pancreatic stump with or without taking bites from anterior part of the duct; 4th layer is seromuscular bite from the bowel 2 cm from the earlier layer and from the pancreatic capsule at corresponding distance. This method is used for either side or end of the jejunal limb **(Fig. 23-54)**.

Hepaticojejunal anastomosis is done as end-to-side of the jejunal loop on to its antimesenteric border. Jejunum is opened at antimesenteric border 15 cm from the pancreaticojejunostomy site; incision should be slightly lesser than or equal to that of hepatic duct. Anastomosis is done using interrupted 4-zero vicryl sutures; posterior layer sutures are placed first with knots outside; first all posterior suture bites are taken and then knots are tied at the end. Anterior layer is sutured with knots outside. Every 3 mm gap sutures should be placed. If surgeon wants stenting of the hepaticojejunostomy, then prior to placing sutures, longitudinal/vertical limb of no. 14 F 'T' tube is passed through cut end of the hepatic duct proximally and is brought out through a small incision through the hepatic duct outside and of the abdominal wall through a separate stab wound. This drains bile outside and also promotes healing of the pancreaticojejunostomy **(Figs 23-55 and 23-56)**.

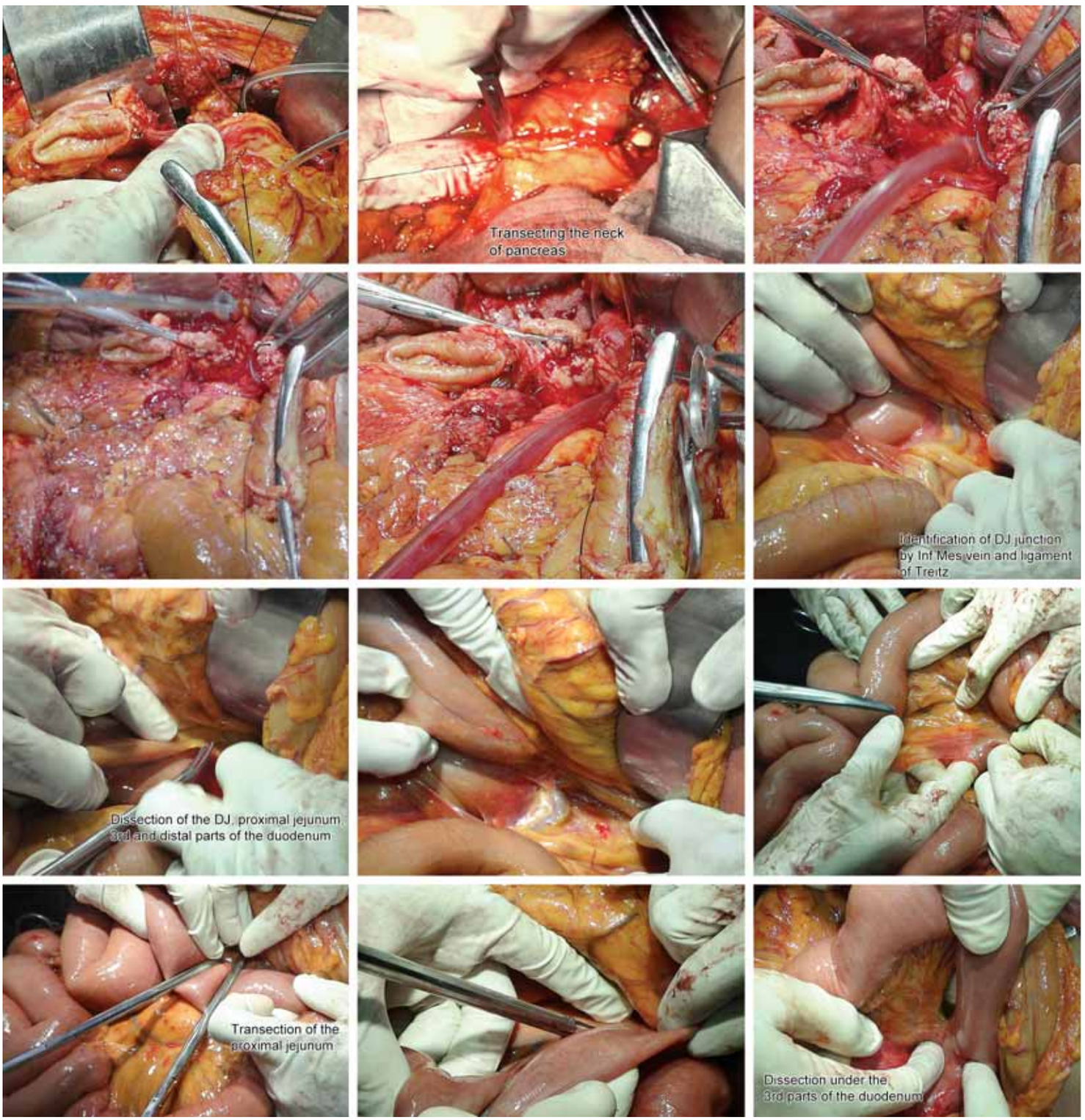
Gastrojejunostomy is done 20 cm distal to the hepaticojejunostomy as an antecolic anastomosis. As already stomach is transected with stapler earlier during procedure, gastrojejunostomy is done using linear stapler device just proximal and posterior to the stapled line. Single layer 3-zero vicryl hand sewn anastomosis also can be done after doing gastrotomy and corresponding jejunotomy **(Fig. 23-57)**.


Bilateral subcostal incision
Exploration
Kocherisation
IVC
2nd part duodenum
Gastrocolic ligament division
and Cattell-Braasch method
of mobilising right colon below
Dissection at porta with cholecystectomy
Cholecystectomy is done
Clockwise dissection
Gastroduodenal artery
dissection and ligation
Divided gastroduodenal artery

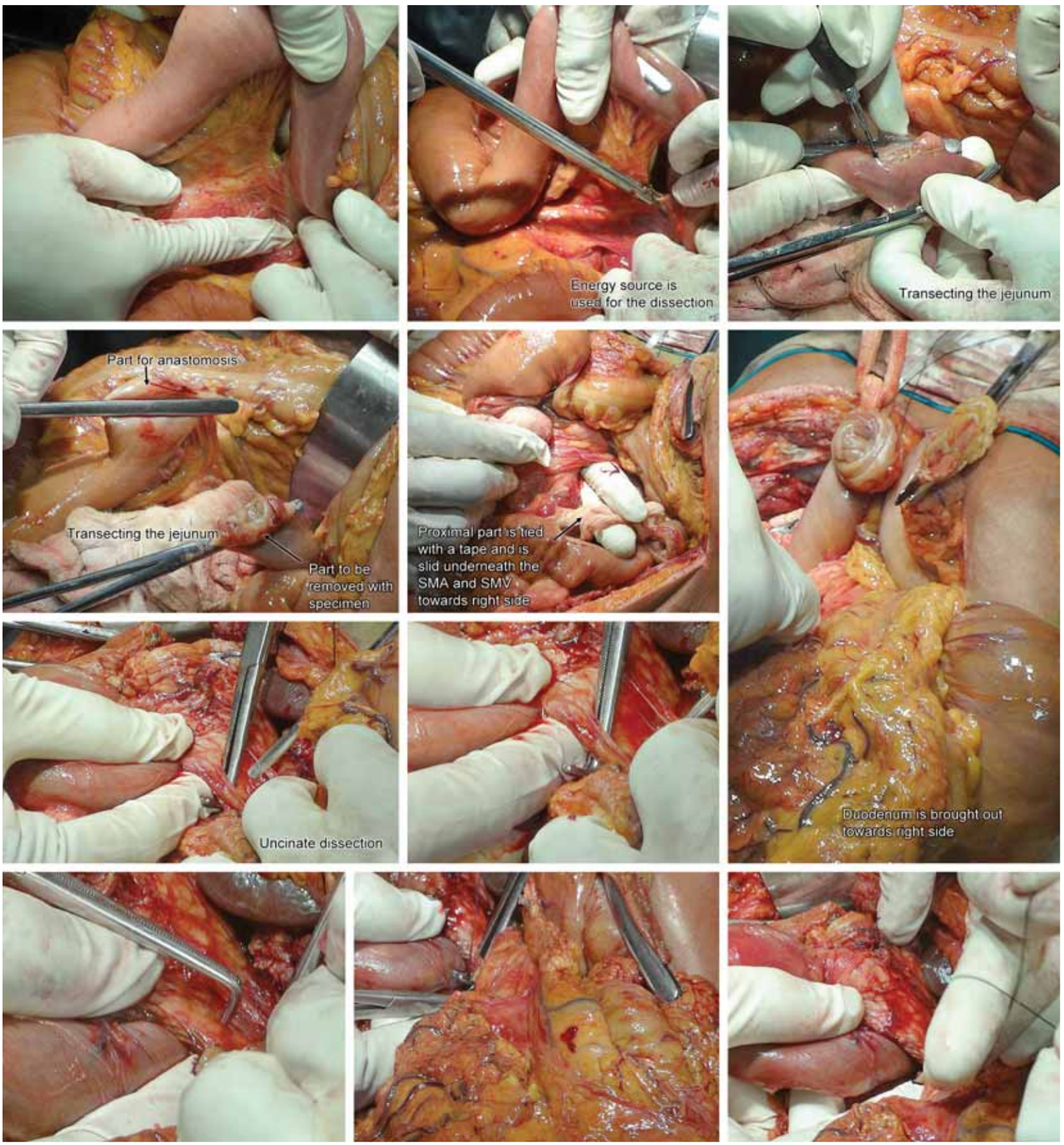
Figs 23-53(1)


Dilated CBD dissection after cholecystectomy
Transection is done above cystic duct ligation
Frozen section of cut margins of
cystic duct and CHD is sent
CBD
Finger underneath the neck
of the pancreas in front of the portal vein
Neck
CBD
Neck
Transection of the stomach at antrum
Transection of the stomach at antrum
Neck of pancreas isolated
Transection of the stomach at antrum
Stay sutures to pancreas at 2–4
superior and inferior

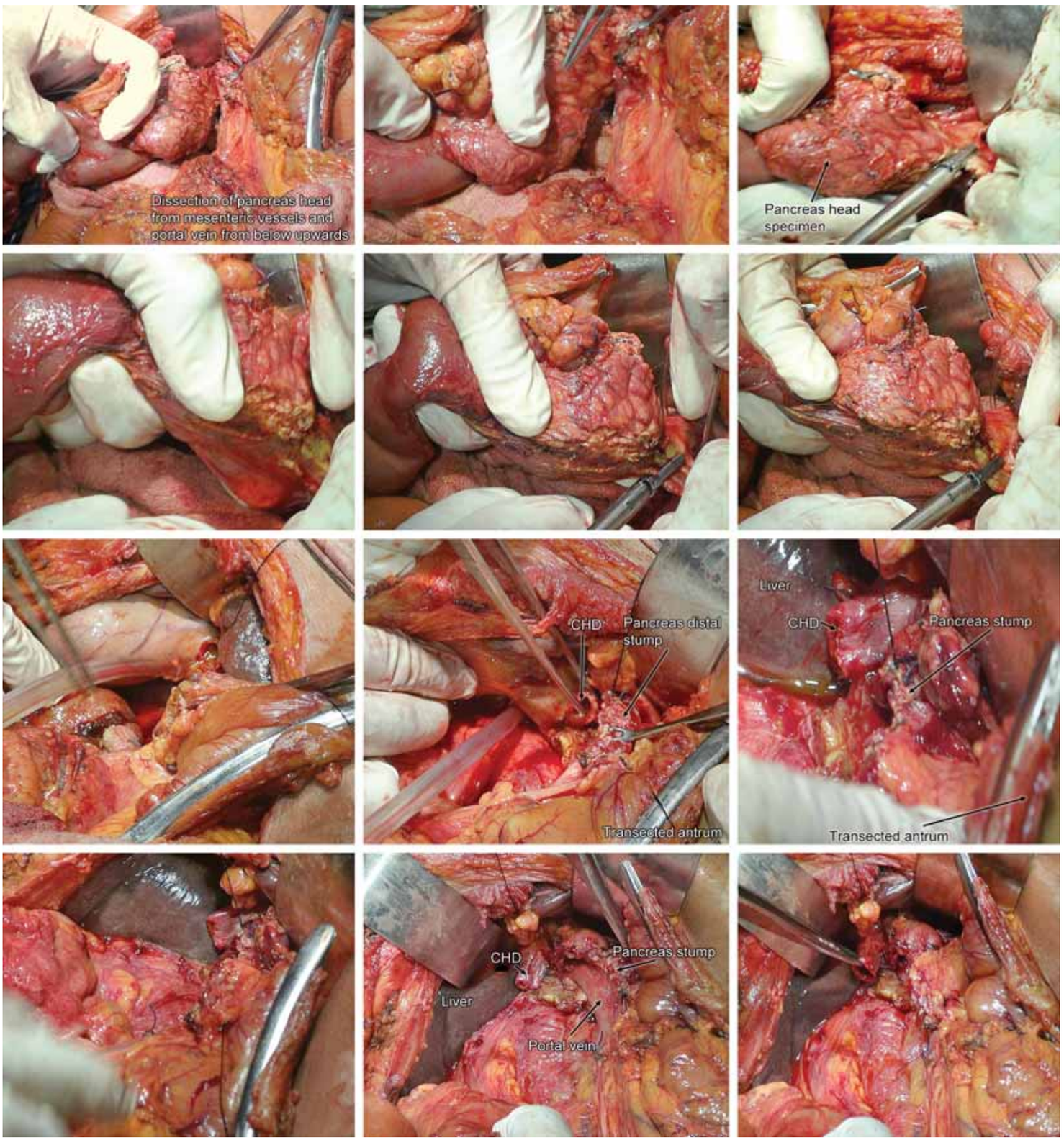
Figs 23-53(2)


Transecting the neck of pancreas
Identification of DJ junction by Inf Mes vein and ligament of Treitz
Dissection of the DJ, proximal jejunum 3rd and distal parts of the duodenum
Transection of the proximal jejunum
Dissection under the 3rd parts of the duodenum

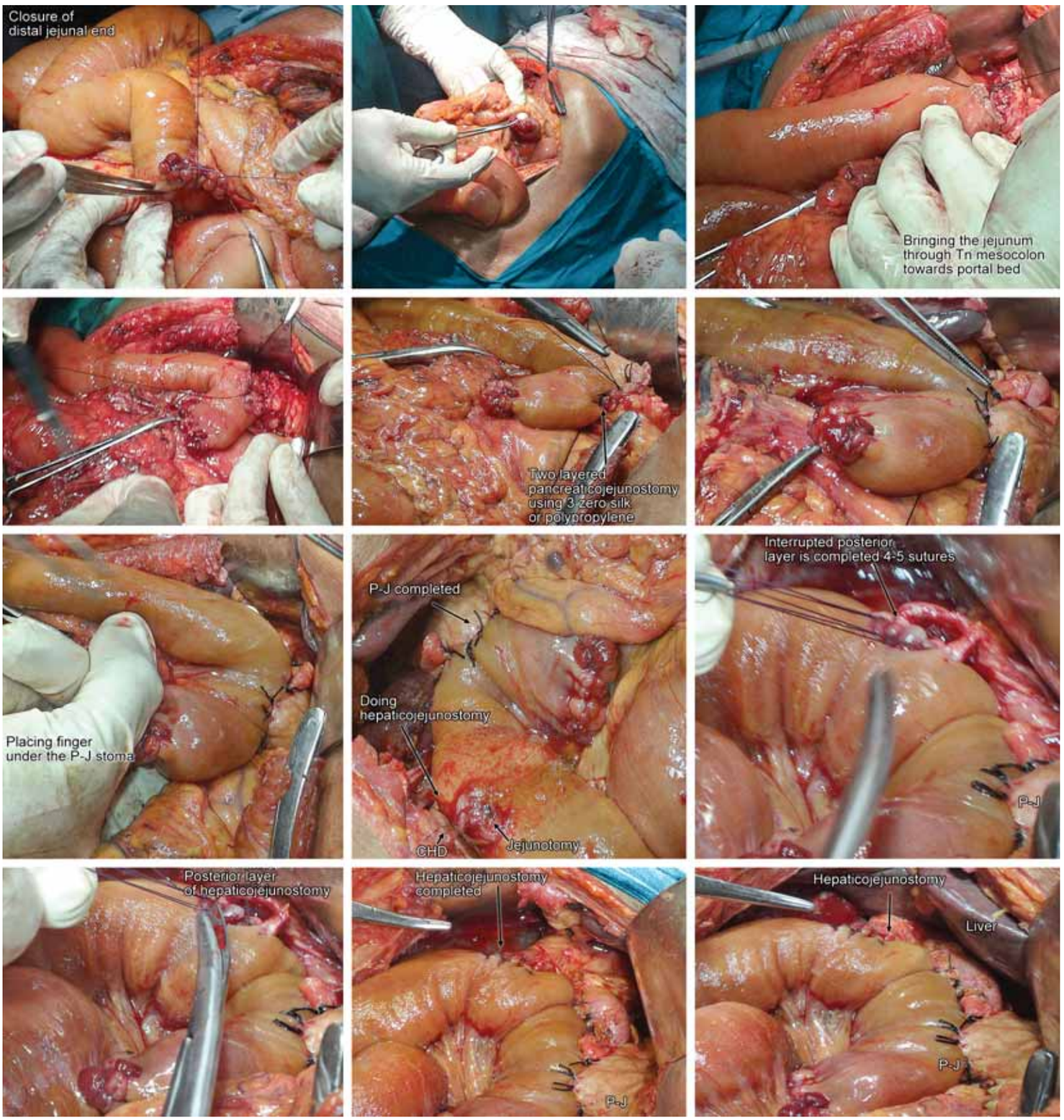
Figs 23-53(3)


Energy source is used for the dissection
Transecting the jejunum
Part for anastomosis
Transecting the jejunum
Part to be removed with specimen
Proximal part is tied with a tape and is slid underneath the SMA and SMV towards right side
Duodenum is brought out towards right side
Uncinate dissection

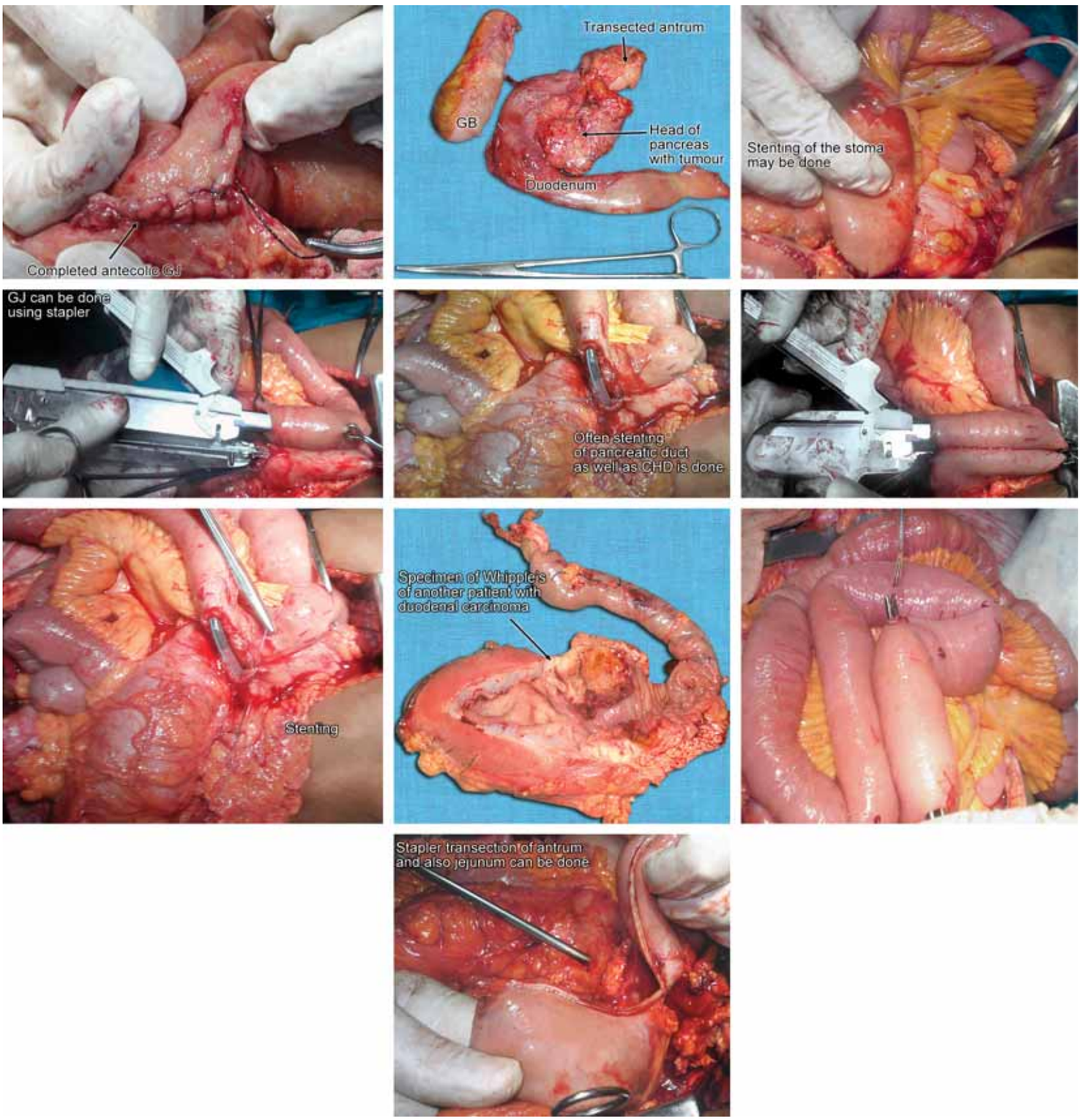
Figs 23-53(4)


Dissection of pancreas head from mesenteric vessels and portal vein from below upwards
Pancreas head specimen
CHD
Pancreas distal stump
Transected antrum
Liver
CHD
Pancreas stump
Transected antrum
CHD
Pancreas stump
Liver
Portal vein

Figs 23-53(5)


Closure of distal jejunal end
Bringing the jejunum through Tn mesocolon towards portal bed
Two layered pancreaticojejunostomy using 3 zero silk or polypropylene
Placing finger under the P-J stoma
P-J completed
Doing hepaticojejunostomy
CHD
Jejunotomy
Interrupted posterior layer is completed 4-5 sutures
P-J
Posterior layer of hepaticojejunostomy
Hepaticojejunostomy completed
P-J
Hepaticojejunostomy
Liver
P-J

Figs 23-53(6)


Completed antecolic GJ
Transected antrum
GB
Head of pancreas with tumour
Duodenum
Stenting of the stoma may be done
GJ can be done using stapler
Often stenting of pancreatic duct as well as CHD is done
Stenting
Specimen of Whipple's of another patient with duodenal carcinoma
Stapler transection of antrum and also jejunum can be done

Figs 23-53(7)

Figs 23-53(1 to 7): Technique of Pancreaticoduodenectomy—steps.

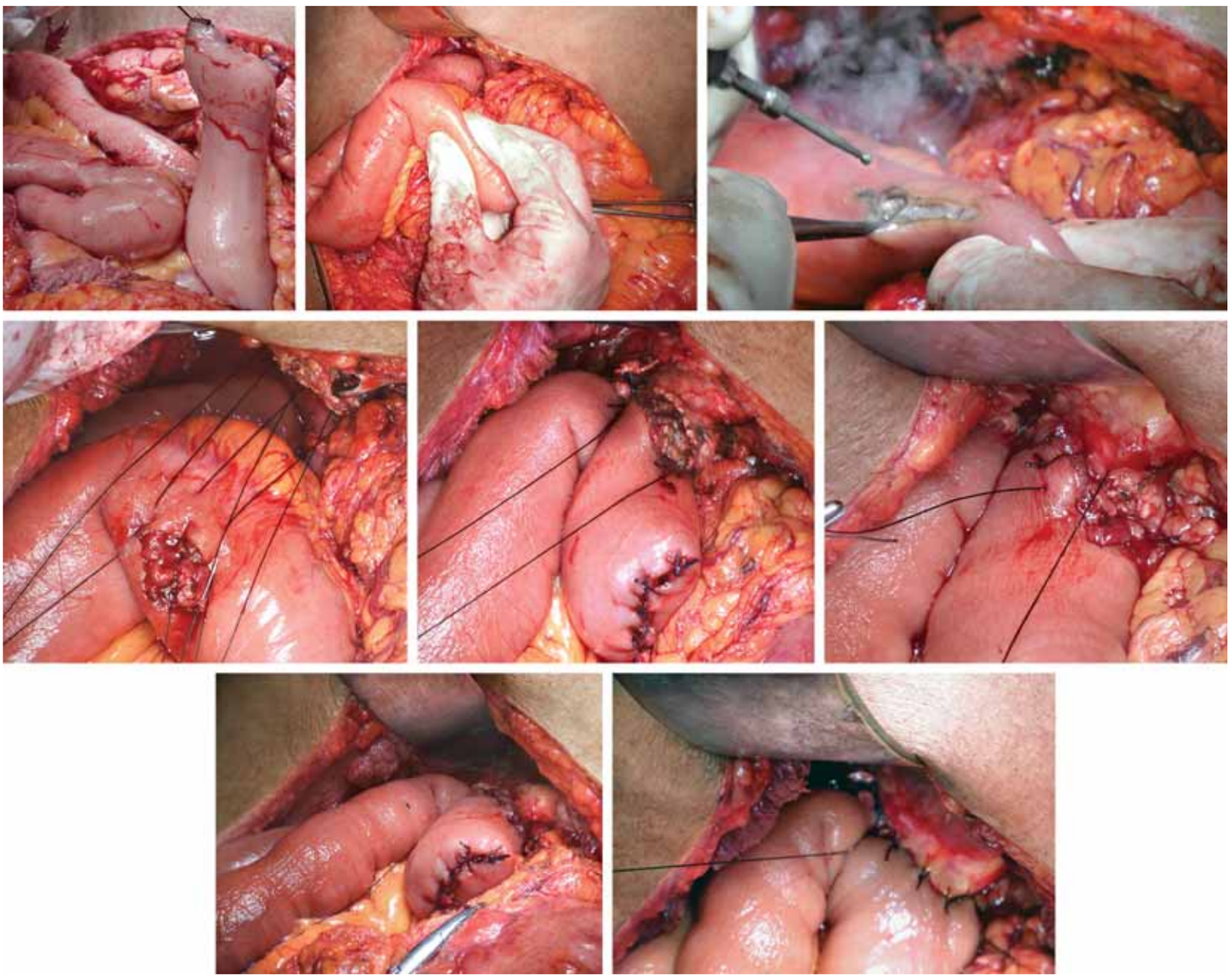


Fig. 23-54: Pancreaticojejunostomy in Whipple's operation.

Jejunostomy is done for feeding purpose at the end and is brought out through left side of the abdomen. Suction tube drain is placed and abdomen is closed in layers.

On table intraoperative octreotide is injected 100 micrograms intravenously usually at the beginning of the pancreatic resection.

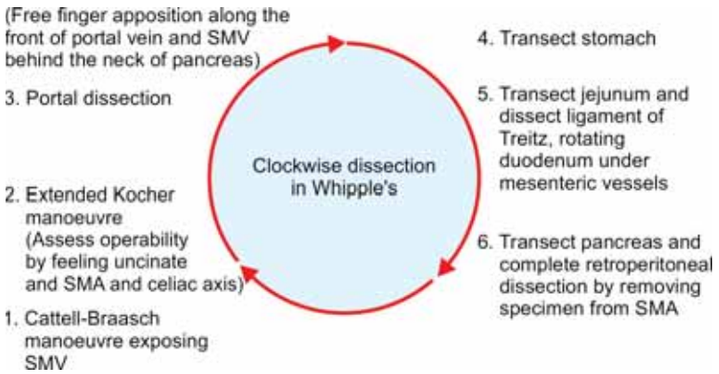
If portal vein is involved, vascular resection can be done with internal jugular vein *(IJV) interposition graft*; usually from left side. Technique is often called as ***extended Whipple's operation or Fortner's regional pancreatectomy***.

Postoperative Care

Nasogastric tube is removed in 5-7 days; jejunostomy feeding is started in 5-7 days along with oral fluid. T-tube and pancreatic tube are kept for 21 days. Antibiotics are given. TPN may be needed. Daily monitoring with liver function, renal function, haemogram (with platelet count) and prothrombin time is needed. CVP line is better for all these purposes, immediate postoperative period despite less bleeding on table, hypotension is common, which is due to lot of fluid loss in 3rd space. So patient needs adequate fluid therapy to combat this. Intravenous octreotide is given daily either as infusion or at regular intervals for 5 days to reduce pancreatic secretions. Pancreatic leak can be identified by clear fluid leak from the drain. It may subside spontaneously; but often needs 1-2 litres saline wash daily. If it persists and patient deteriorates, then relaparotomy done and remaining pancreas including spleen has to be removed to save the life **(Figs 23-58 and 23-59)**.

The Surgical Resection is Divided into the following Six Clearly Defined Steps

1. ***A Cattell-Braasch* manoeuvre** is performed by mobilising the right colon and incising the visceral peritoneum to the ligament of Treitz. When complete, this manoeuvre allows retraction of right colon and small bowel downward and towards right exposing the third and fourth parts of duodenum. The omental bursa is entered by taking the greater omentum from the transverse colon. The middle colic vein is identified, ligated and divided before its junction with the

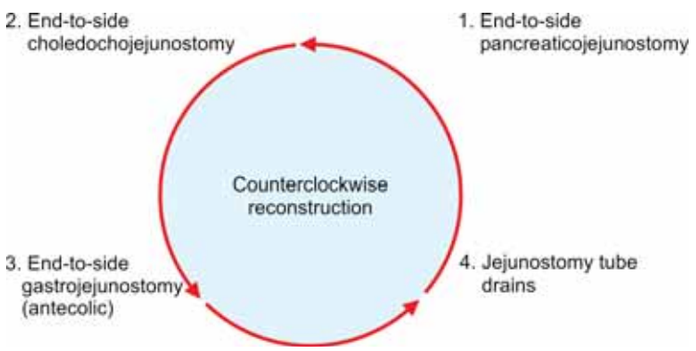

(Free finger apposition along the front of portal vein and SMV behind the neck of pancreas)
3. Portal dissection
2. Extended Kocher manoeuvre (Assess operability by feeling uncinate and SMA and celiac axis)
1. Cattell-Braasch manoeuvre exposing SMV
Clockwise dissection in Whipple's
4. Transect stomach
5. Transect jejunum and dissect ligament of Treitz, rotating duodenum under mesenteric vessels
6. Transect pancreas and complete retroperitoneal dissection by removing specimen from SMA

SMV. This allows greater exposure of the infrapancreatic SMV and prevents iatrogenic injury during dissection of the middle colic vein—MV junction.

2. ***The Kocher's manoeuvre*** is begun at the junction of the ureter and the right gonadal vein. The right gonadal vein is ligated and divided, and all fibro fatty and lymphatic structures overlying the medial aspect of the right kidney and inferior vena cava is removed with the specimen. The Kocher's manoeuvre is continued to the lateral edge of the aorta (extended Kocher manoeuvre), carefully identifying the left renal vein. Traditionally, the relation of the tumour to the SMA is assessed by manual palpation following a complete Kocher manoeuvre.
3. ***The portal dissection*** is initiated by exposing the common hepatic artery proximal and distal to the gastroduodenal artery. The gastroduodenal artery is then ligated and divided. Two large lymph nodes are commonly encountered during portal dissection, removal of this en-block with the specimen is necessary to adequately mobilise the hepatic artery and portal vein. The gallbladder is dissected out of the liver bed and the common bile duct transected just cephalad to its junction with the cystic duct. The anterior wall of the portal vein is easily exposed following division of common hepatic duct and medial retraction of the common hepatic artery. Bleeding caused by injury to posterior superior pancreaticoduodenal vein may be difficult to control at this time in the operation. Portal vein should be mobilised after stomach and pancreas have been divided as in step 6. The portal dissection is made more difficult in the presence of anomalous hepatic arterial circulation, particularly in reoperative cases when preoperative arteriography is of help.
4. The stomach is transected at the level of third or fourth transverse vein on the lesser curvature and at the confluence of the gastroepiploic veins on the greater curvature. The omentum is divided at the level of the greater curvature transection.
5. The jejunum is transected approximately 10 cm distal to the ligament of Treitz, and its mesentery is sequentially ligated and divided. The duodenal mesentery is similarly divided to the level of the aorta, and the duodenum and jejunum are then reflected beneath mesenteric vessels.
6. After traction sutures are placed on the superior and inferior borders of the pancreas using 2-0 silk (this is important to reduce bleeding from marginal vessels during transection), the pancreas is transected with an electrocautery at the level of portal vein. If there is an evidence of tumour adherence to the portal vein or the SMV, the pancreas can be resected at a more distant location in preparation for segmental venous resection. The specimen is cleared from SMV and often SMA depending on its posterior extension by ligating and dividing small venous tributaries to the uncinate process and pancreatic head. Complete resection of the uncinate process along with medial retraction of the superior mesenteric-portal vein confluence facilitates exposure of the SMA, which is then dissected out to its origin at the aorta. Frozen section analysis of the pancreatic and common hepatic duct transection margin is obtained. Positive resection margins mandate further resection until clear margins are achieved.

Pancreatic, Biliary and Gastrointestinal Reconstruction

Reconstruction proceeds in the counterclockwise direction and again in a stepwise and orderly fashion.



1. ***Pancreaticojejunal anastomosis***
   The pancreatic remnant is mobilised from retroperitoneum and splenic vein for a distance of 2 to 3 cm. The transected jejunum is brought through a small incision in the transverse mesocolon to the right or left of middle colic vessels. A two-layered, end-to-side, duct-to-mucosa pancreaticojejunostomy is performed. If the pancreatic duct is small (<4mm), a small silastic internal stent can be left behind under the anastomosis. Following completion of posterior row of interrupted 3-0 seromuscular sutures, a small full thickness opening is made. The anastomosis between the pancreatic duct and the small bowel mucosa is completed with 4-0 or 5-0 monofilament sutures either vicryl or prolene depending on the centre preference. The anastomosis is completed with placement of anterior row of 3-0 seromuscular sutures.

   Pancreaticogastric anastomosis
   The advantage claimed in this type of anastomosis is that there are less chances of pancreatic fistulae formation due to the good blood supply of the stomach and the presence of acidic environment that prevents activation of pancreatic enzymes causing less autodigestion at anastomosis site. The anastomosis is technically simple because the stomach is right in front of the cut remnant of the pancreas. The remnant is mobilised off the bed for 2-3 cms and brought into the stomach through an opening in the posterior wall of stomach. The pancreas is anastomosed using single layer of suture running from the pancreatic capsule to the gastric serosa using prolene 3-0 suture. Internal stent can be left in situ if the pancreatic duct is very small.
2. A single-layer biliary enteric (***hepaticojejunostomy***) anastomosis using interrupted, 4-0 absorbable monofilament sutures (PDS). It is important to align jejunum with the bile duct to avoid tension on the pancreatic and biliary anastomosis. A stent is rarely used in the construction of the hepaticojejunostomy.

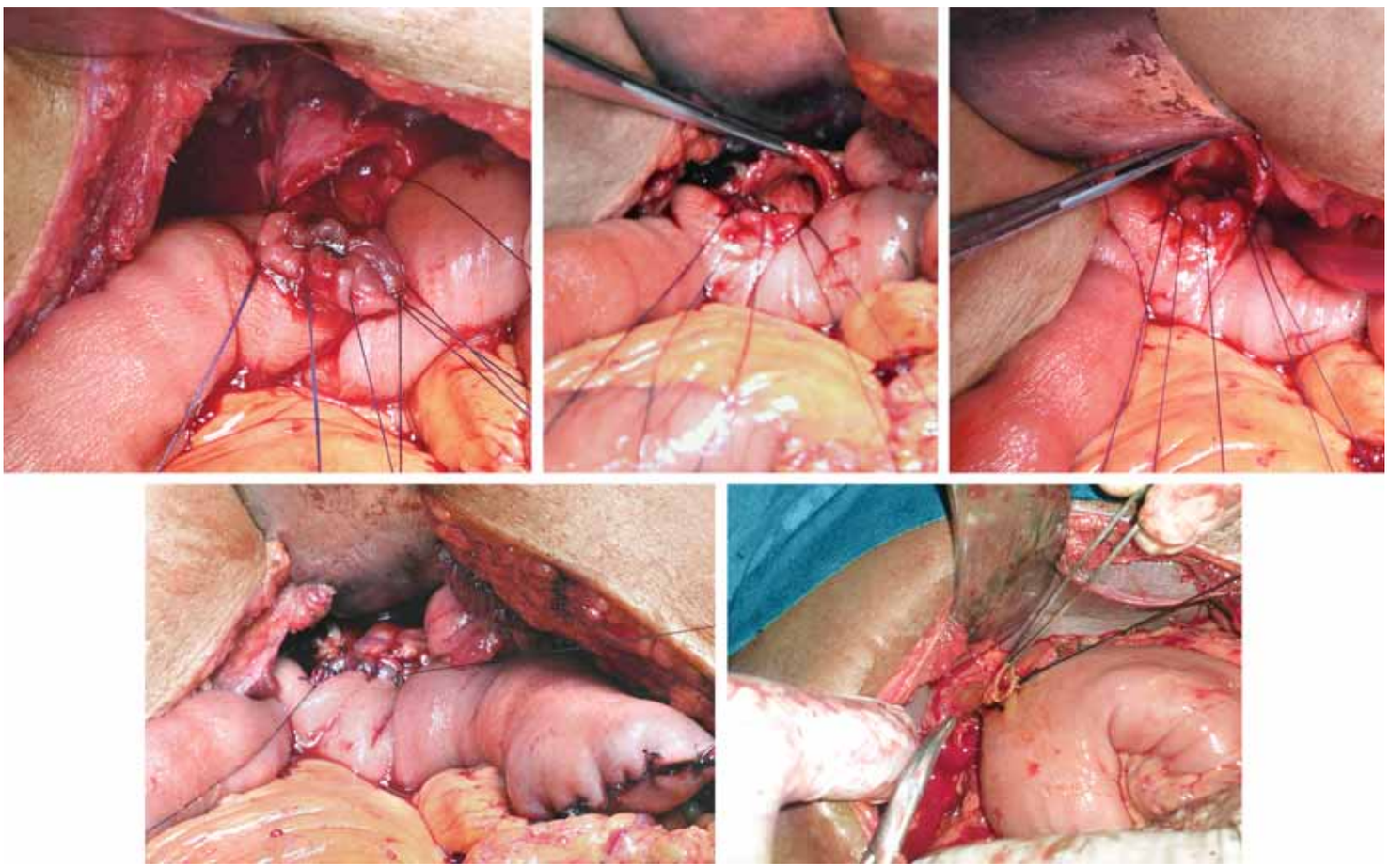


Fig. 23-55: Hepaticojejunostomy in Whipple's operation.

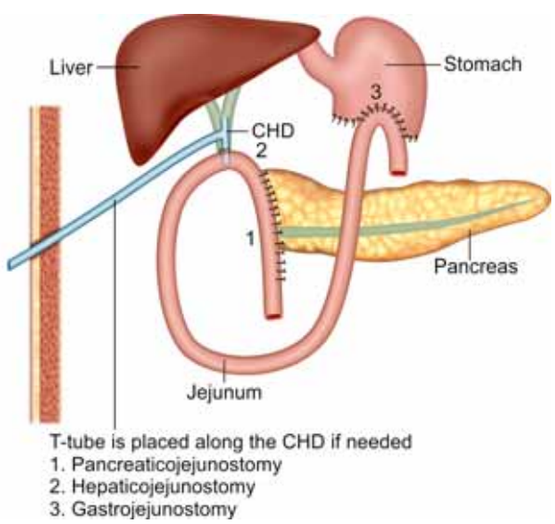


Fig. 23-56: T-tube may be placed in the CHD and across the hepaticojejunostomy if needed; but it is not mandatory.

3. An antecolic, and end-to-side ***gastrojejunostomy*** is constructed in two layers. A posterior row of silk sutures is followed by a running, monofilament, full-thickness inner layer; the anterior row of silk sutures completes the anastomosis. The distance between the biliary and gastric anastomosis should allow the jejunum to assume its antecolic position (for the G-J) without tension. There is no harm in making a long (25-30 cm) afferent limb.
4. ***Feeding jejunostomy*** tubes are placed using the Witzel technique, and then two closed suction drains are placed. Enteral feeding via a jejunostomy tube avoids a delay in the hospital discharge due to poor oral intake.

Complications of Whipple's Operation

Pancreatic fistula, biliary fistula, sepsis, subphrenic abscess, respiratory complications, cholangitis and hepatic failure, renal failure, anastomotic dehiscence of any stomas, bleeding, postoperative acute pancreatitis, marginal ulcer, SMA or SMV thrombosis, portal vein thrombosis, gastric bezoar formation.

Pylorus Preservation Partial Pancreaticoduodenectomy (Traverso Longmire)

Preservation of the antropyloroduodenal segment in combination with pancreaticoduodenectomy was first described by Traverso and colleagues in 1978 (Traverso Longmire). Proponents of the technique argue that preservation of the antropyloric pump mechanism results in long-term upper gastrointestinal tract function with associated salutary nutritional squeal. Published data to date involve a retrospective comparison that has yielded mixed results.

Nevertheless, most pancreatic surgeons agree that pylorus preservation should not be performed for patients with bulky tumours

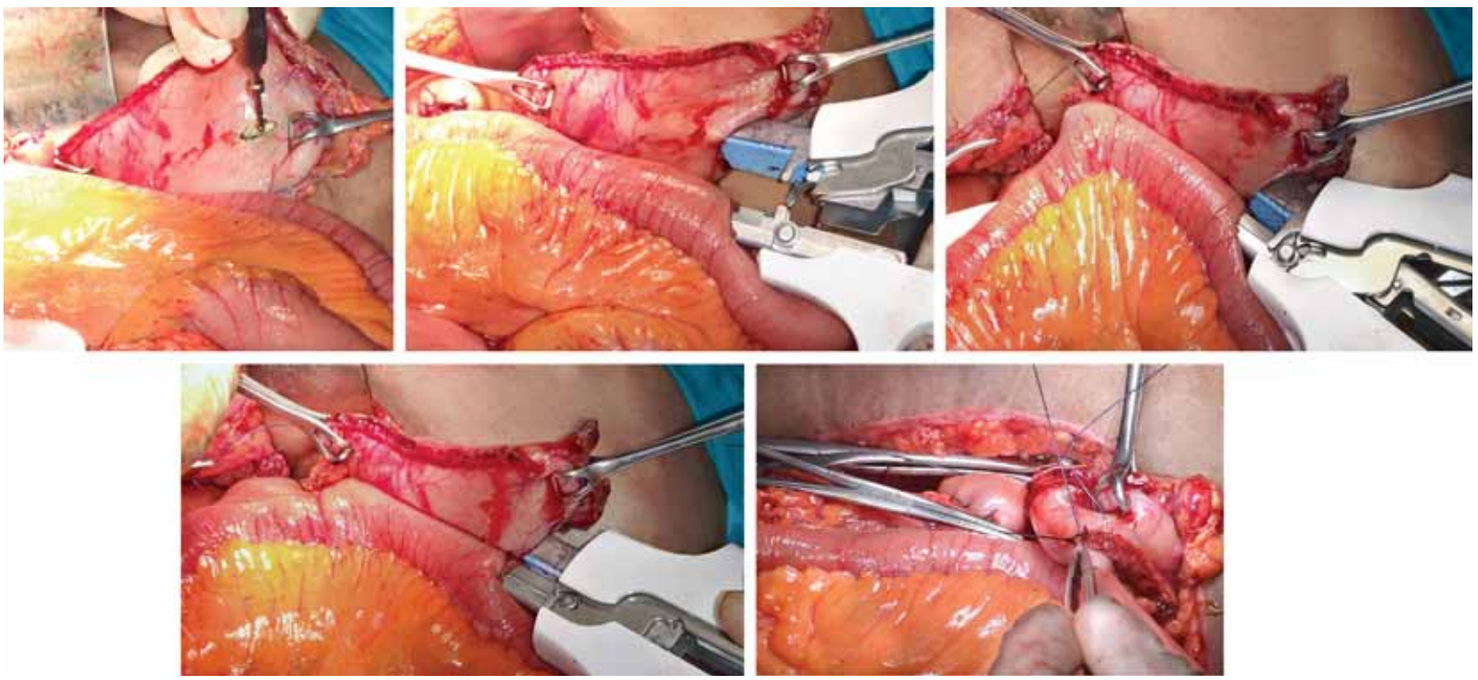


Fig. 23-57: Gastrojejunostomy in Whipple's operation. It can be hand-sewn or by using stapler on the posterior surface of the earlier transected part of the stomach.

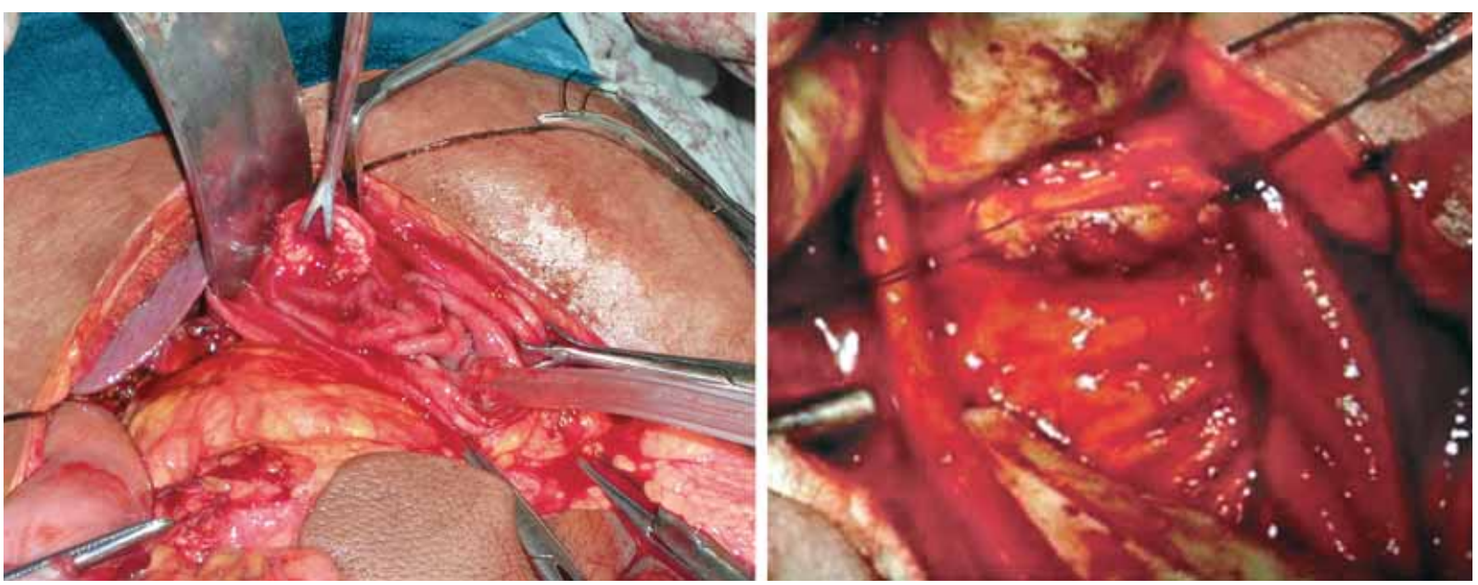


Fig. 23-58: Pancreaticogastrostomy in Whipple's operation. Pancreatic secretion is neutralized in gastric acid pH.

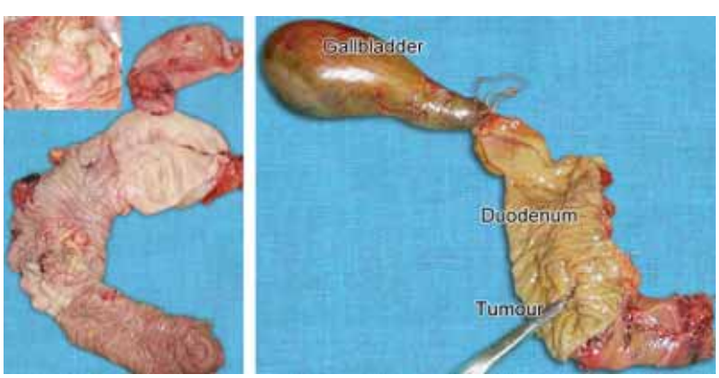


Fig. 23-59: Periampullary carcinoma of pancreas—gross look in two different patients.

of the pancreatic head, duodenal tumours involving first or second part of the duodenum, or lesions in which pyloric and peripyloric lymph nodes are grossly positive.

The steps in pylorus preserving pancreaticoduodenectomy are identical to that of standard pancreaticoduodenectomy, except in the approach to the antrum, pylorus and the duodenum. Preservation of sufficient blood supply to the proximal duodenum and preservation of vagal innervation to the antrum and pylorus are critical. Therefore, appropriate caution must be exercised during the portal dissection to avoid unnecessary division of the right gastric artery or injury to the nerves of Latarjet. This is the fundamental technical difference in the pylorus-preserving procedure and is essential to facilitate a well-vascularised duodenojejunostomy and to avoid postoperative gastroparesis **(Fig. 23-60)**.

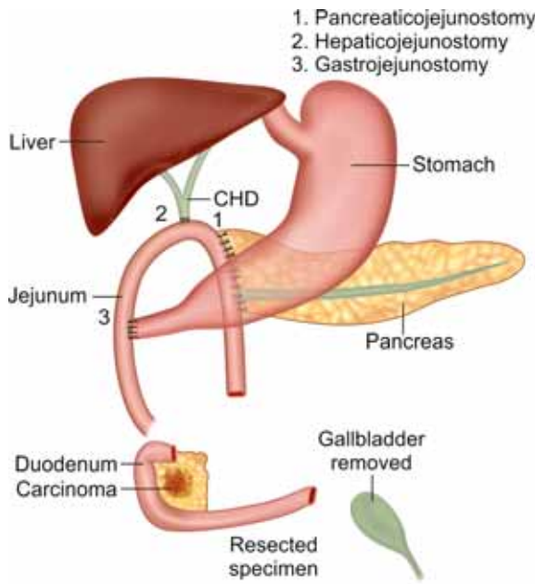


Fig. 23-60: Pylorus preserving pancreaticoduodenectomy.

The duodenum is divided approximately 2 to 3 cms beyond the pylorus. The blood supply to the first portion of the duodenum arises from the proximal branches of the gastroduodenal artery and the supraduodenal artery, both of which arise from the hepatic artery. When possible, the supraduodenal artery should be preserved. The duodenojejunostomy is performed in an end-to-side fashion using a single-layer technique with monofilament absorbable sutures.

TOTAL PANCREATECTOMY (TOTAL PANCREATICODUODENECTOMY)

Total pancreatectomy is rarely required for adenocarcinoma of pancreas. It can be performed for carcinoma of the body and tail that present early or are incidentally picked up on ultrasound. Total pancreatectomy is performed by modifying step 1 in the six-step pancreaticoduodenectomy. Following the completion of the Cattell-Braasch manoeuvre and identification of the infrapancreatic SMV, the greater omentum is separated from the left side of transverse colon and the splenic flexure is mobilised. The peritoneum lateral to the spleen is then incised in the cephalad direction to the gastroesophageal junction. The short gastric vessels are ligated and divided, allowing medial and cephalad retraction of the stomach. Mobilisation of the spleen and the pancreas from their retroperitoneal attachments to the kidney and the adrenals is completed. The inferior mesenteric vein is divided and the mesenteric root divided from the lateral border of the SMV to the lateral border of the aorta, staying anterior to the SMA. Division of the splenic artery and vein is delayed until steps 2 through 5 are completed. Then, in preparation for completion of the retroperitoneal dissection, the spleen and the distal pancreas are again reflected medially, exposing the origin of the splenic artery and the splenic vein—SMV junction. The splenic artery and vein are then ligated and divided. Hepaticojejunostomy and gastrojejunostomy are done similarly **(Fig. 23-61)**.

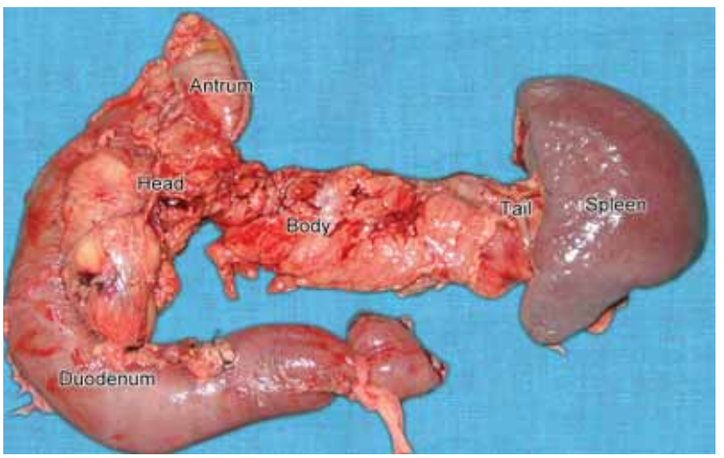


Fig. 23-61: Total pancreatectomy—specimen.

DISTAL PANCREATECTOMY

Any tumour in the body and tail of the pancreas; endocrine tumours when cannot be excised locally; trauma to the tail of the pancreas; in selected patients when chronic pancreatitis is localised to the tail of the pancreas with or without pseudocyst in the tail **(Fig. 23-62)**.

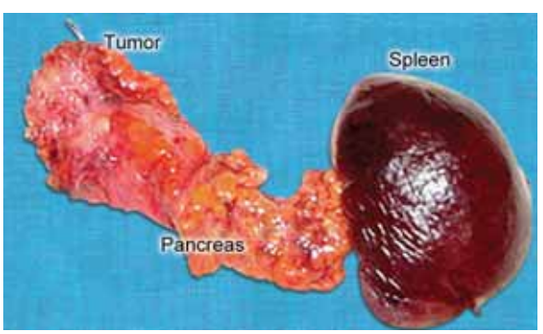
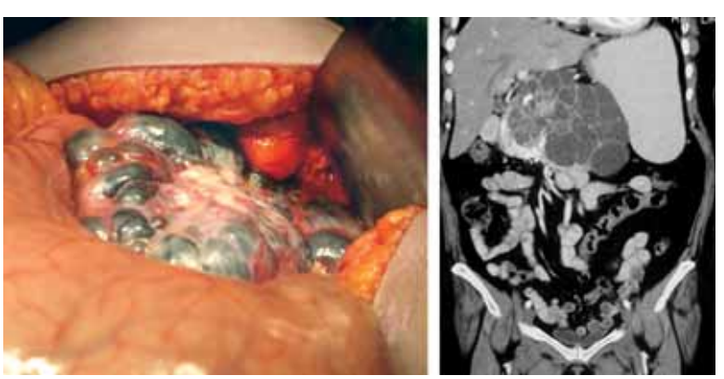


Fig. 23-62: Distal pancreatectomy specimen.

Usually distal pancreatectomy is done with splenectomy. Splenic preservation is often tried. Open and laparoscopic approaches are used for distal pancreatectomy. Invasion of the junction of splenic vein and portal vein by the tumour is an inoperable sign of the tumour. Any attempt of resection in such situation makes disastrous portal vein laceration **(Figs 23-63A and B)**.



Figs 23-63A and B: Cystadenocarcinoma of pancreas. CT picture of same patient.

Technique

Under general anaesthesia, patient is placed in supine position with left side upwards slightly. Lengthy upper midline incision or left subcostal incision is used. Abdomen is explored for operability and metastases.

Greater omentum is divided between ligatures and detached completely from the transverse colon. Splenic flexure is mobilised downwards and separated completely. Peritoneal layer is incised at the lower part of the pancreas to expose the lower margin. Care should be taken at this stage not to injure inferior mesenteric vein which will be ligated at a later period. Peritoneum along the superior margin is also incised with care as tortuous splenic artery is on the upper margin of the pancreas. Splenic artery near the neck of the pancreas is identified by feeling its pulsation. One should not get confused with the common hepatic artery. Splenic artery is dissected, isolated and ligated but divided only at later period **(Fig. 23-64)**.

Spleen is mobilised towards right of the patient by dividing splenorenal ligament. Posteriorly kidney, renal vessels and adrenal gland will be present from which tail of the pancreas is gently separated by blunt and sharp dissection as usually the plane is avascular. But if tumour is close to the tail of pancreas, there may be adhesions due to desmoblastic reaction or invasion of the tumour to these structures. Adrenal vein may close to the dissecting area which should be safeguarded. If tumour invasion occurs into the renal vessels (which are very well identified preoperatively by proper imaging), left side nephrectomy is to be done provided opposite kidney is functioning well. Spleen with tail, body of the pancreas is lifted upwards into the wound. Left gastroepiploic vessels and short gastric vessels are carefully ligated. Further dissection and elevation of the body of the pancreas will visualise the inferior mesenteric vein joining the splenic vein. Inferior mesenteric vein is doubly ligated with silk and divided. Further dissection posteriorly with finger or peanut will show the splenic vein joining the SMV to form portal vein. 2 cm away from this junction splenic vein is gently dissected from the tissues around as often it is embedded in the pancreatic tissue. Splenic vein is encircled with a right angle and doubly ligated and divided. Previously ligated splenic artery is divided with double ligation **(Figs 23-65 and 23-66)**.

Peripancreatic tissues are dissected to bare the neck of the pancreas. Neck is divided using stapler. Specimen is retrieved. Usually stapler transected proximal cut end of pancreas does not require any additional sutures. If stapler is not used then transected pancreas is closed using interrupted mattress sutures by 3-zero nonabsorbable suture—polypropylene or silk. Pancreatic duct needs a separate transfixation using 3-zero polypropylene suture. Cavity is inspected for any bleeding. Sutured pancreatic stump is again inspected. Tube suction drain is placed in the left subphrenic space. Abdomen is closed in layers.

Post-operative Care

Fluid therapy is continued; nasogastric tube is removed in 72 hours; drain is kept for 5-7 days. Antibiotics may be needed as sepsis can occur. Serum amylase and lipase estimation may require to be done during post-operative period.

Complications

Pancreatic fistula can occur which usually subsides spontaneously by conservative therapy.

Subphrenic abscess formation, acute pancreatitis, left-sided pleural effusion, complications of splenectomy like OPSI, injury to left kidney, left renal vessels, diaphragm and colon can occur.

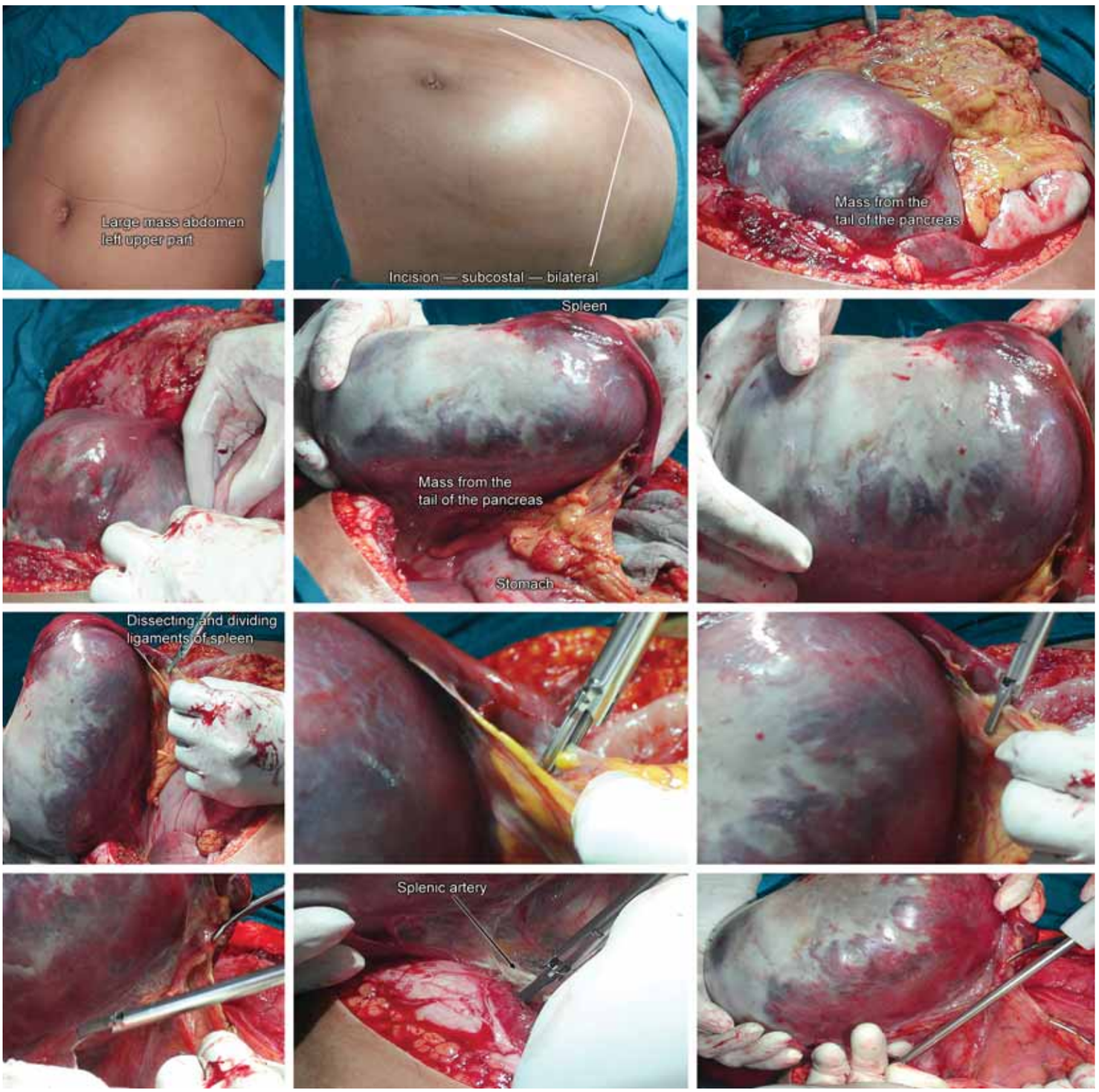
RADICAL ANTEGRADE MODULAR PANCREATOSPLENECTOMY (RAMPS)

Here distal pancreatectomy with splenectomy is done from right towards left instead of standard left to right technique. This gives early control of splenic vessels and also achieves optimum tumour clearance. It is done for tumours of body and tail of the pancreas. Nodal clearance is also important in this technique. Greater omentum is freed from colon. Short gastric vessels are ligated and divided. Right colon is mobilized, SMV is identified; portal dissection is done; gastroduodenal artery is not divided; all lymph nodes are removed and reflected towards left on the body of the pancreas. Kocherisation should be done. Portal vein and SMV are separated from the neck of the pancreas like in Whipple's operation. Neck towards left of portal vein is transected after placing 4 stay sutures. Stump towards head of the pancreas is sutured securely using nonabsorbable sutures (polypropylene). Posterior peritoneum is opened; fat and lymph nodes are cleared from crus of the diaphragm, in front of the common hepatic artery; nodes adjacent to left gastric artery are dissected; left gastric vein (coronary vein) is dissected, ligated and divided. Splenic artery originating from the celiac trunk is identified, ligated with transfixation at its origin. Spleen and tail of the pancreas is dissected off. Dissection can be done anterior to adrenal gland (anterior RAMPS) or posterior to adrenal gland if tumour has invaded adrenal gland (posterior RAMPS). Inferior mesenteric vein is ligated here where it joins the splenic vein. But renal vessels and kidney are kept away from dissection. Once final mobilisation is done, splenic vein is doubly ligated and divided. Neck is transected using stapler or hand suturing of the cut head end of the pancreas is done using 3 zero polypropylene interrupted sutures after transection. Duct may be separately sutured.

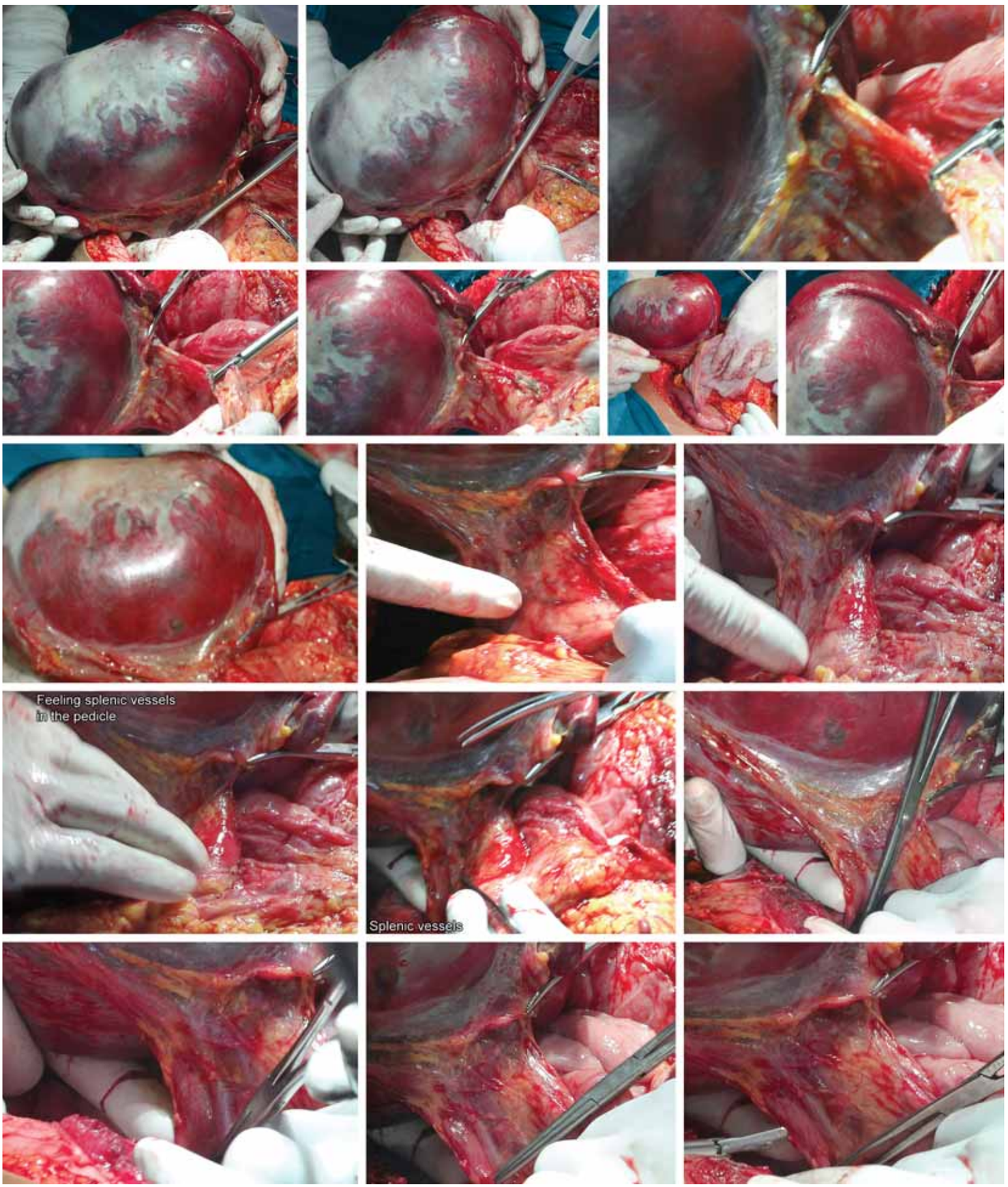
Modified Appley's (Canadian surgeon, 1954) technique is RAMPS with resection of the celiac or common hepatic artery. Here blood supply to liver, duodenum and pancreas is achieved through inferior pancreaticoduodenal artery arising from SMA. Often an arterial (PTFE) graft from the aorta to proper hepatic artery is also done.

CHOLCECYSTOJEJUNOSTOMY

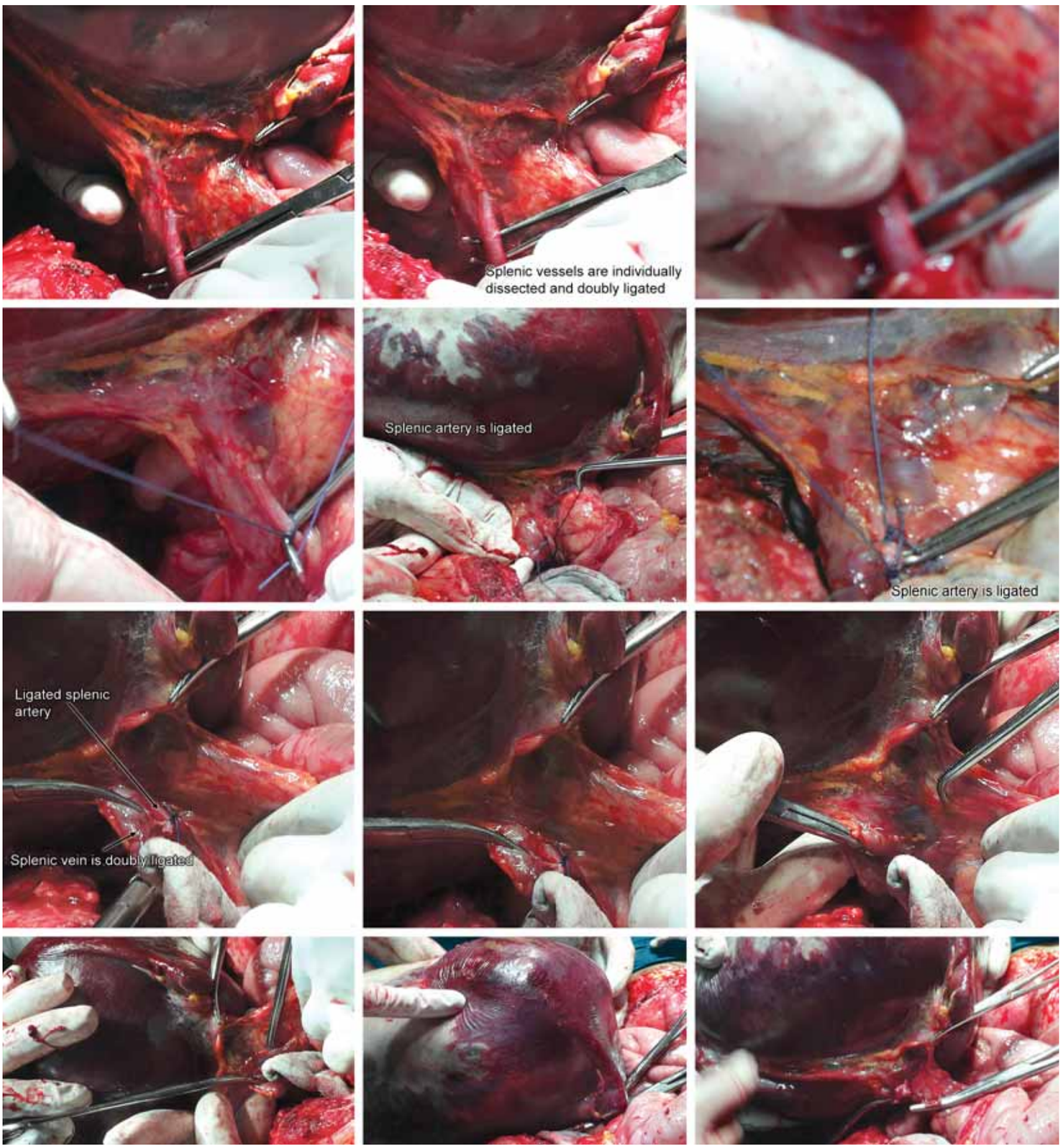
Cholecystojejunostomy is occasionally done as a palliation in carcinoma of pancreas. Even though choledochojejunostomy is better and ideal for palliation and also to relieve obstruction, in advanced malignancy with involvement of mesocolon and extensive nodes, simpler surgery like cholecystojejunostomy still carries a role because of its simplicity in doing it in selected patients. However, it is useful only if cystic duct remains patent. Technique is detailed in the chapter on gallbladder **(Fig. 23-67)**.


Large mass abdomen left upper part
Incision — subcostal — bilateral
Mass from the tail of the pancreas
Spleen
Mass from the tail of the pancreas
Stomach
Dissecting and dividing ligaments of spleen
Splenic artery

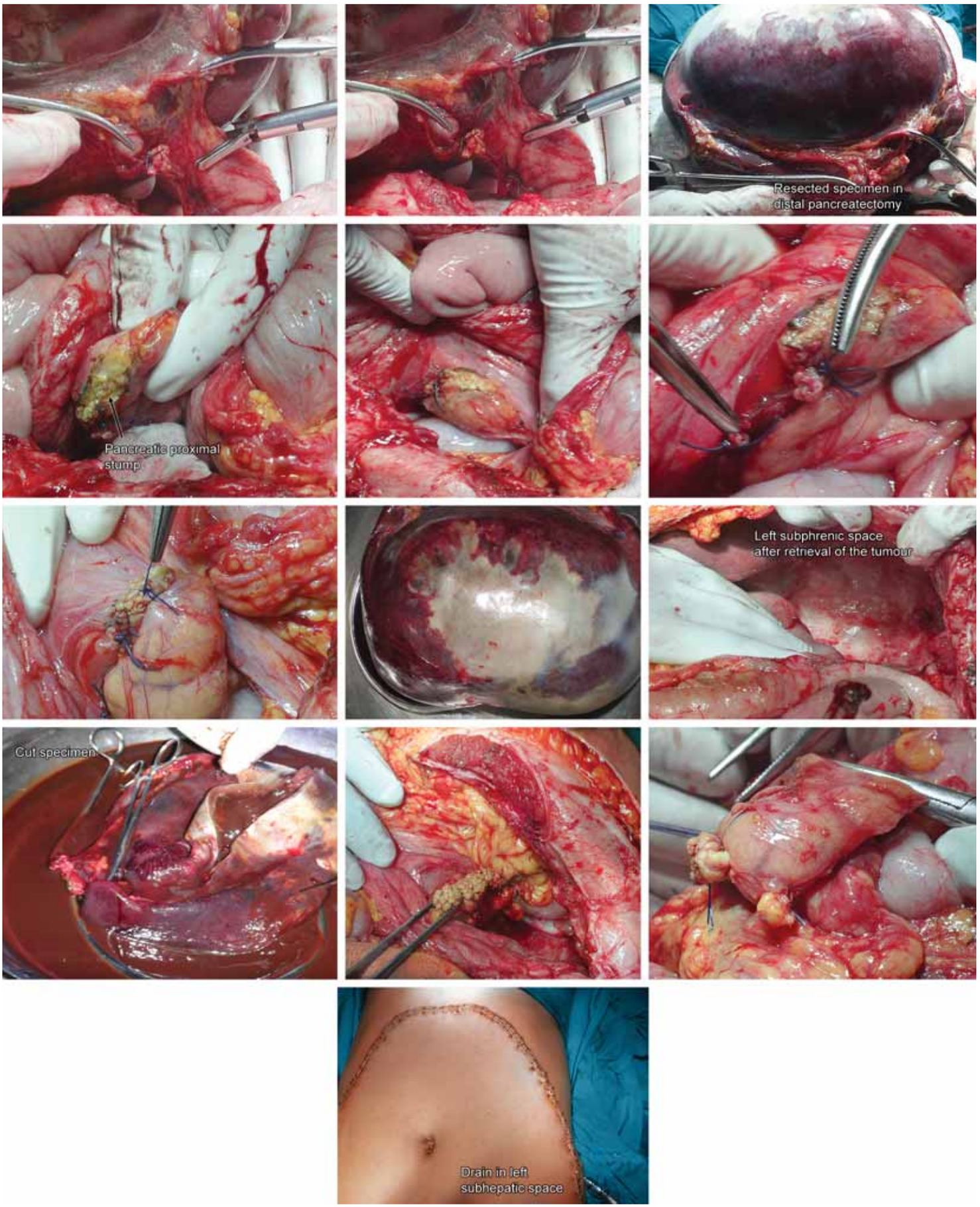
Figs 23-64(1)



Figs 23-64(2)


Splenic vessels are individually dissected and doubly ligated
Splenic artery is ligated
Splenic artery is ligated
Ligated splenic artery
Splenic vein is doubly ligated

Figs 23-64(3)


Resected specimen in distal pancreatectomy
Pancreatic proximal stump
Left subphrenic space after retrieval of the tumour
Cut specimen
Drain in left subhepatic space

Figs 23-64(4)

Figs 23-64(1 to 4): Distal pancreatectomy for pancreatic tail tumour/mass.

Fig. 23-65: Mucinous cystadenocarcinoma of pancreas.

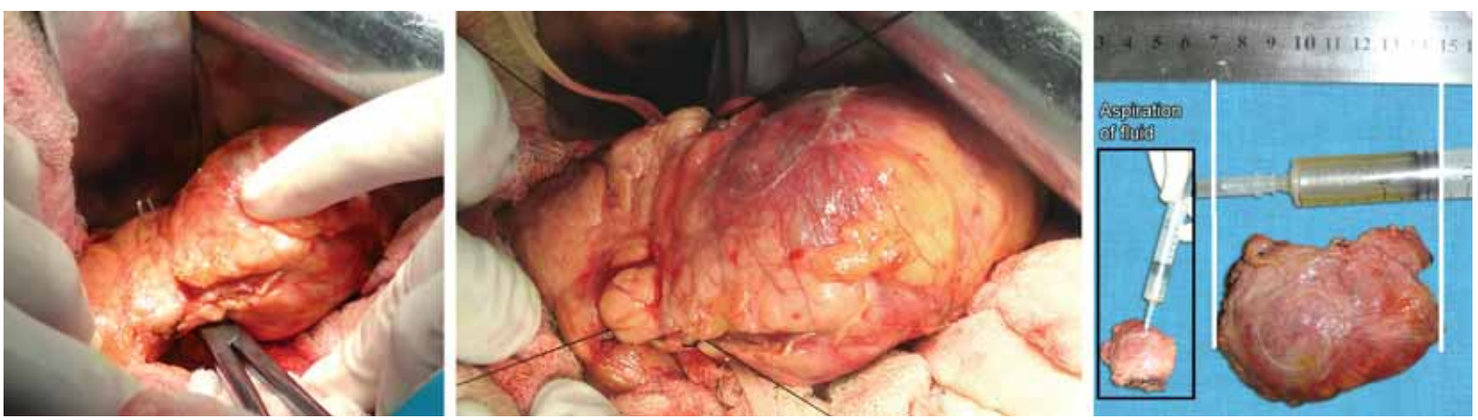


Fig. 23-66: Mucinous cystadenoma of pancreas [*Courtesy:* Dr Arunkumar MCh (Gastro) Kochin].

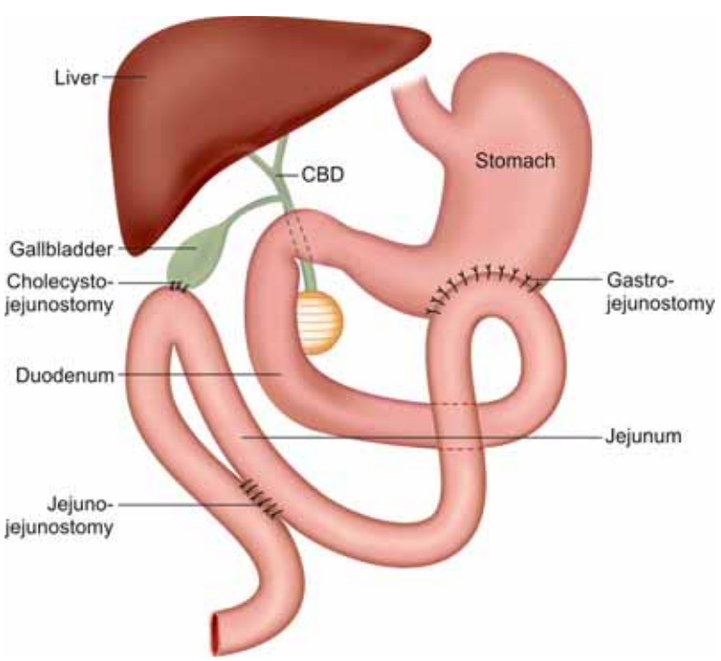


Fig. 23-67: Cholecystojejunostomy as a palliation in advanced carcinoma of pancreas is done occasionally. Gastrojejunostomy is added for possible duodenal obstruction.

SPLEEN

SURGICAL ANATOMY

Spleen is derived from the word *splen* in Greek; and *lien* from Latin. It is a wedge-shaped organ lying mainly in left hypochondrium, along the long axis of 10th rib. It is obliquely placed along the 10th rib downwards, forwards and laterally. It is wedged between fundus of stomach and diaphragm. Hilum of spleen transmits splenic vessels and nerves. Spleen has got anterior and posterior ends; two surfaces (parietal and visceral); three borders (superior is notched in front; inferior; intermediate) **(Fig. 23-68)**.

It is vascular purple-coloured soft organ. It is 12 cm in length; 7-8 cm in width; 2-3 cm in thickness. Normally spleen is not palpable. Its weight is 200 grams.

It is posteriorly related to left side diaphragm, diaphragmatic recess and left 9th, 10th, and 11th ribs. It is being related to left lung and pleura above these structures.

Its parietal surface is related to diaphragm; the visceral surface is related to stomach, splenic flexure of colon, pancreas and kidney. Upper pole is close to stomach and often may be fixed to stomach having short gastric vessels there. Lower pole is 4-7 cm away from the stomach **(Figs 23-69 and 23-70)**.

Ligaments of Spleen

Spleen is suspended by two ligaments *(a) lienorenal ligament, (b) gastrosplenic ligament.* These two are main/chief splenic ligaments

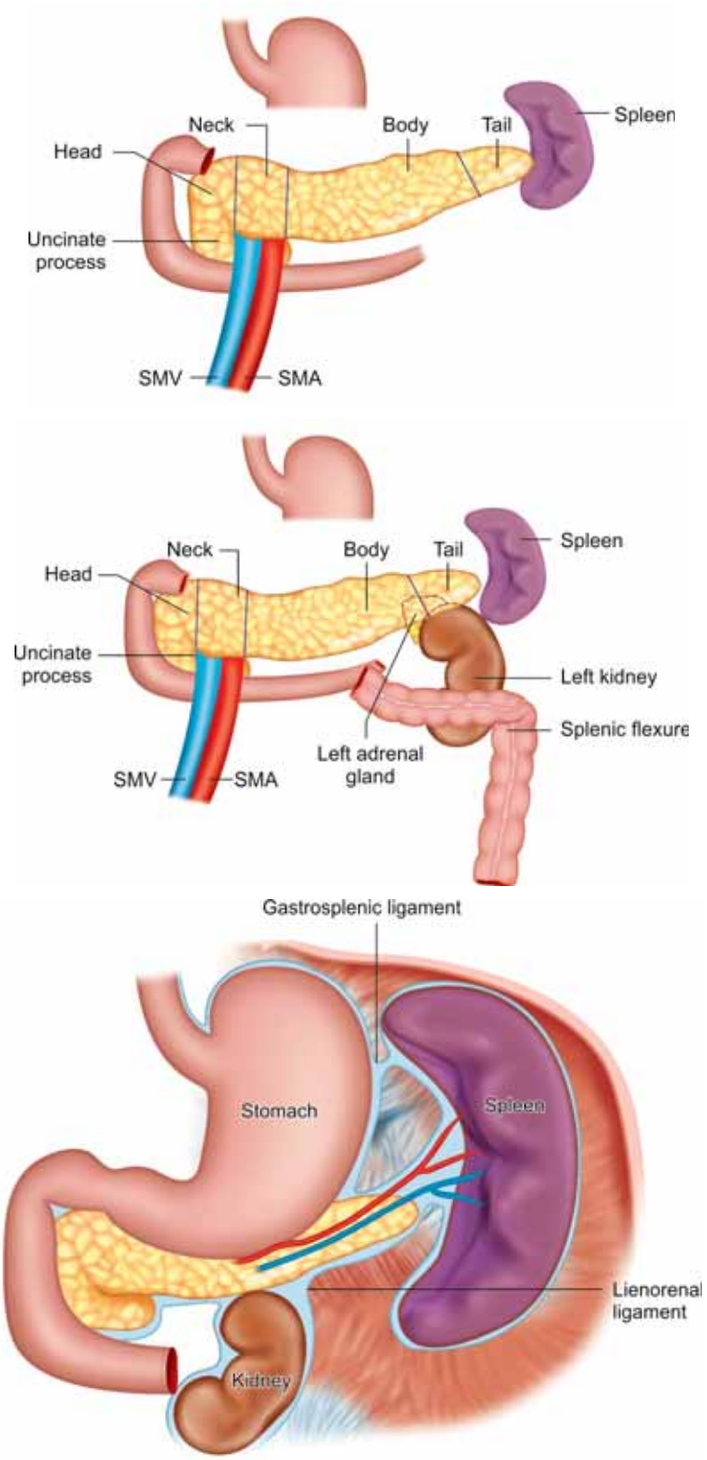


Fig. 23-68: Anatomy of spleen. Note the different relations of spleen which are surgically important during splenectomy.

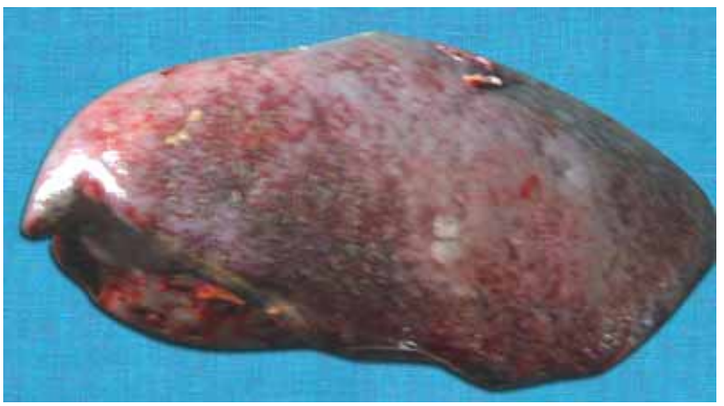


Fig. 23-69: Parietal surface of the spleen.

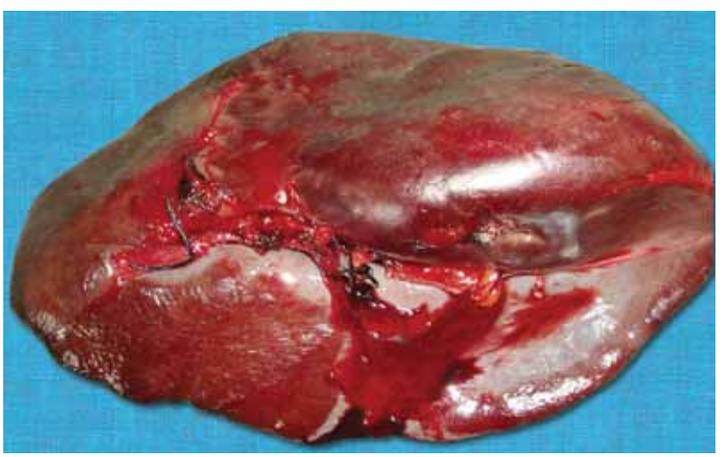


Fig. 23-70: Visceral surface of the spleen.

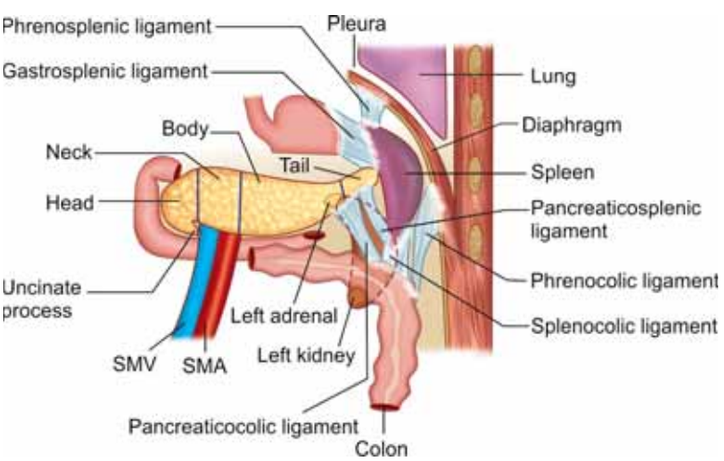


Fig. 23-71: Ligaments and relations of the spleen.

which form splenic pedicle. Lienorenal ligament transmits blood vessels to spleen. The tail of pancreas lies in this ligament, which can be damaged during splenectomy. Outer layer of lienorenal/splenorenal ligament forms posterior layer of gastrosplenic ligament. The gastrosplenic ligament contains short gastric vessels which supply the left half of greater curvature of stomach. Gastrosplenic ligament also contains left gastroepiploic vessels below. Presplenic fold may be present in front of this gastrosplenic ligament which during traction may get torn and can cause bleeding from the left gastrosplenic ligament **(Fig. 23-71)**.

Phrenicocolic ligament comes in contact with lower pole of spleen, which may be damaged during mobilisation of splenic flexure of colon. It extends below from the lateral margin of the splenic flexure of the colon reflecting upwards laterally touching to the lower pole of the spleen to reach diaphragm; it is closely related to the spleen as spleen stays on its surface forming splenic floor. It is not attached to the spleen.

Splenophrenic ligament reflects between upper pole of spleen and stomach towards inferior surface of the diaphragm. Even though it is avascular, it may cause bleeding while dividing and so bipolar cautery or other energy sources should be utilised, otherwise ligation may be required **(Fig. 23-72)**.

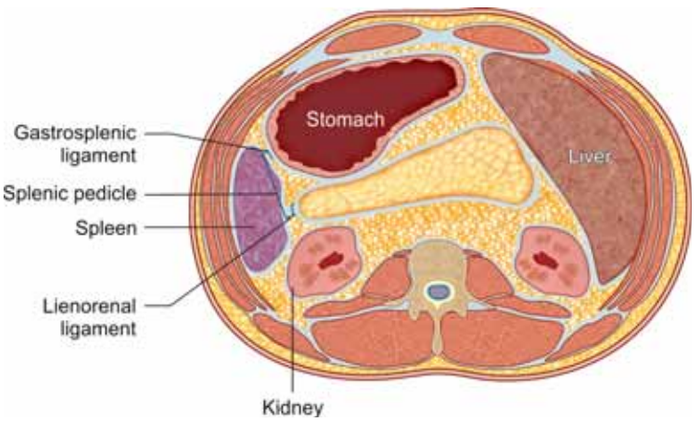


Fig. 23-72: Splenic pedicle contains lienorenal (splenorenal) and gastrosplenic ligaments; they are main/chief ligaments of the spleen (view from above).

Pancreaticocolic ligament runs between tail of pancreas and splenic flexure. Splenocolic ligament reflects from splenic flexure of the colon towards lower pole of the spleen medial to phrenocolic ligament.

Spleen is palpated under left costal margin during inspiration. It has to enlarge 2-3 times its normal size to become palpable.

Blood Supply

Arterial Supply

Splenic artery is the largest branch of coeliac artery but may arise from aorta or superior mesenteric artery, blood flow is 300 ml/min. Often it may arise from a common gastrosplenic trunk (left gastric artery and splenic artery) or common hepatosplenic trunk (common hepatic artery and splenic artery). Artery is 0.6 – 1.3 cm in diameter with 7-30 cm in length. It is tortuous. It runs in the upper margin of the pancreas. It initially crosses the left border of the aorta, then runs on the front of the tail of the pancreas and upper pole of kidney before reaching the splenic hilum. Tortuosity of the artery allows free movement of the spleen. Branches are dorsal pancreatic artery, posterior gastric artery, left gastroepiploic artery and arteria pancreatica magna. Artery passes through the lienorenal ligament to reach the splenic hilum where it divides into 5 or more branches. Short gastric arteries may arise from splenic artery or left gastroepiploic artery **(Fig. 23-73)**.

Splenic artery shows one of the two patterns of branches towards spleen. (1) *Magistral type* where there is long main splenic artery with short terminal branches as—superior terminal artery gives superior polar artery and often short gastric arteries. Inferior terminal artery gives penultimate and an ultimate branch and other branches inside the spleen. Inferior polar artery runs downwards towards inferior pole of the spleen. (2) *Distributive type*—Here superior polar artery directly originates from the splenic artery having an anastomotic branch with inferior terminate branch.

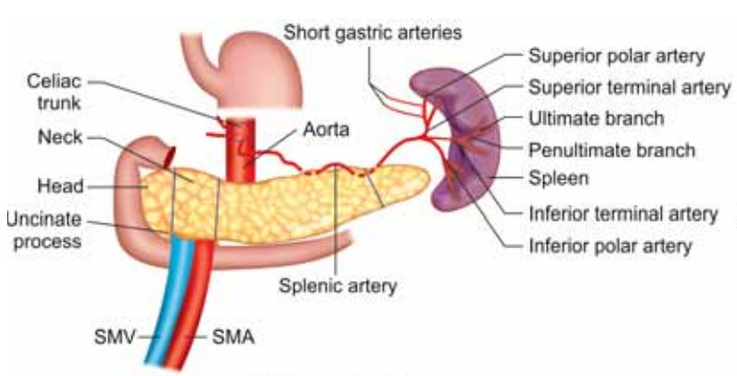
Venous Drainage

Splenic vein joins the superior mesenteric vein at right angle behind the neck of pancreas to form the portal vein. Often 2 or more splenic vein tributaries join and form splenic vein. Its other tributaries are left gastroepiploic vein, short gastric vein and pancreatic veins. Commonly inferior mesenteric vein joins splenic vein just before it joins the portal vein; but inferior mesenteric vein may join SMV or directly into the portal vein **(Fig. 23-74)**.

Splenic parenchyma contains *white pulp* and *red pulp*. *White pulp* lies in centre surrounding the central artery, which is a branch of trabecular artery. It is made up of lymphatic nodules with germinal centres and periarterial lymphatic sheaths with a network containing lymphocytes and macrophages. White pulp is surrounded by marginal zone which contains end arteries from central and peripheral peniciliary arteries **(Fig. 23-75)**.

Marginal zone contains marginal sinus which filters the materials from the white pulp. Immunoglobulins secreted by white pulp enter marginal zone and into main bloodstream. *Red pulp* is located outer to marginal zone. Red pulp contains cords and sinuses. Central artery gives reticular branches which open into these sinuses and cords wherein particles are phagocytosed. Commonly central artery eventually ends in these cords and sinuses. Few end branches of the central artery directly enter the pulp vein. Cords and sinuses eventually drain into pulp vein. Blood circulation through these cords and sinuses is known as '*open*' circulation (90%). Blood circulation through white pulp but not entering these cords and sinuses is known as '*closed*' circulation (10%).

Removal of non-deformable intracellular substances from deformable cells is known as "*pitting*". *Heinz bodies/Howell-Jolly bodies, Pappenheimer siderotic bodies* are removed by this method from RBCs. Post-splenectomy patients will show these bodies in



Figs 23-73A and B: Arterial distribution of the spleen (Splenic artery).

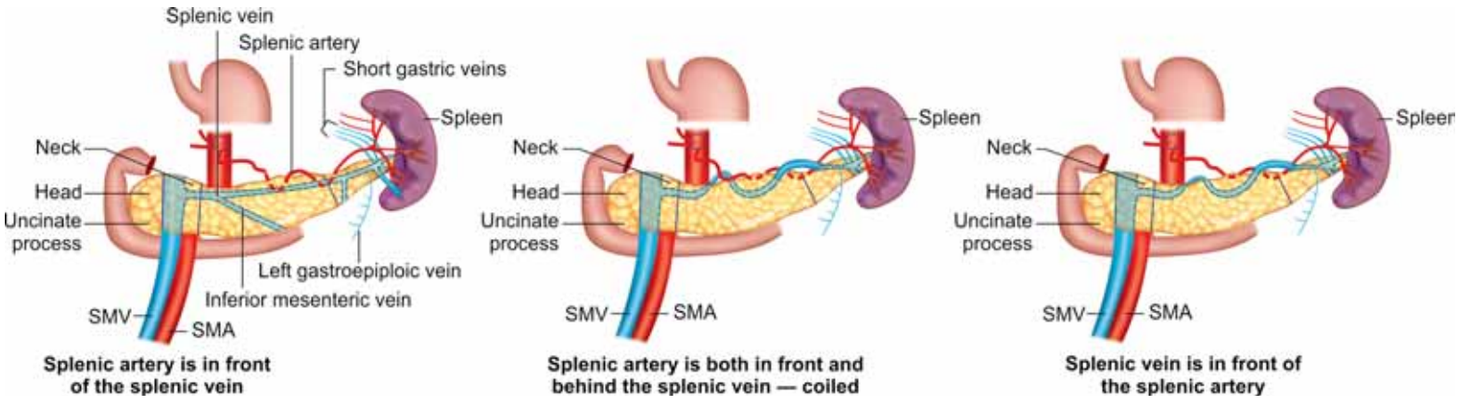


Fig. 23-74: Splenic vein tributaries and different patterns of its course.

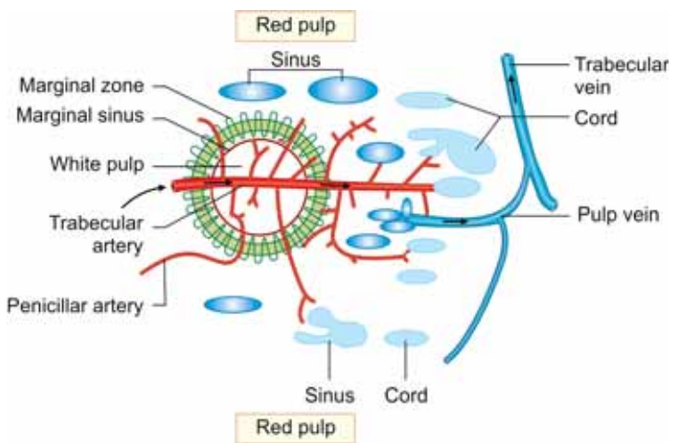


Fig. 23-75: Splenic architecture. Architecture of spleen showing red pulp (peripheral); white pulp (central); open and closed circulation; marginal zone and sinuses and trabecular artery and vein.

the RBCs in peripheral smear. In splenunculi, these bodies will be absent even after splenectomy. Removal of aged/abnormal red cells is done by the process of "*culling*". RBCs which lose osmotic balance and membrane integrity are known as non-deformable and they are removed by this method. Half life of platelets is 10 days. In splenomegaly, 80% of platelets may be sequestered in spleen causing thrombocytopenia. Normally spleen is reservoir for platelets. 1/3rd of total platelet mass is present in spleen. In pathological status like immune diseases phagocytosis of platelets in spleen is accelerated by many folds. Splenomegaly and hypersplenism can cause neutropenia. Half life of Neutrophil is 6 hours. Bacterial clearance also occurs in spleen by phagocytosis. After splenectomy, patients are more prone to OPSI, *immunologic functions* like synthesis of antibody IgM; formation of lymphocytes; production of tuftsin, opsonins, properdin and interferons.

Lymphatic Drainage

It is to supra- and infrapancreatic nodes and splenic nodes.

Splenic Segments

Usually spleen has got two segments—superior and inferior. 15% of individuals may have three segments—superior, middle and inferior.

SPLENUNCULI (30%) (FIG. 23-76)

30% of individuals can have accessory spleen. These are single (60%), or two (20%) or multiple accessory spleens. Size of these accessory spleens varies from 0.5 cm to 10 cm.

Sites—Hilum of spleen (50%); near splenic vessels; tail of the pancreas (30%); splenic ligaments—gastrosplenic/splenorenal; mesocolon; greater omentum. After splenectomy, they undergo hyperplasia and lead to recurrence of the disorder for which spleen was removed. Blood peripheral smear in these patients with splenunculi *will not show* Howell-Jolly bodies, Pappenheimer siderotic bodies. Accessory spleen can also be occasionally present adjacent to left ovary or adjacent to left testis.

PRINCIPLES IN SPLEEN SURGERY

Initial immunisation for pneumococci, meningococci, haemophillus influenza by appropriate vaccines is necessary. Vaccine should be given 2 weeks prior to surgery.

Proper pre-operative evaluation depending on the condition to which patient undergoes splenectomy is important. CT, peripheral smear, platelet count, osmotic fragility test, prothrombin time, coagulation profile and bone marrow aspiration, when needed, have to be done.

Splenic surgery needs proper exposure of surrounding ligaments and structures, proper dissection of the splenic vessels, avoiding trauma to pancreas, stomach, colon and left kidney.

Laparoscopic splenectomy is ideal unless spleen is massively enlarged.

Accessory splenic tissue should be identified and removed. It is difficult to identify often these splenunculi but becomes mandatory when dealing with hereditary spherocytosis or idiopathic thrombocytopenic purpura.

Spillage of spleen during dissection or retrieval should be avoided. It will be troublesome in conditions like ITP.

Post-splenectomy sepsis is a life time risk to the patient. OPSI is more troublesome in splenectomy for trauma. Partial splenectomy, splenorrhaphy, mesh splenorrhaphy, splenic autotransplantation are other options that should be kept in mind. Splenic preservation in trauma is preferred unless patient is haemodynamically unstable or life-threatening haemorrhage sets in. On table Argon beam laser often helps to control bleeding from the splenic surface. Splenic salvage in

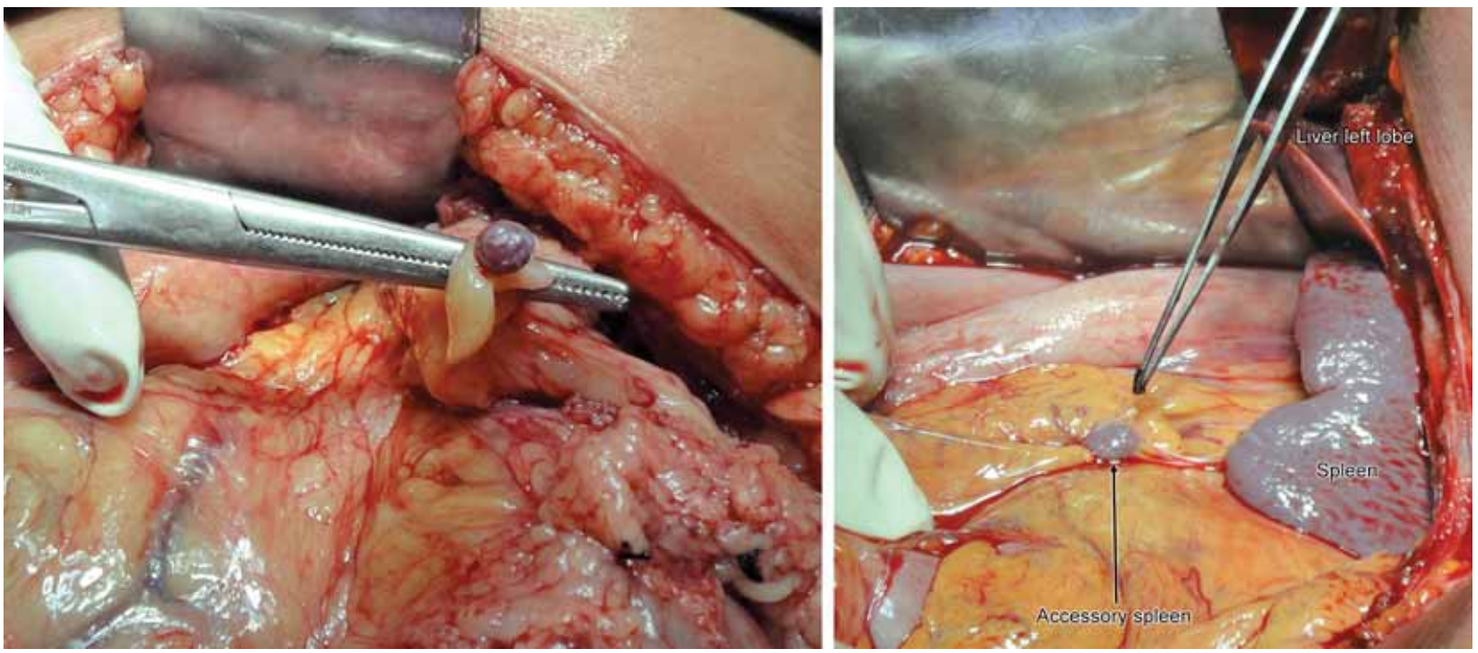


Fig. 23-76: On table photo of splenunculi with splenomegaly. Splenunculi should be removed, otherwise disease will recur.

splenic trauma could be non-operative and operative. Hilar injury, large splenic haematoma with a contrast splenic blush in CT are the contraindications for conservative/salvage approaches.

Post-operative sepsis like subphrenic abscess, pancreatitis, OPSI, pancreatic fistula, injury to adjacent organs, post-operative deep vein thrombosis are to be taken care of.

Before splenectomy, pre-operative splenic artery embolisation is occasionally done only in very large spleen to reduce the size of the spleen; but splenectomy should be done in specified period of 7-10 days, otherwise splenic necrosis, sepsis can occur.

Laparoscopic splenectomy is ideal for elective splenectomy unless spleen is very large in size. It is ideal for ITP as spleen would not be enlarged enormously here.

Adequate exposure should be achieved through a large incision. Small incision does not have a role in open splenectomy. Thoracoabdominal incision may be needed when spleen is adherent to diaphragm or usual abdominal incision may require to be extended as thoracoabdominal if there is difficulty in dissecting the spleen.

Splenic ligaments are usually vascular; they cause troublesome oozing and so need careful dissection, ideally using bipolar cautery. Perisplenic adhesions are also vascular and need ligation prior to division. Splenic vessels at the hilum are prone to tear as they are fragile.

Proximal control of the splenic artery at its origin is better in large spleen. Anatomical variation like coiling of splenic vein on the splenic artery may get injured causing torrential bleeding. In ITP splenic artery should be ligated first and platelets should be transfused only later. Even if splenic artery is ligated proximally, it should be ligated again distally at the hilum during final stage of the dissection.

Short gastric vessels should be carefully ligated and divided. Harmonic scalpel or transfixation sutures are better.

Proximal greater curvature should be invaginated using sero-muscular continuous or interrupted silk sutures to avoid greater curve necrosis.

In portal hypertension and myelofibrosis and in massive spleen normal avascular splenic ligaments will be very much vascular and can cause torrential bleeding.

Blood products like fresh frozen plasma, platelets are often needed while doing splenectomy in massively enlarged spleen.

Absolute haemostasis after removal of spleen is essential; bleeding from tail of the pancreas should be suture ligated with fine polypropylene transfixation. In other areas, bipolar cautery or ligation of the bleeders should be done.

Pancreatic injury should be avoided as pancreatic fistula or pancreatitis can occur. Gastric trauma, if it occurs, can result in gastric fistula which is very difficult to manage.

SPLENECTOMY

Indications for splenectomy:

1. Trauma.
2. In distal pancreatectomy, total pancreatectomy, rarely radical gastrectomy—removed "*en bloc*" with stomach.
3. Staging laparotomy in case of Hodgkin's lymphoma.
4. Hereditary spherocytosis and other haemolytic anaemias.
5. Idiopathic thrombocytopaenic purpura (ITP).
6. Portal hypertension with variceal bleeding—mainly gastric varices with splenic vein thrombosis.
7. Tuberculosis of spleen.
8. Others:
   Gaucher's disease.
   Chronic myeloid leukaemia, myelofibrosis.
   Felty's syndrome.
   Carcinoma of tail of the pancreas during distal pancreatectomy.
   Schistosomiasis.
   Splenic artery aneurysm.
   Splenic infarction.
   Cystic disease of spleen.
   Splenic tumours.

Elective Splenectomy

Pre-operative vaccine; haemogram; Adequate blood is kept ready if need arises, antibiotics, nasogastric tube, urinary catheterisation are needed preoperatively.

Incision—Left subcostal incision is commonly used; it can be extended towards right side or upwards as Kehr's incision. Lengthy midline incision is also used but not a preferred one. In trauma lengthy midline incision is the preferred one always to explore and address other parts of the abdomen. Midline incision may be preferred when spleen extends massively towards right iliac fossa. Occasionally, thoracoabdominal incision may be a need **(Figs 23-77 and 23-78)**.

There are two approaches for splenectomy—*anterior approach* wherein through lesser or greater omentum, splenic artery is isolated for ligation first, then dissected in front to later mobilise spleen medially to complete the splenectomy; *posterior approach* is first used in mobilising the spleen from lateral side medially, then dissection is done in the hilum of the spleen. In elective cases, anterior approach is ideal; in trauma and emergency situation, posterior approach is the preferred one **(Fig. 23-79)**.

Anterior Approach

Lesser omentum is opened to identify superior border of the pancreas. Splenic artery is identified. Peritoneum over it is opened. Splenic artery at the level of the body of the pancreas is dissected, isolated and ligated. Instead of ligating it, an umbilical tape or vascular clamps can be applied to it to have a good control. Alternatively, splenic artery can be approached after opening the gastrocolic ligament (greater omentum, left gastroepiploic vessels are ligated; superior margin of the body of the pancreas is dissected to identify the splenic artery which is ligated doubly using silk sutures. Short gastric vessels are ligated from below upwards along the gastrosplenic ligament; energy source like harmonic scalpel or ligaseal will be very helpful here **(Fig. 23-80)**.

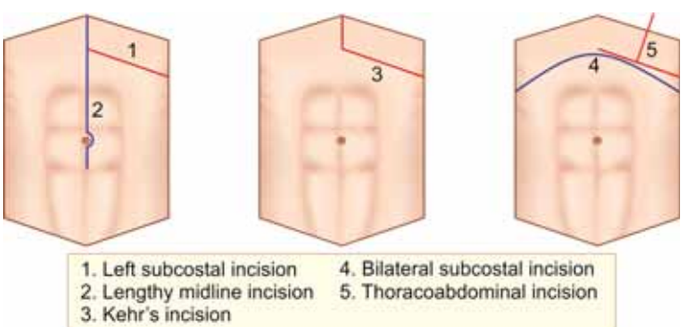


Fig. 23-77: Incisions used for splenectomy.

Fig. 23-78: Kehr's incision splenectomy.

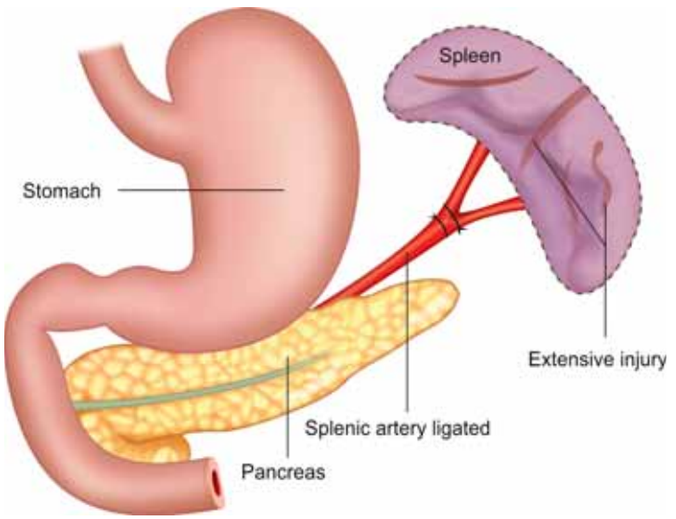


Fig. 23-79: Splenectomy.

Splenophrenic and splenorenal ligament is gently divided as it is usually avascular but ligation and division are better or by using energy sources. Spleen is dissected off from the Gerota's fascia. Plane is created between tail of the pancreas at its lower border and posterior abdominal wall and with finger dissection, finger can be encircled around.

Splenocolic ligament is divided and left flexure of the colon is released downwards. Remaining short gastric vessels and other peritoneal attachments are released using bipolar cautery and scissor or by ligation and division. Phrenicocolic ligament is also divided properly.

Spleen is elevated forward and medially to reach the splenic hilum and tail of the pancreas from behind. Splenic artery above and splenic vein below is identified and gently separated from tail of the pancreas. Splenic artery is dissected, isolated and ligated doubly using silk and divided. Branches of the splenic vein are divided after prior ligation. Splenic vein needs two or three proximal ligations; splenic vein is ligated at the end but care should be taken not to tear the vein by undue traction on the spleen towards front and medially. Splenic hilum with splenic vein is divided to get the splenic specimen out.

In elective cases for haemolytic diseases, meticulous search for accessory spleen is made out and should be removed properly. Spillage of the spleen should be avoided absolutely.

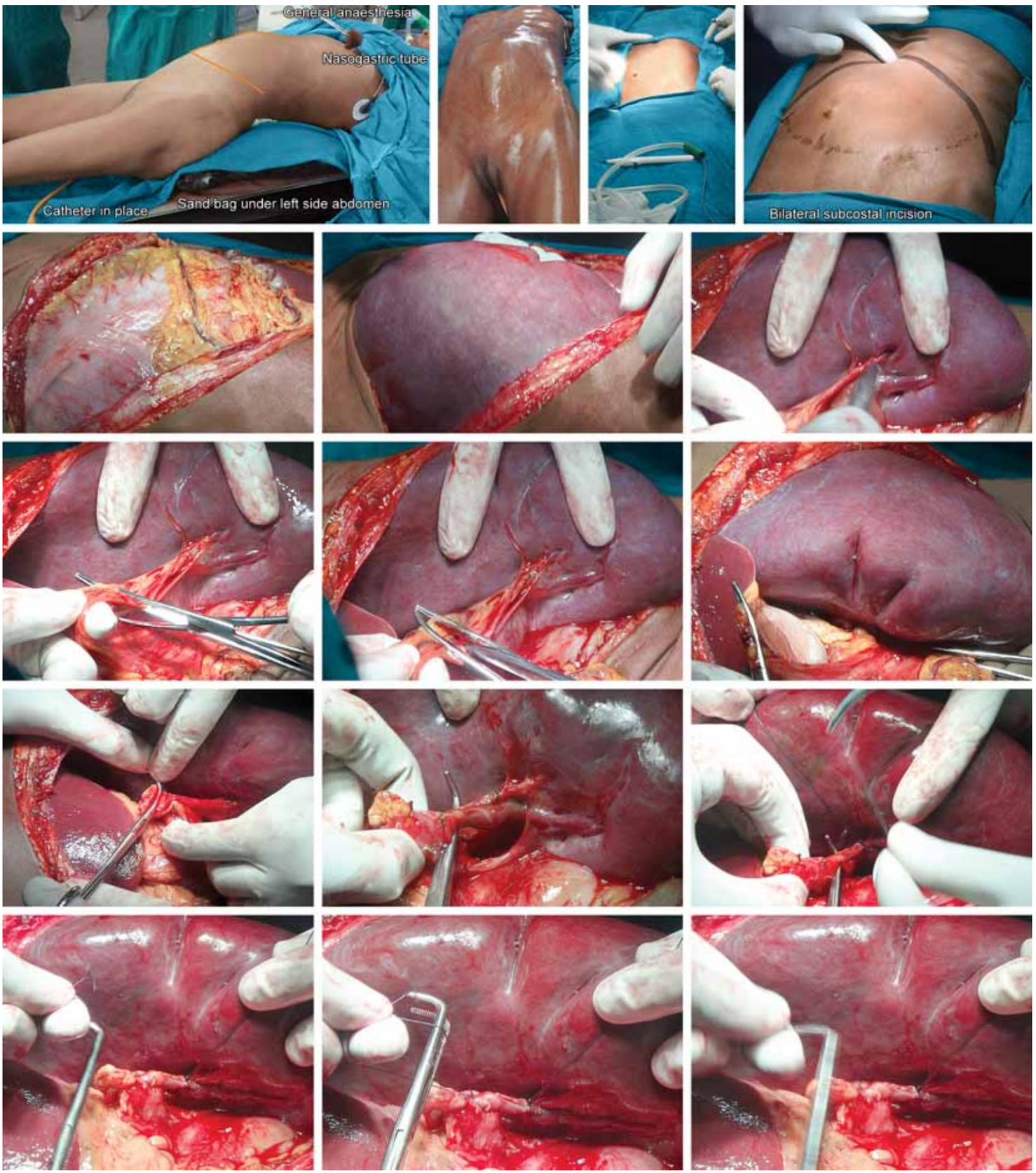
Seromuscular sutures should be placed on the greater curvature of the stomach towards fundal half side to prevent gastric necrosis or bleeding or leak. Either continuous or interrupted 2-zero silk sutures should be placed **(Figs 23-81 and 23-82)**.

Absolute meticulous haemostasis on the surface near the tail of pancreas and in relation to different ligaments is essential. Transfixation ligatures or bipolar cautery should be used to achieve that.

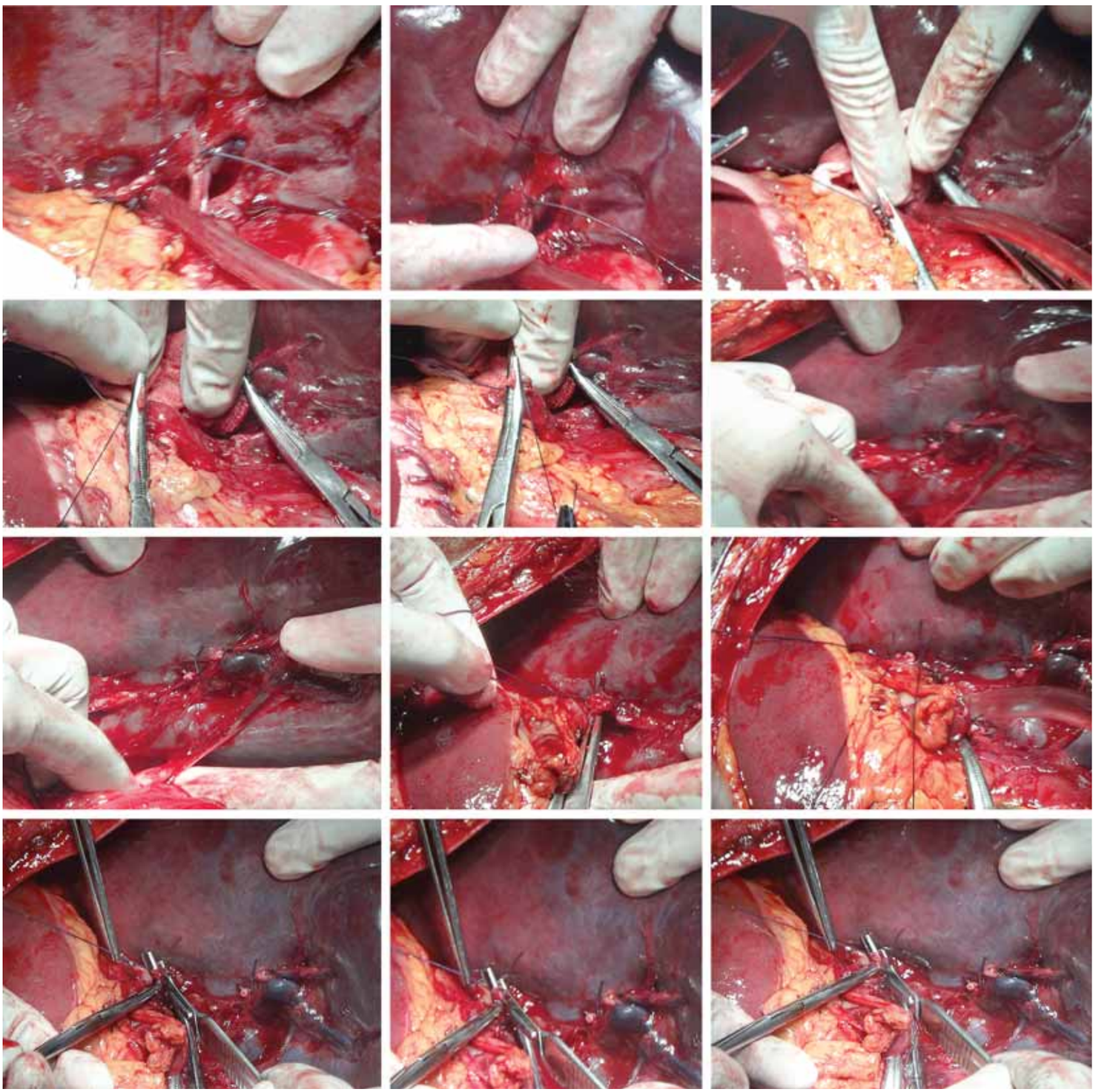
Suction tube drain is placed. Abdomen is closed in layers.

Posterior Approach

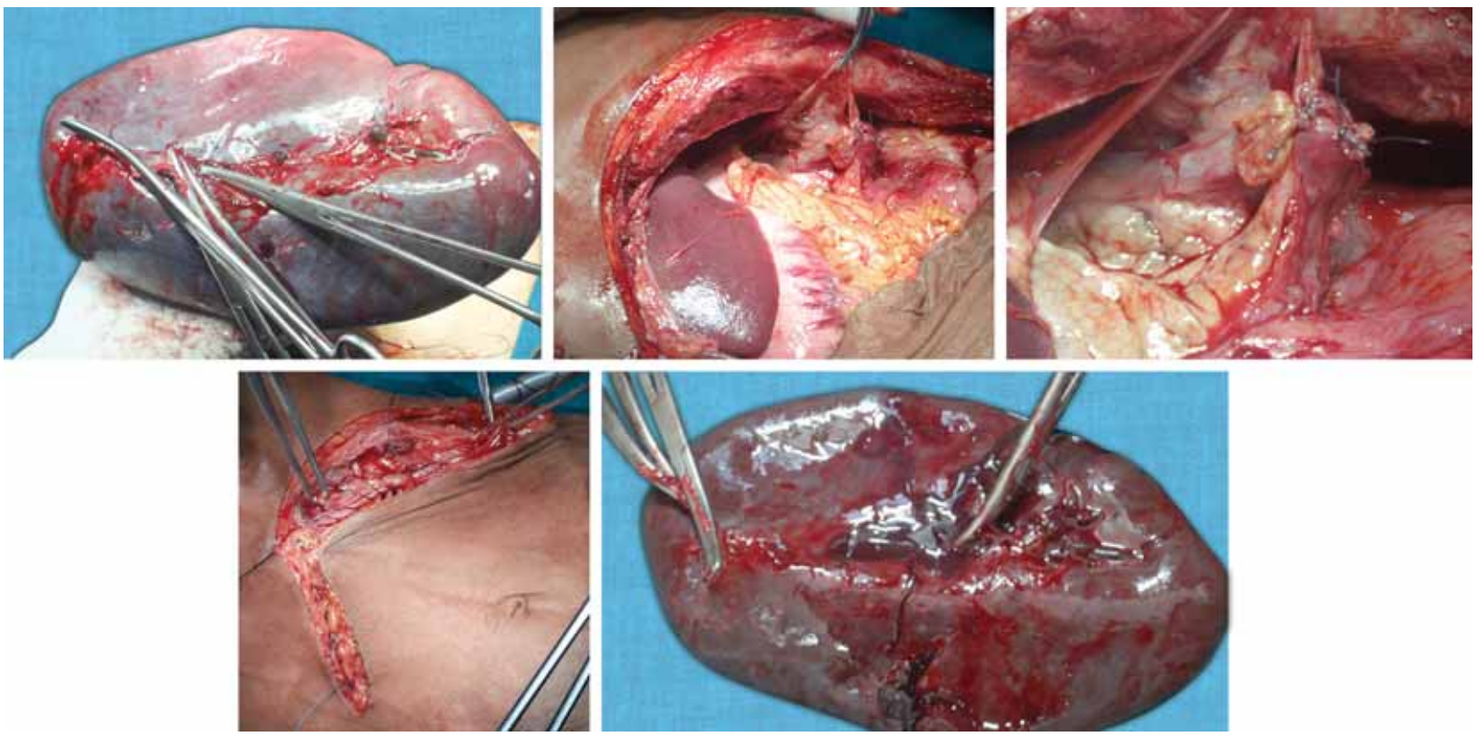
Spleen is held medially towards right. Splenocolic and phrenocolic ligaments are divided to make splenic flexure of the colon descend downwards. Splenophrenic ligament is released. Splenorenal ligament is identified from behind which is incised carefully to expose the splenic vessels. In trauma where there will be continuous bleeding, assistant is made to put his thumb and index finger between the


General anaesthesia
Nasogastric tube
Catheter in place
Sand bag under left side abdomen
Bilateral subcostal incision

Figs 23-80(1)



Figs 23-80(2)



Figs 23-80(3)

Figs 23-80(1 to 3): Splenectomy in a large spleen through open bilateral subcostal incision.

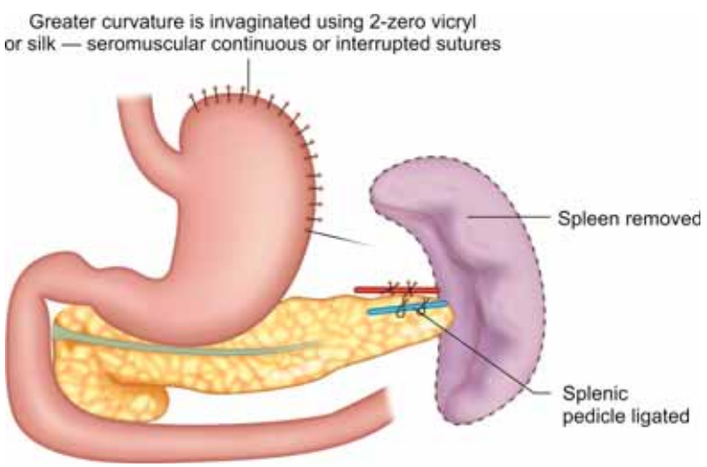

Greater curvature is invaginated using 2-zero vicryl or silk — seromuscular continuous or interrupted sutures
Spleen removed
Splenic pedicle ligated

Fig. 23-81: Greater curvature of the stomach near fundus and proximal body should be invaginated using seromuscular sutures. It prevents greater curve necrosis.

pedicle, otherwise an atraumatic occlusion clamp can be placed across the tail of the pancreas including the hilum to control the bleeding temporarily. Splenic artery is doubly ligated; branches of vein are ligated. Splenic vein is ligated doubly. Spleen is removed. Occlusion clamp is released. Any bleeding points in the pedicle are again transfixed using vicryl or silk and ligated. Tube drain is placed. Abdomen is closed in layers.

Postoperative Care

It is usual to keep a nasogastric tube in place for 24-48 hours; urinary catheter may be needed. Often antibiotics are needed in post-operative period. Coagulation profile monitor, observation for sepsis, left-sided atelectasis and pleural effusion are a must. Low molecular weight heparin, leg exercises and respiratory physiotherapy are always given.

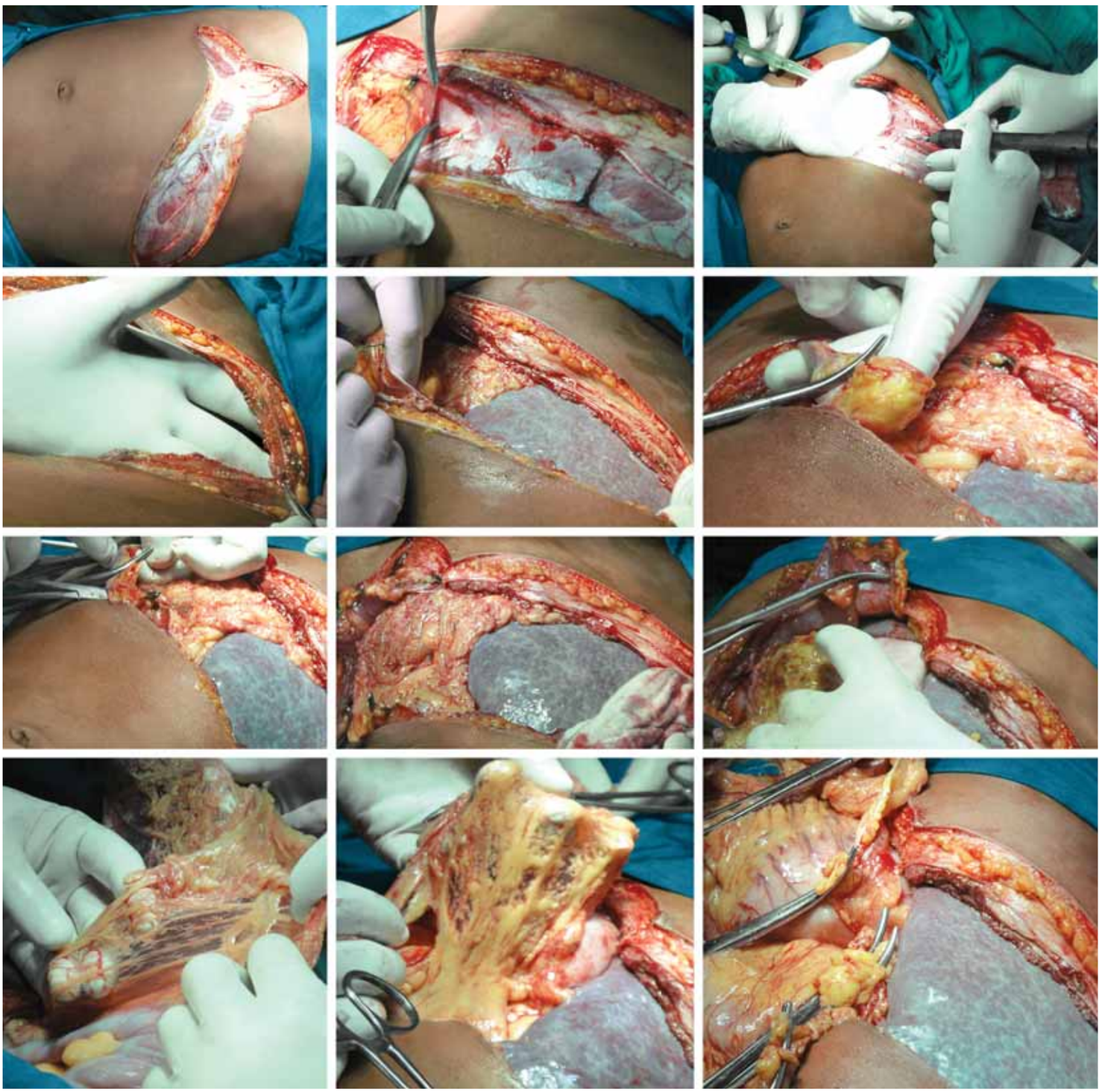
MANAGEMENT OF SPLENIC TRAUMA

Splenic trauma is the *most common* blunt injury in the abdomen. Injury can be simple avulsion to hilar transection. It may be associated with injuries to left lobe liver, diaphragm, left lung, splenic flexure, small bowel or pancreas **(Figs 23-83 to 23-91)**.

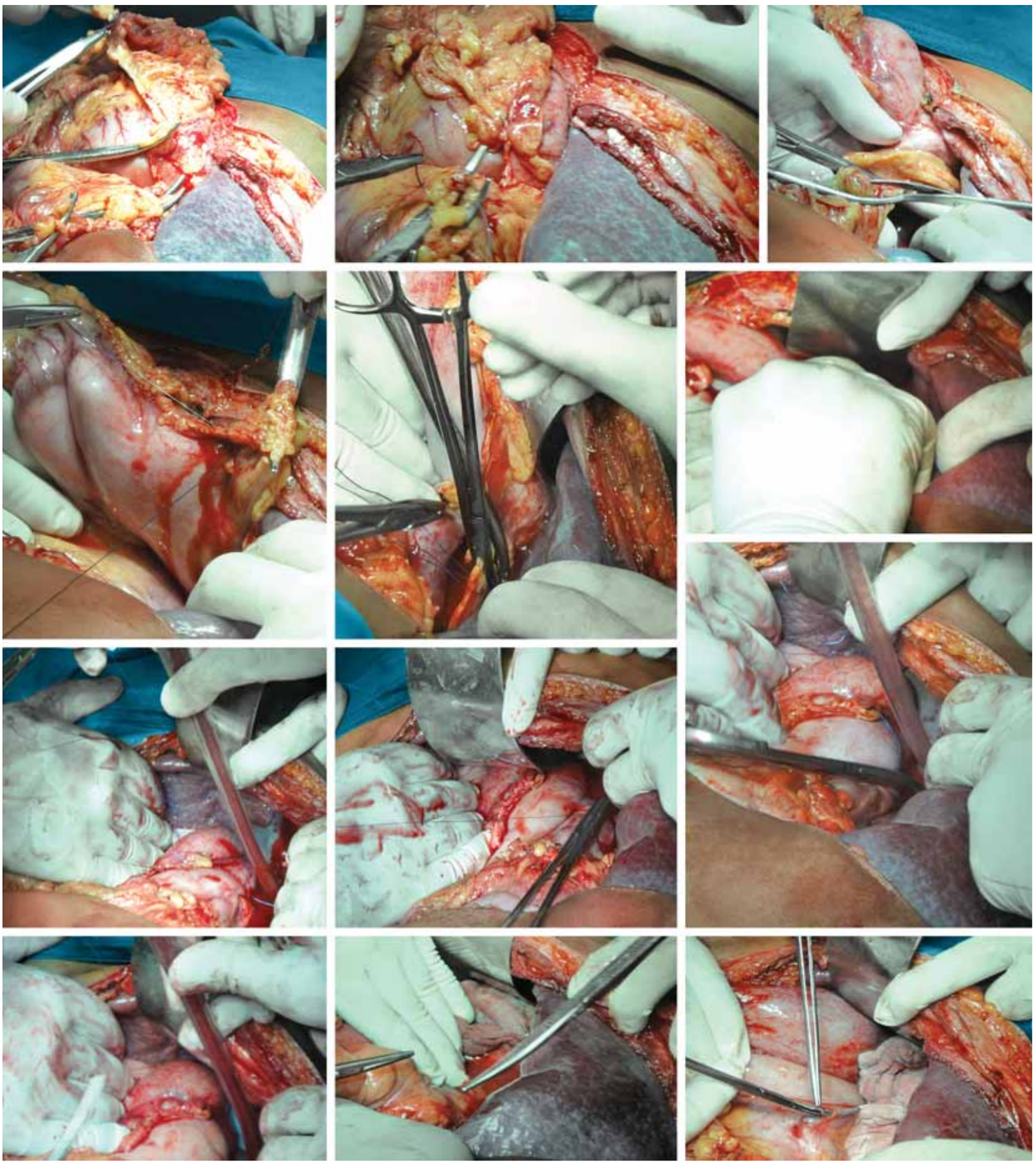
Splenic organ injury scale (1994)	
Grade I	Non-expanding subcapsular haematoma < 10% surface area. Non-bleeding capsular laceration with < 1 cm depth
Grade II	Non-expanding subcapsular haematoma, 10-50% surface area. Non-expanding intraparenchymal haematoma < 5 cm in diameter Laceration—capsular tear 1-3 cm in depth, which does not involve trabecular vessel
Grade III	Expanding subcapsular or > 50% surface area or ruptured bleeding subcapsular haematoma/intraparenchymal haematoma. Intraparenchymal haematoma > 5 cm or parenchymal laceration > 3 cm depth involving trabecular vessels
Grade IV	Laceration involving segmental or hilar vessels with > 25% devascularisation
Grade V	Shattered or avulsed spleen; hilar devascularsation with entire spleen devascularisation

Non-operative Management

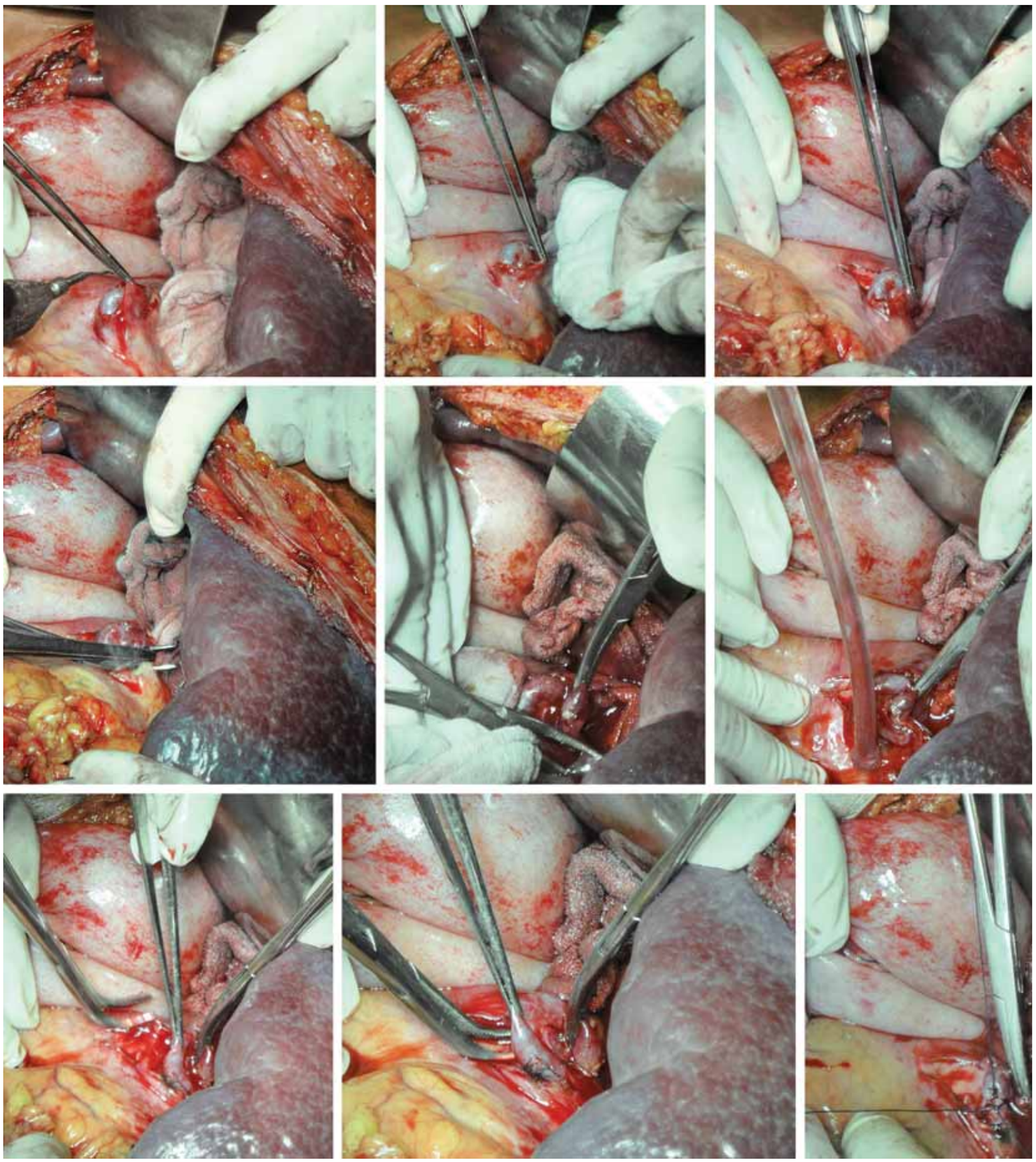
Splenic trauma can be managed in majority of patients (65%) by non-operative management by observation, haemodynamic monitoring, output chart and abdominal girth measurement. Initial CT scan is a must to assess the grading of injury. Daily ultrasound monitoring and haematocrit are also important. Absolute bed rest for initial 7-10 days is needed until clot gets localised and organised. Antibiotics, blood and plasma transfusions and fluid management are needed. If any time the surgeon feels that non-operative management is not suitable, then one should go ahead for surgical intervention.



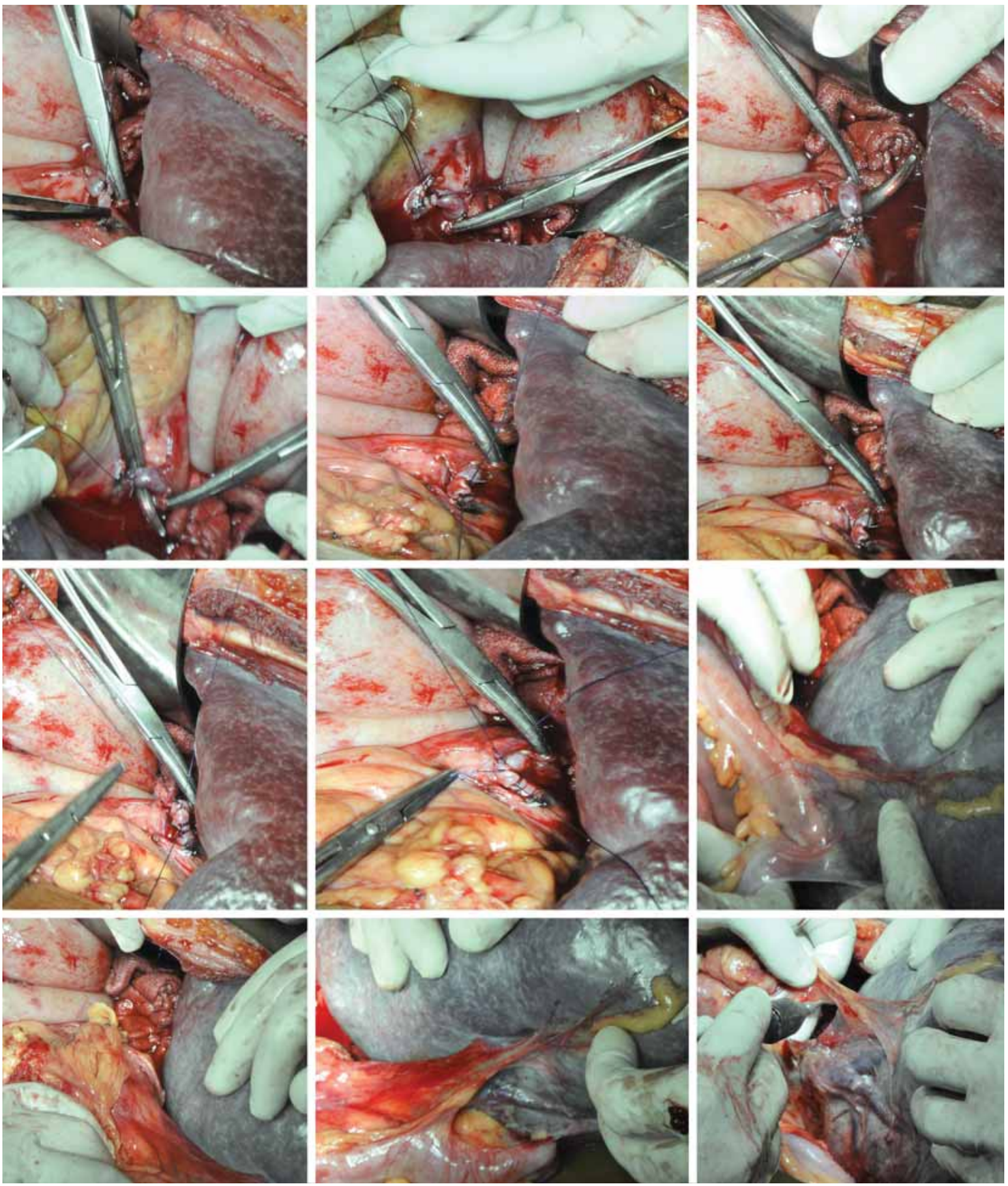
Figs 23-82(1)



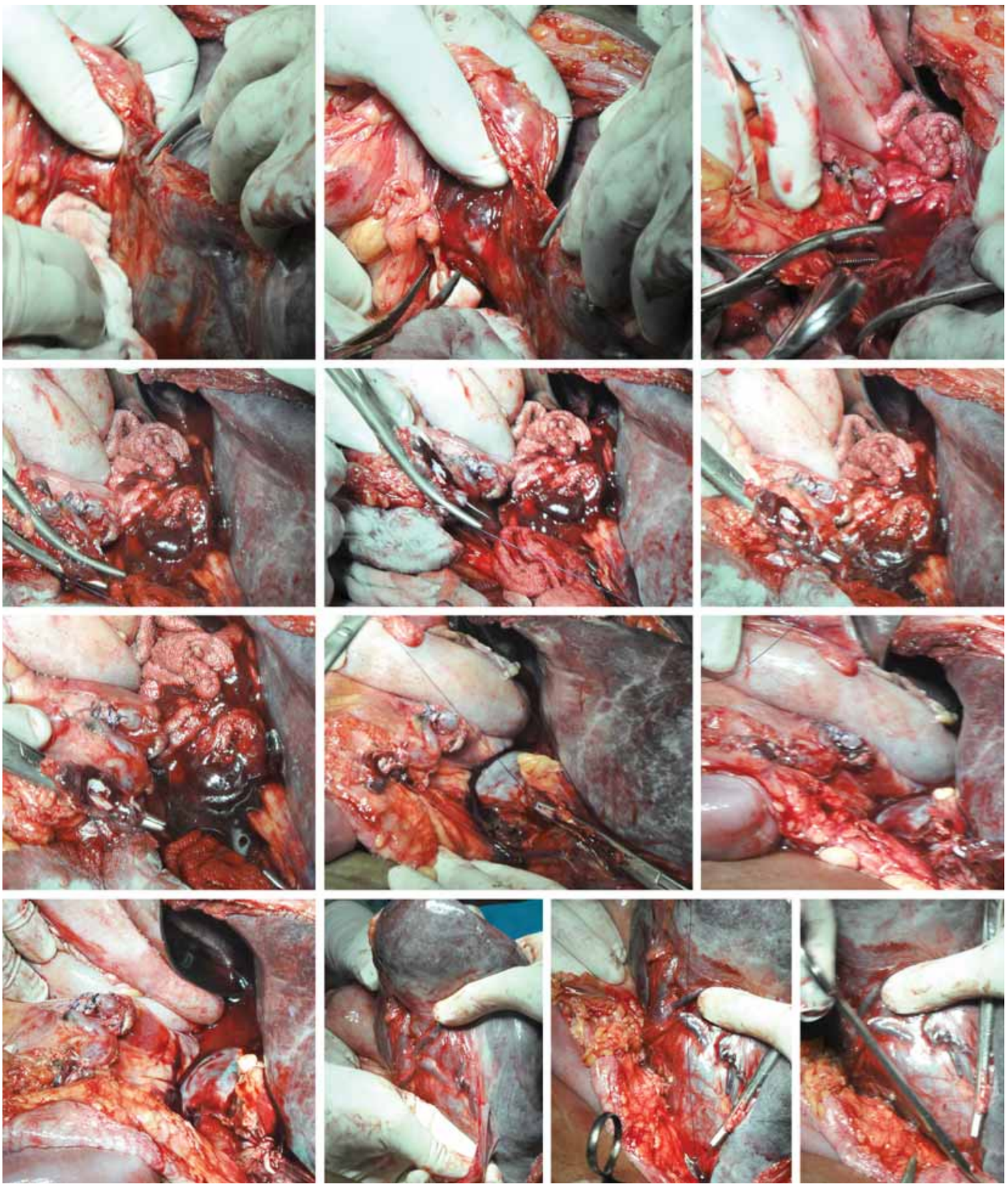
Figs 23-82(2)



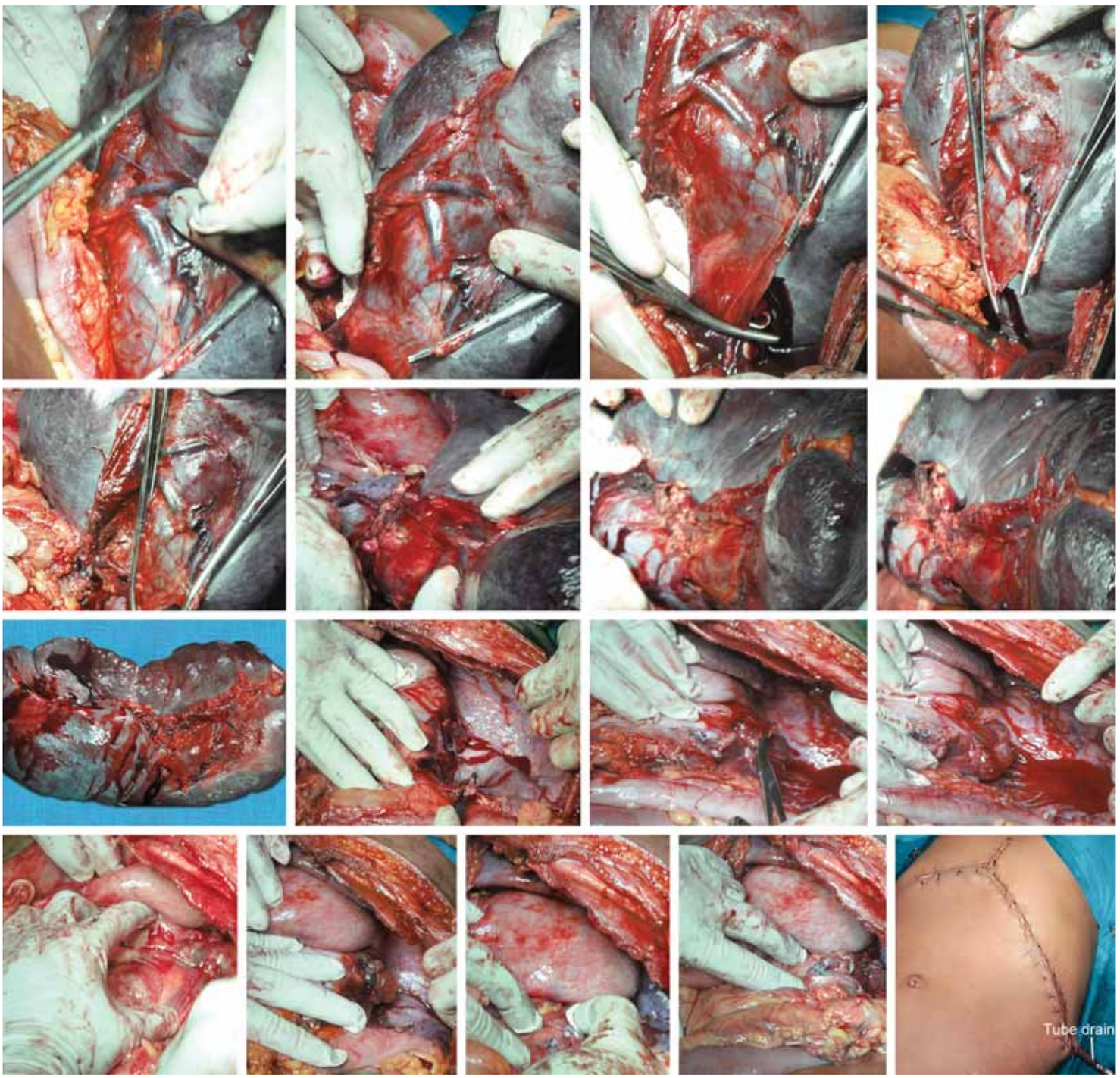
Figs 23-82(3)



Figs 23-82(4)



Figs 23-82(5)



Figs 23-82(6)

Figs 23-82(1 to 6): Splenectomy in a massive spleen—subcostal incision extending towards right.

Splenic trauma may be avulsion of the capsule, superficial tears, partial transverse tears, complete transverse tears, longitudinal tears, stellate tears, subcapsular haematoma and hilar injuries.

Note:

- If patient shows features of haemodynamic instability—blood pressure below 90 mm Hg, pulse rate above 120/minute, if patient does not show any positive response after 2 litres of crystalloid solution infusion, then non-operative management should be abandoned.
- Non-operative approach prevents possibility of OPSI, thrombocytosis causing possible DVT
- 80% of children (due to more elastin in spleen and complete coverage with ribs in childhood) and 50% of adult with splenic injury are treated with nonoperative method.
- Failure rate in nonoperative management up to grade II is 15-20% which is gradually reducing to 5% in many centres. It is more in patients with age more than 55 years.
- Delayed splenic rupture and formation of splenic pseudoaneurysm are problems in non-operative approach.
- Normal activity of the patient can be resumed only after 3 weeks following non-operative treatment in grade I and II injuries; after 8 weeks in grade III or beyond usually with a confirmation by CT scan.

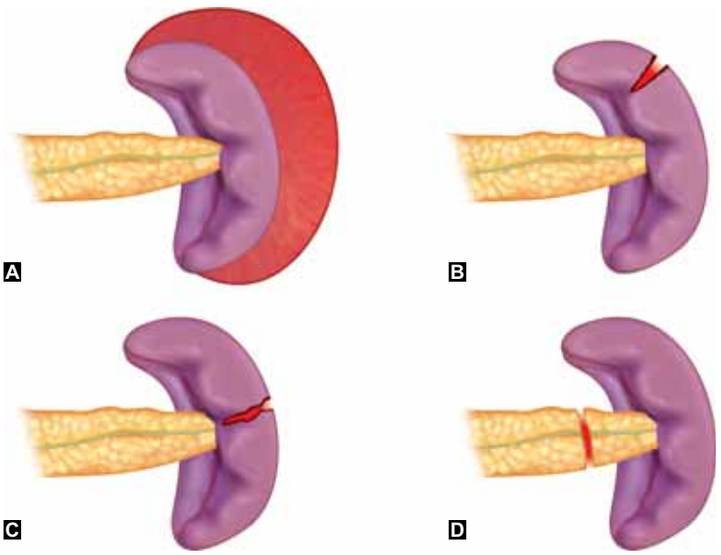


Fig. 23-83: Types of splenic injury: (A) Subcapsular hematoma; (B) Incised wound; (C) Lacerated wound; and (D) Hilar injury.

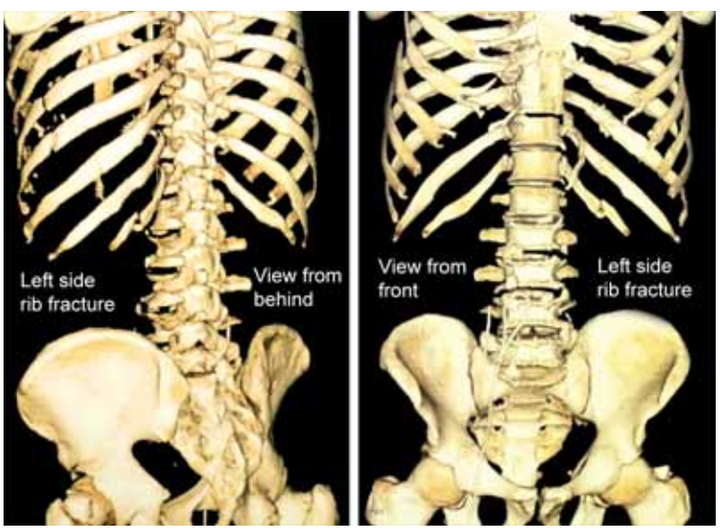


Fig. 23-84: Reconstructed CT image of left lower rib fracture. It is often associated with splenic injury and left lung and diaphragmatic injuries.

Surgical Intervention

Splenectomy

Type of intervention needed is decided based on CT finding as well as on table operative findings. If there are extensive lacerations, large progressive splenic laceration with haematoma or perisplenic haematoma extending on both poles of the spleen, then splenectomy may be the only option. Splenectomy for trauma is done through posterior approach for quick reach and control. An occlusion clamp or vascular clamp is placed across the pedicle close to the tail of the pancreas initially by placing index finger underneath the pancreas. Lacerated spleen is held medially and towards right **(Fig. 23-92)**.

Splenophrenic, splenocolic and phrenocolic ligaments are divided to reach the splenic hilum along the lienorenal ligament. Splenic artery is identified, dissected and ligated doubly using silk. Splenic vein will b e at lower part of the spleen is also ligated and divided. Rest of the attachments are also better ligated and divided. If surgeon is holding

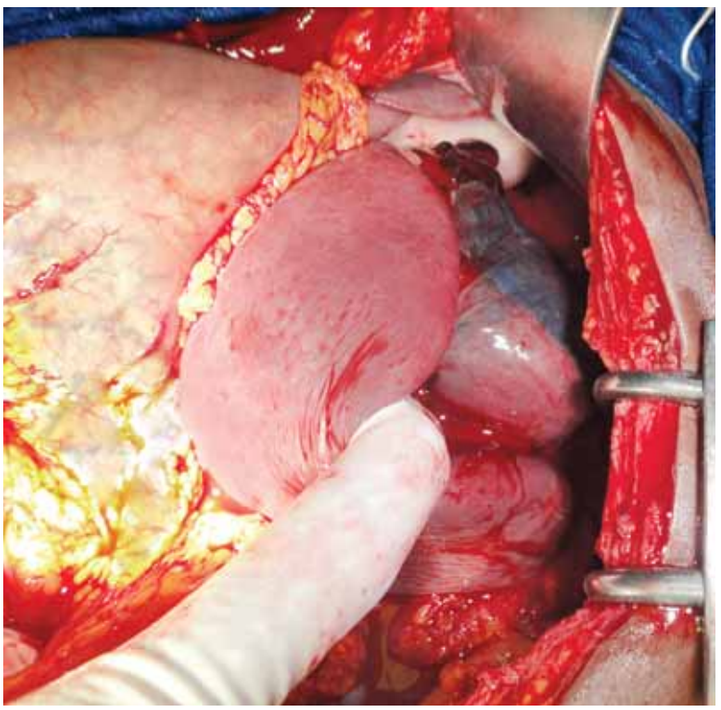


Fig. 23-85: Splenic subcapsular haematoma.

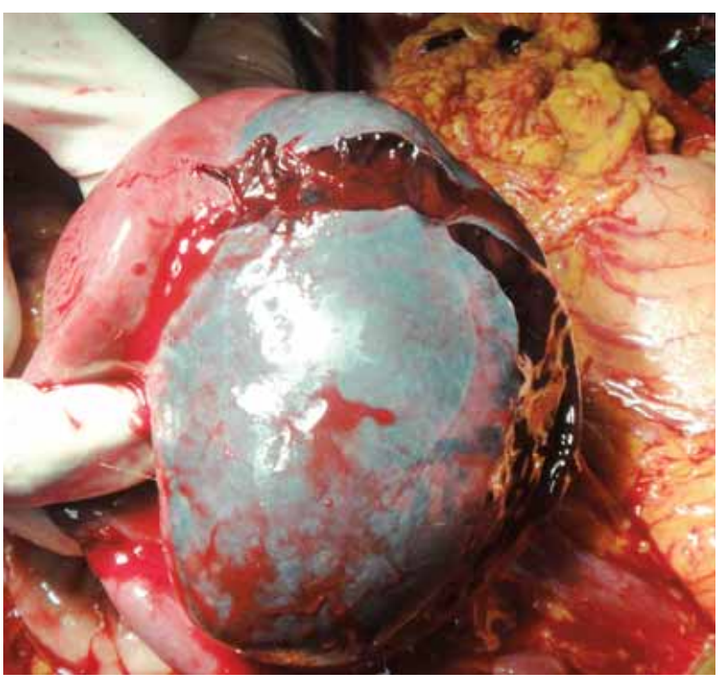


Fig. 23-86: Deep transverse splenic lacerations.

the spleen, then through right-angled Mixter instrument, dissection is done to pass ligatures and assistant will tie the knots; otherwise assistant should hold the spleen gently but firmly towards right and surgeon himself can place the ligatures. Spleen is removed. Rest of the abdomen is observed for additional injuries like that of diaphragm, liver, kidney, colon, small bowel and pancreas. Blood transfusion is done as commonly it is indicated. If there are no bowel and liver injuries, then autotransfusion of collected blood of haemoperitoneum can be done in theatre after proper filtering.

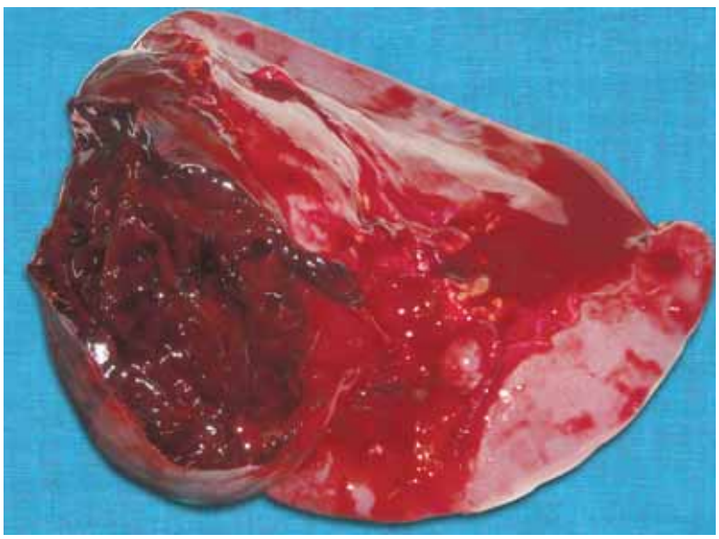


Fig. 23-87: Large splenic haematoma—splenectomy was done.

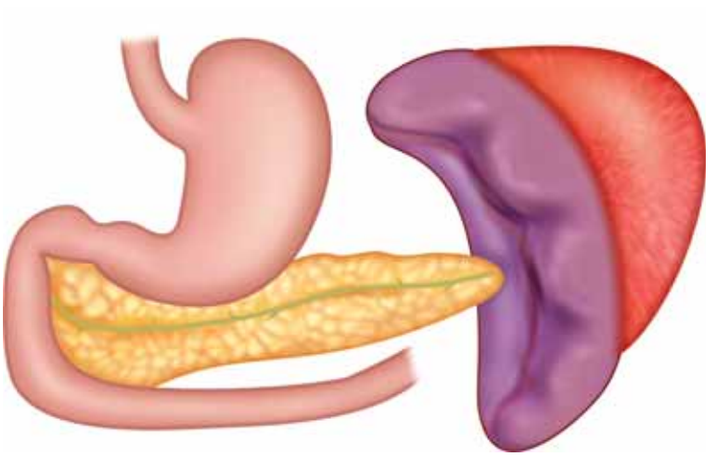


Fig. 23-90: Subcapsular haematoma. It can rupture late and can cause shock in the hospital or after discharge. Straining may precipitate rupture of the haematoma. Haematoma resolution should be confirmed by imaging prior to when the patient starts heavy straining works.

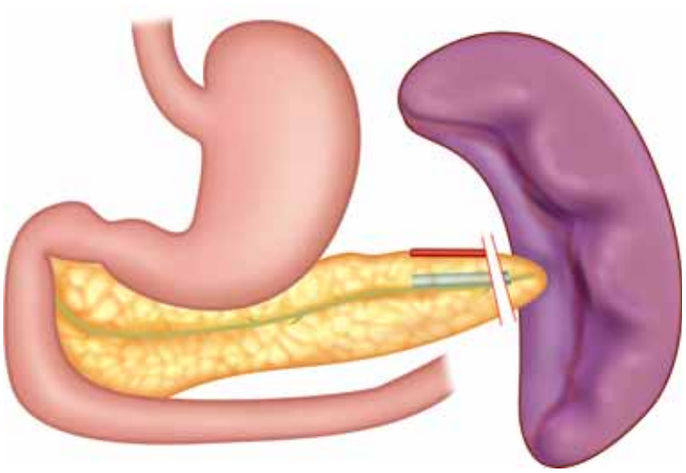


Fig. 23-88: Hilar injury—needs splenectomy.

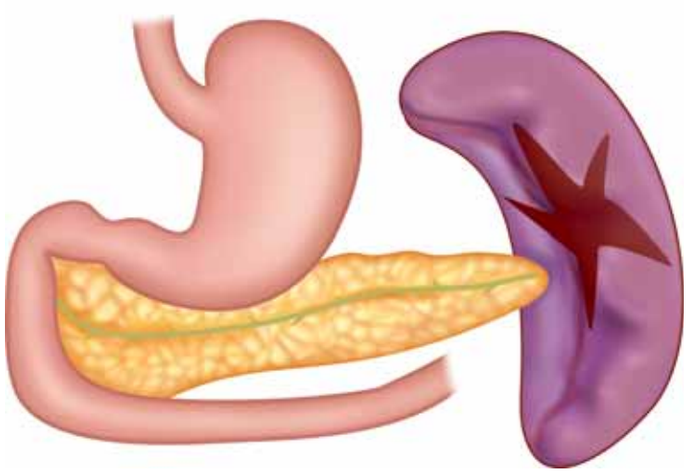


Fig. 23-91: Stellate tear in the spleen.

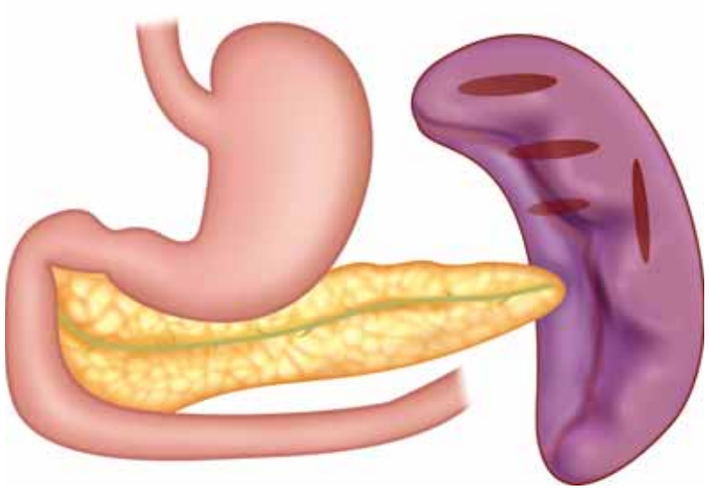


Fig. 23-89: Multiple tears often need splenectomy. If it is on to one segment, then partial splenectomy can be tried.

Splenic Preservation Surgeries

Small injuries like superficial lacerations which are often observed as iatrogenic injury during gastrectomy, pancreatic surgeries can be controlled by pressure, packing, haemostatic agents, surgical, haemoclips, omental pedicle patch, suturing, etc. Argon beam laser is useful for surface oozing. These are superficial avulsions of capsule of the spleen. *Surgicel* is oxidized cellulose. Initially a gauze is placed gently but continuous firm pressure is applied for 10 minutes. Then gauze is removed; two layers of surgicel are applied again and another gauze over it; pressure is applied for 10 minutes. Gently apply pressure and outer gauze is removed to retain the surgicel at place. Avitene is another alternative to control the capillary ooze. Using forceps avitene is applied on the raw area for about 4 mm thickness; gentle pressure is applied using dry gauze for 5 minutes. Gauze is removed.

Transverse tears: Partial transverse tears can be sutured using 2-zero vicryl interrupted sutures. Initially haemostasis is required. Complete transverse tear needs partial splenectomy. Segment which is blue and

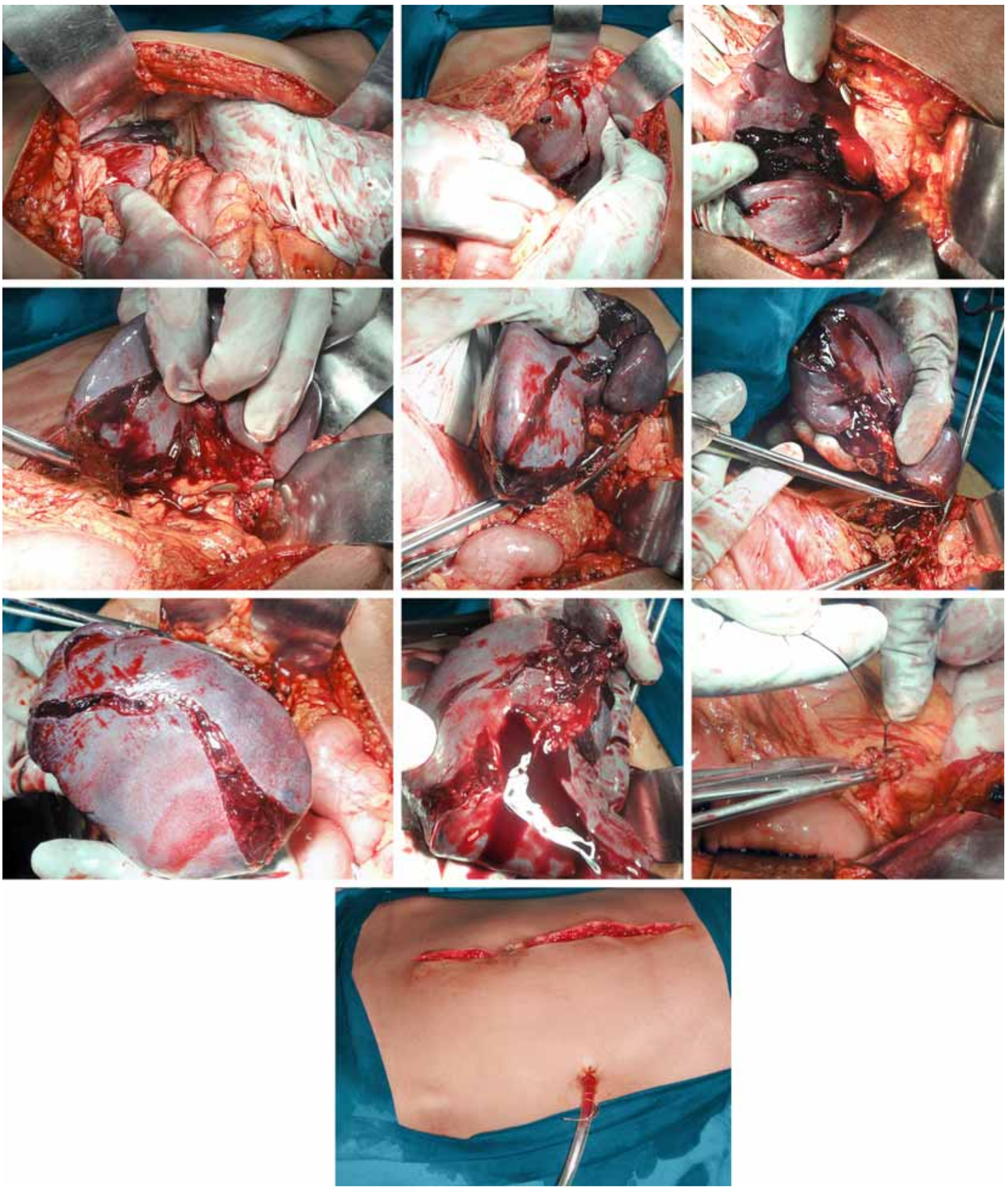


Fig. 23-92: Splenectomy in a trauma patient; lengthy midline incision is used; posterior approach is better. Soft vascular or occlusion clamp can be applied to begin with on the pedicle near the tail of the pancreas to control bleeding.

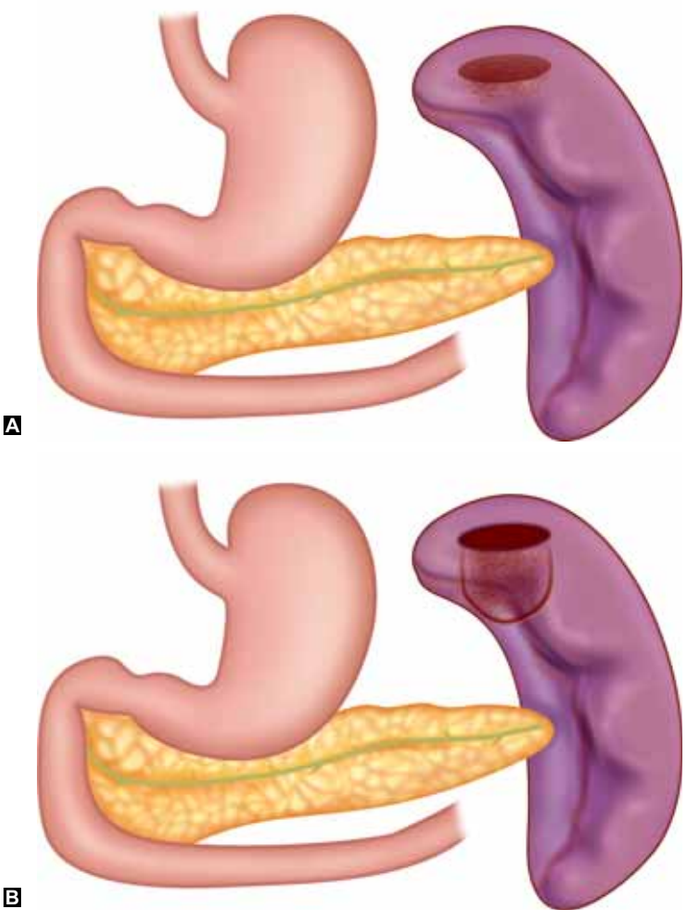
dusky is removed retaining opposite one, either superior or inferior, depending on the involvement **(Figs 23-93 and 23-94)**.

Longitudinal tears: As they cross across the segments, it is often difficult to manage and conserve. However, conservation is possible if one could be able to achieve proper haemostasis. Once it is so, omental pedicle is wrapped on the lacerated defect of the spleen and sutured over it. Further bleeding warrants splenectomy **(Fig. 23-95)**.

Splenorrhaphy

Splenorrhaphy is one of the methods of splenic conservation practised. Here spleen should be carefully mobilized from the lateral aspect of the spleen and omentum. Posterior part of the spleen is packed with a mop. Assistant can gently place the thumb on the splenic artery to control bleeding. Clot on the left subphrenic area and on the lacerated wound is gently removed; care should be taken not to extend the laceration during this step. Small bleeders inside the wound are ligated using 4-zero vicryl. Wound is sutured with mattress sutures using 2-zero vicryl by taking bites from the capsule. Surgicel and Teflon pledgets can be used during capsular suturing. Just simple sutures will not hold the wound **(Fig. 23-96)**.

Splenorrhaphy by suturing is usually done for a transverse tear, usually single or often two. Longitudinal tear is difficult to appose by suturing. Multiple tears are difficult to manage. In such a situation, absorbable mesh is placed around the spleen by completely wrapping



Figs 23-93A and B: Transverse tear may be superficial or deep. Superficial tear is sutured—mattress interrupted one. Deep tear needs omental buttress or mesh wrapping; observation and repeat imaging are essential. If general condition deteriorates, partial or complete splenectomy should be done.

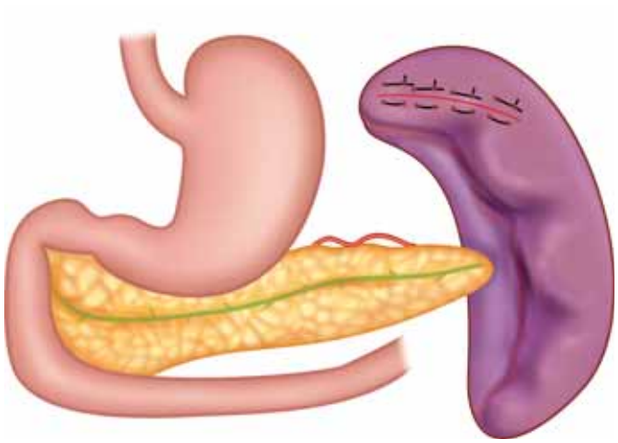


Fig. 23-94: Superficial avulsion or simple tear can be sutured by interrupted mattress vicryl 2-0 sutures.

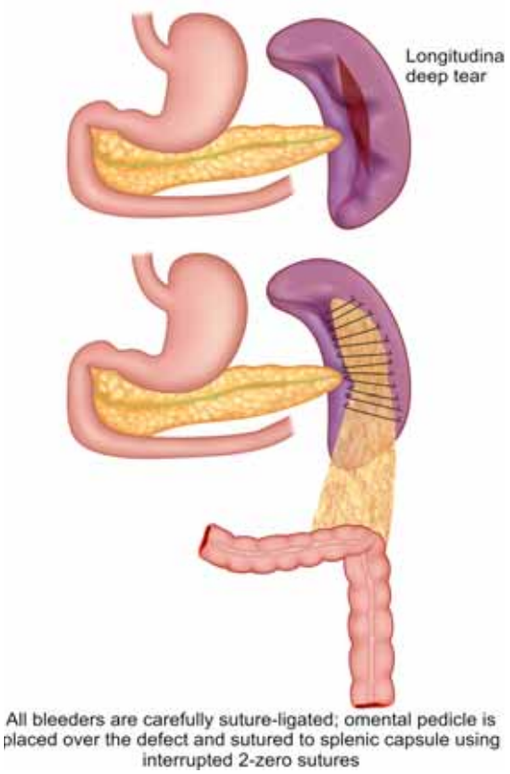

Longitudina
deep tear
All bleeders are carefully suture-ligated; omental pedicle is placed over the defect and sutured to splenic capsule using interrupted 2-zero sutures

Fig. 23-95: Longitudinal tear needs omental buttressing on the wound.

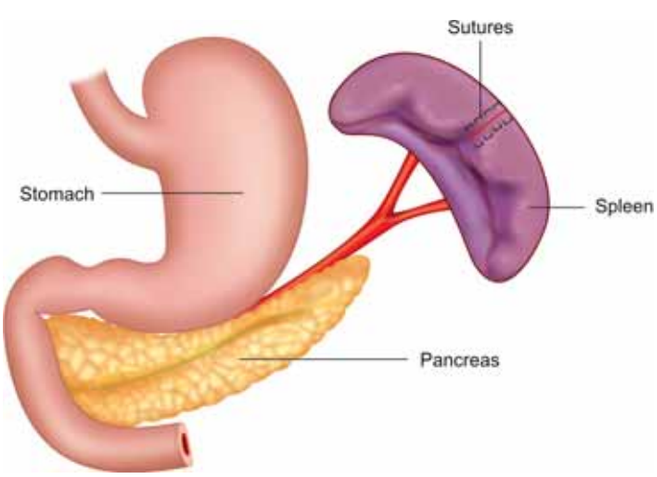


Fig. 23-96: Splenorrhaphy—diagrammatic look.

it around; a loose purse string is placed on the mesh on the inner aspect round the hilum. 2-3 plication sutures are placed on the outer surface to fix it (*mesh wrapping*).

In especially clean incised wound, spleen can be salvaged by suturing the wound carefully with placement of gel foam, topical thrombin, absorbable mesh wrap over the wound. Suture repair, oxidised cellulose and debridement of lacerated spleen—are other methods used. Temporary occlusion of splenic artery is often needed during splenorrhaphy. 10% of splenic injuries undergo splenorrhaphy. Its application is getting reduced due to non-operative approach in such patients. But in class IV or V injuries, splenorrhaphy is not possible.

Advantages of Splenorrhaphy: It avoids OPSI; avoids dead space and so prevents potential space for subphrenic abscess; cellular components of blood are better maintained.

Partial Splenectomy (Hemi)

If deep injury to one of the segments of the spleen has occurred and if it is not possible to suture it by Splenorrhaphy, then partial splenectomy can be tried. Splenic artery is isolated proximally after initial lateral mobilisation of the spleen gently. Its branches—superior polar and inferior polar vessels are identified. Artery of the injured segment is dissected and ligated very close to the spleen in the hilum. On the other hand, without dividing the polar artery at the hilum, partial splenectomy can also be done; here splenic artery is isolated and silastic tape is placed around to control the bleeding; all bleeders on the hilum towards injured side are ligated and divided; injured spleen part is divided. Small bleeders are ligated on the surface with 4-zero vicryl. Sling on the splenic artery is released; surface is observed for any bleeding if it is so controlled with sutures. Cut edge of the partial splenectomy is sutured with mattress sutures with or without Teflon pledgets on both sides **(Figs 23-97 and 23-98)**.

Suction tube drain is placed; wound is closed in layers. Even though the patient is undergoing conservative surgery, vaccine should be given; children should receive penicillin prophylaxis.

LAPAROSCOPIC SPLENECTOMY

First laparoscopic splenectomy was done in 1991 by Delaitre et al. He also started hanging spleen approach in 1995. Richardson adapted leaning spleen approach later.

Indications

Haematological diseases like ITP, Felty's syndrome, thrombotic thrombocytopenic purpura, Thalassaemia and pancytopenia. ITP is the commonest indication.

Hypersplenism, mobile spleen causing recurrent torsion, splenic cysts.

Splenic artery aneurysm.

Benign tumours of the spleen.

Staging in Hodgkin's lymphoma.

Contraindications

Massively enlarged spleen, splenic injury, splenectomy in portal hypertension, splenic vein thrombosis, pregnancy, previous upper abdominal surgery and splenic abscess are contraindications. However, these indications may be relative. In certain situations, laparoscopic splenectomy can be tried if experts are doing it. Obesity, spleen more than 30 cm and approximately of 3 kg weight is contraindicated.

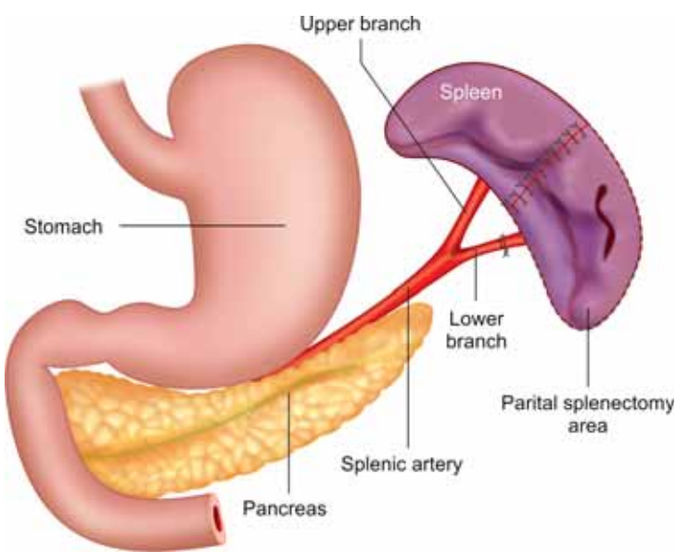


Fig. 23-97: Partial splenectomy.

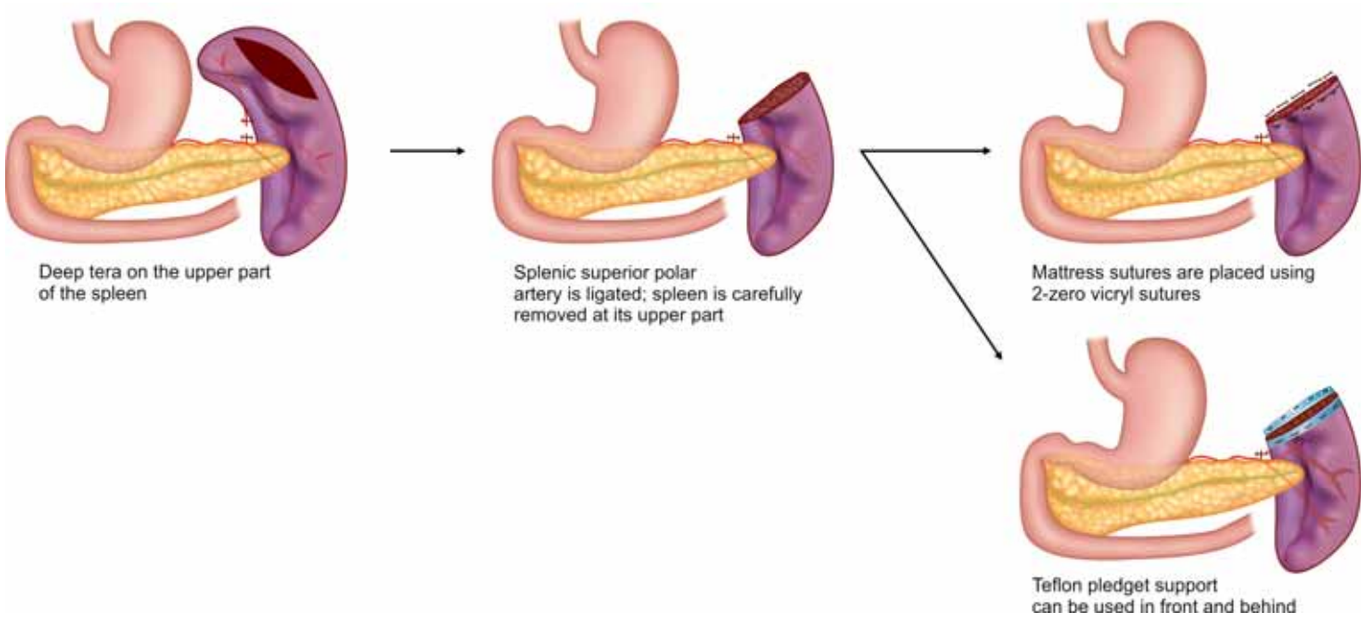

Deep tera on the upper part of the spleen
Splenic superior polar artery is ligated; spleen is carefully removed at its upper part
Mattress sutures are placed using 2-zero vicryl sutures
Teflon pledget support can be used in front and behind

Fig. 23-98: Partial splenectomy—technique.

Preoperative Preparation

Evaluation is same as for open method. 2 weeks prior to the surgery immunisation against pneumococcal, meningococcal and haemophillus bacteria should be given.

Approaches

Anterior approach shows easier exploration for accessory spleen, splenic artery, easier rapid conversion into open midline incision, when need arises **(Fig. 23-99)**.

Fig. 23-99: Port positions and patient position for laparoscopic splenectomy.

Lateral approach allows easier retraction of stomach and colon; easier dissection of tail of pancreas and lower pole; splenic pedicle can be assessed and addressed easily; trocar positions are easier; operative ergonomics are better; easier control of short gastric vessels and minimum manipulation of the spleen which prevent splenic trauma and spillage.

Rotating operative table is ideal for this procedure. Right up position with surgeon standing on the right side; cameraman on the left of the surgeon on the right side of the patient. 30-degree telescope and harmonic scalpel are better and ideal.

10 mm port is umbilical for camera; 5 mm left hand working port is between epigastrium and camera; 10 mm right hand working port is at left midclavicuar line, if endovascular stapler is being used this port should be 12 mm; 5 mm epigastric port for retraction of the stomach; left anterior axillary line 5 mm port when needed to retract spleen.

Technique—Spleen is retracted using an instrument through the anterior axillary line port; stomach is retracted through the epigastrium port.

Dissection starts with identifying the splenic artery. Two-hand technique, traction and counter-traction are needed for easy dissection. After dividing gastrosplenic ligament by dividing the short gastric vessels using harmonic scalpel or clips or bipolar cautery, stomach is mobilised and retracted medially and in front.

Peritoneum on the splenic artery adjacent to the upper border of the pancreas is incised to identify it. Splenic artery is gently dissected circumferentially to place a silk ligature. Ligature is tied but artery is not divided now; artery is divided only at a later period (ligation in continuity).

Splenic flexure of the colon is mobilised by dividing splenocolic, phrenocolic and other attachments; inferior pole of the spleen and lower part of the splenic hilum are visualised. Splenophrenic ligament is divided using harmonic scalpel to expose the splenorenal and retrosplenic ligaments. These ligaments are also divided to expose the hilar contents/vessels properly. Now spleen is hanging by its diaphragmatic attachment above. Splenic vein is seen in the lower part of the opened splenorenal ligament; often its wide tributaries also may be present. Ideal way to tackle these vein/veins is to pass a ligature around it using silk. Bipolar, harmonic clipping may not be adequate for this. Endostapler also sometimes may not hold. Splenic artery is doubly ligated again and divided. Splenic artery can be divided using harmonic scalpel as already once it is ligated proximally.

Once hilar vessels are divided, remaining parts of the attachment are released using harmonic scalpel. Separate upper pole vessel may be present which needs ligation, if harmonic scalpel is used.

Spleen is placed into a plastic impermeable retrieval bag; bag opening is brought through the left 10 mm port but may require lengthening of the port incision to retrieve the bag. Otherwise through bag opening, morcellator is passed to crush the spleen and retrieve the bag with specimen.

Laparoscopic splenectomy is also a good alternative in many splenectomies when splenomegaly is not massive. It is not useful in massive spleens and trauma.

Problems in laparoscopic splenectomy

Large spleen finds it difficult to manipulate and visualise; splenic artery can be approached through the lesser sac like often which is done in open method after opening the lesser omentum.

Adhesions between spleen and diaphragm often may be vascular and difficult to release through laparoscopy.

Venous tear and bleeding is often difficult to control; such bleeding needs real pressure and packing and that is difficult to achieve.

Spillage during dissection and retrieval of specimen may be hazardous in conditions like ITP; splenunculi might get missed, leading into failure in outcome.

Pre-operative splenic artery embolisation in a large/massive spleen, splenic artery aneurysm, portal hypertension reduces the size of the spleen which makes dissection and surgery much easier; but it is not done always. But it may induce severe perisplenitis creating troublesome dissection itself.

Capsular disruption during manipulation should be avoided to prevent splenosis from developing.

COMPLICATIONS OF SPLENECTOMY

Complications

1. Haemorrhage and shock
2. Haematemesis
3. Pancreatitis
4. Pancreatic fistula
5. Gastric dilatation
6. Left-sided pleural effusion
7. Left-sided colonic injury
8. Severe sepsis
9. Changes in cellular component of blood
10. DIC

Haemorrhage—mainly from short gastric vessels. Re-exploration and control of bleeding are needed.

Acute gastric dilatation—needs nasogastric tube aspiration.

Haematemesis due to mucosal congestion following ligation of short gastric vessels.

*Left-sided pleural eff*usion and left basal atelectasis (left lobe atelectasis is the commonest complication) (30%).

Left subphrenic abscess.

Pancreatitis following damage to tail of the pancreas and pancreatic fistula (3%).

Haematologic changes: Rise in WBC and platelet count, rise in abnormal RBCs and RBC bodies.

Gastric fistulas—it is better to invaginate the greater curvature using seromuscular silk or vicryl interrupted sutures.

Left-sided colonic injury.

Infection—Post-splenectomy septicaemia, OPSI—most dangerous.

Portal vein thrombosis can occur.

DVT as late sequelae after splenectomy is often dangerous. Risk is 4 times more than non-splenectomised people and also pulmonary embolism. It is better to put them on long-term small dose of *aspirin* to reduce the incidence of thromboembolism.

Overwhelming Post-splenectomy Infection (OPSI)

As there is reduced IgM, tuftin, properdin and other antibodies, phagocytosis of encapsulated bacteria is defective. So, the post-splenectomised patient is more prone for *Pneumococcal septicaemia* (commonest), *N. meningitides, H. influenzae and Babesia microti* infections. Risk is more in patients on chemotherapy, radiotherapy and haemolytic diseases. Incidence is 4% or less. It is common in first two years after splenectomy. But it can occur any time. Risk persists for lifetime. Features—Prodromal phase—fever, chills, sore throat; hypotension, shock; DIC; respiratory distress, coma, death. Mortality for fully developed OPSI—50-70%.

Prevention

Pneumococcal vaccine should be given to all splenectomised patients. Polyvalent pneumo-vac is given 2-3 weeks prior to surgery and soon after recovery from surgery and it is repeated once in 5 years (given to patients older than 2 years). Other vaccines advised are meningococcal vaccine (only to those who travel with high risk), *H. influenzae* 'B' vaccine (to all, whatever the age, once in 10 years). In malaria endemic areas, antimalarial prophylaxis is given for patients after splenectomy.

Treatment of OPSI—Antibiotics like Cefoperazone, Ceftazidime, Amikacin; Ventilatory support—ICU care; blood transfusion; immunoglobulin transfusion; nutrition (TPN) and maintaining of urine output.

Prevention of OPSI—Lifelong prophylaxis using benzathine penicillin 12-24 lakh units controversial in adults (mainly it is given to children; changing concepts say it is selective in adults); pneumococcal vaccine given 2-3 weeks prior to splenectomy—gives 70% protection. *H. influenzae* B-type vaccine and meningococcal vaccine are given only to high-risk groups, as its effects are for short-term. So, it is not routinely given.

Note: Protection by vaccine is not completely guaranteed **(Fig. 23-100)**.

Note:

- OPSI is more common when splenectomy is done for malignancy or haematological diseases or done in young individuals.
- Usage of prophylactic penicillin (benzathine) is controversial in adults even though it is beneficial in children up to 16 years.
- OPSI can occur at any time after splenectomy. Drugs like erythromycin, amoxicillin are also used as prophylactic agents.
- Mortality in fully developed OPSI (hypotension, DIC, MODS) is 60%—very high.
- Patients who survived after OPSI with therapy may develop residual problems like—gangrene of limbs, deafness, meningitis, mastoid osteomyelitis, heart valve destruction.
- 7% of OPSI cases have S pneumonia sepsis. Others are – N meningitidis, H influenzae, Capnocytophaga canimorus after dog bite.
- PPV 23 is the commonest vaccine used. Revaccination is done once in 5 years; decline in pneumococcal antibody level may be the criteria for revaccination.
- Preservation of 25% of spleen is sufficient to protect against pneumococcal infection. So, partial splenectomy is definitely helpful.
- Splenic autotransplantation into the omental pouch is under trial at present to reduce chances of OPSI.

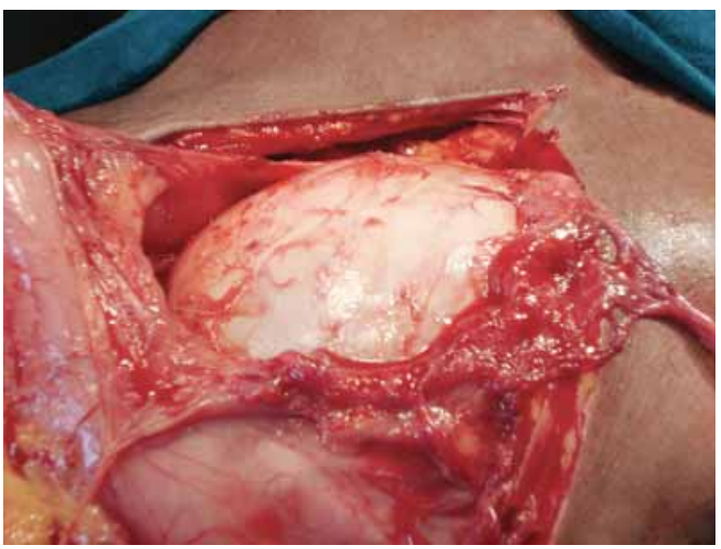


Fig. 23-100: Splenic aneurysm. It is the commonest site of aneurysm in the abdomen after aorta. Most common in women, due to atherosclerosis. Congenital splenic artery aneurysm can occur. Splenic artery pseudoaneurysm (10%) can occur after an attack of acute pancreatitis which may cause life-threatening rupture.

MESH SPLENOPEXY

It is also known as splenic mesh wrap. It is done for trauma. Electively it is often used in wandering/mobile spleen (*Splenoptosis)*.

In open method in trauma, absorbable mesh is wrapped around completely. It is partly haemostatic and creates tamponade also.

Different methods are there to place the mesh as a wrap. Mesh may be wrapped around completely and at the hilar level it is bunched loosely using purse string suture. As per another method, a large absorbable mesh is taken. At its centre, a circular gap is made through which poles of the spleen are slid and mesh is wrapped from hilum outwards; mesh margins are sutured on the parietal surface of the spleen.

In wandering spleen, spleen is rotated to correct the torsion; after mobilisation, spleen is placed over one large mesh, which is fixed above and lateral to the lateral abdominal wall. Another similar mesh is placed on the front aspect of the spleen, which is also fixed to the lateral abdominal wall above and mesocolon below.

Procedure can be done in open or laparoscopic method also.

Chapter

24

Colonic Surgeries

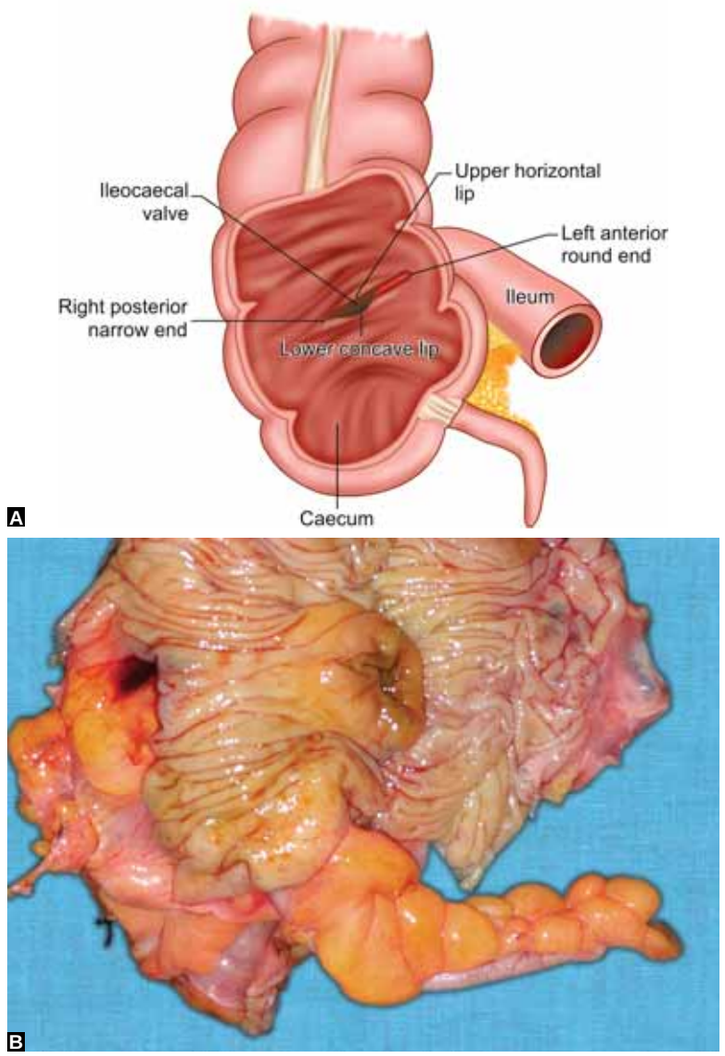
SURGICAL ANATOMY

Colon extends from ileocaecal valve to rectum. It is 135-150 cms in length. Right colon is caecum, ascending colon and hepatic flexure; left colon is sigmoid colon, descending colon and splenic flexure. Transverse colon which is freely mobile joining part of right and left surgical units.

Caecum is below the ileocaecal valve, usually of 6 cm long and 7.5 cm in width. It is situated in the lateral part of the right iliac fossa. Posteromedially there is appendix. Posteriorly caecum is related to right iliopsoas, genitofemoral, femoral and lateral cutaneous nerve of thigh, genital vessels and external iliac artery. Retrocaecal appendix will be behind it. Caecum may be of different types depending on its development (caecum develops from postarterial segment of the midgut loop as caecal bud). Usual *ampullary* type is 80% common where right caecal pouch is larger and appendix arises at its medial side. *Conical* type has appendix at its tip (12%); *intermediate* has right and left parts of the pouch of equal size with appendix coming out from its depression. Caecum gets its arterial supply from caecal branch of ileocolic artery; venous drainage into SMV. Its nerve supply is of midgut—T11; L1, parasympathetic is vagus. Ileocaecal valve opens on its posteromedial part of caecocolic junction. Ileocaecal valve has got two lips (upper lip is horizontal at ileocolic junction and lower lip is concave, is at ileocaecal junction) and two frenulae (anterior left is rounded; posterior right is narrow and pointed). When caecum distends valve closes preventing reflux of caecal contents **(Figs 24-1A and B)**.

Caecum is fixed to posterior abdominal wall. In 25% of individuals, caecum is mobile. Mobility may precipitate volvulus or intussusception. Ileocolic / superior ileocaecal fossa, which opens towards left, is formed by fold of the peritoneum formed by anterior caecal artery. It is related to ileum and its mesentery, ascending colon and ileocaecal vessels in front. Inferior ileocaecal fossa is formed by bloodless fold of Treves extending from the terminal ileum and caecum in appendicular mesentery. It is below the ileum and its mesentery, in front of the mesentery of the appendix. Retrocaecal fossa is located behind the caecum, left of the right paracolic gutter, right of the mesentery **(Fig. 24-2)**.

Ascending colon is usually *fixed posteriorly* but can be mobile with a mesentery in 11-35% of individuals. In such situation, caecum will also be mobile along with ascending colon; it may lead into caecal volvulus along with ascending colon. Often there will be an abnormal connective tissue band running across the ascending colon called as *Jackson's veil*; it may often be vascularised. From the right sided



Figs 24-1A and B: Anatomy of ileocaecal valve.

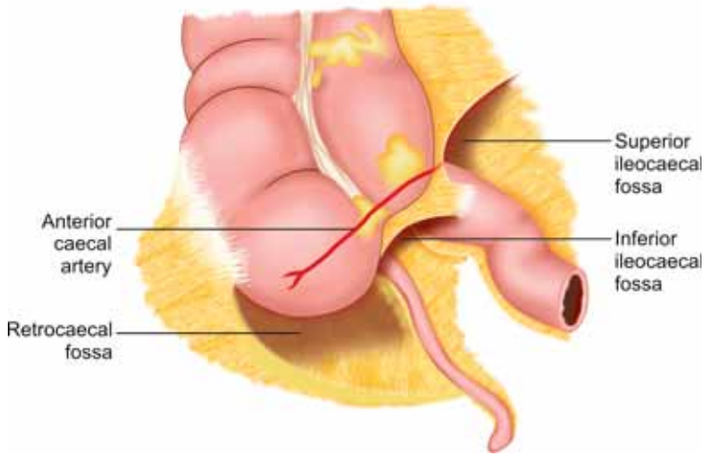


Fig. 24-2: Fossae in relation to caecum.

posterior abdominal wall it extends downwards and inwards getting attached to the anterior longitudinal ligament of ascending colon; often this veil may extend into caecum also. Ascending colon is 12 cm in length extending from caecum to hepatic flexure up to the inferior surface of the right lobe of liver. Behind it is related to iliacus, iliolumbar ligament, quadratus lumborum, transversus abdominis, lateral cutaneous, ilioinguinal and iliohypogastric nerves, iliolumbar vessels, 4th lumbar artery and right kidney **(Fig. 24-3)**.

Right colic (hepatic) flexure: Ascending colon forms right colic / hepatic flexure; hepatic flexure bends forwards, downwards and left to continue as transverse colon. Hepatic flexure is related to lower part of the right kidney and inferior surface of the right lobe of the liver.

Transverse colon is 50 cm in length extending from right flexure to left flexure. It hangs in the middle downwards like a suspension. It is suspended by transverse mesocolon, which is attached to anterior border of the pancreas and so creates wide range of mobility. In front it is related to greater omentum; behind it is related to 2nd part of the duodenum, head of the pancreas. Transverse mesocolon is double fold of peritoneum, which begins from the anterior border of the pancreas; middle colic artery runs in it. Middle colic artery may get damaged during gastrectomy due to adhereons during division of the greater omentum due to adhesions.

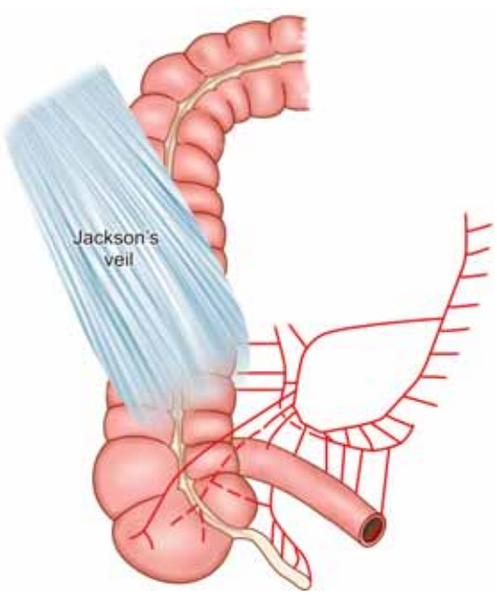
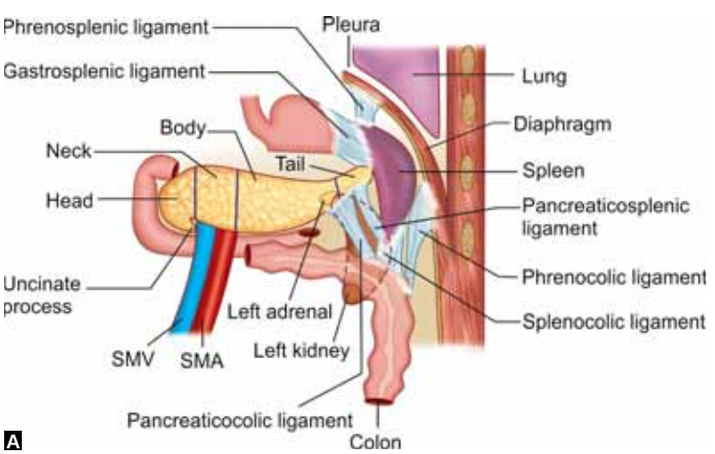


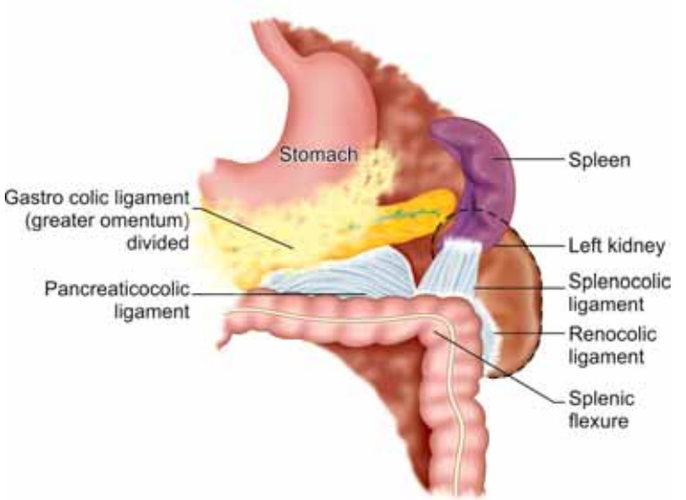
Fig. 24-3: Jackson veil/membrane extending from lateral abdominal wall on the anterior surface of the ascending colon.

Left colic (splenic) flexure: It extends from the junction of the transverse colon to descending colon; it bends backwards and downwards towards descending colon. It is related behind to left kidney and diaphragm below to anterior end of the spleen. *Phrenocolic ligament* extends as peritoneal fold from the splenic flexure to the 11th rib at midaxillary line; it also supports the spleen forming bed for it. It forms the upper limit of the left paracolic gutter. Splenocolic ligament is located between spleen and splenic flexure **(Figs 24-4A and B)**.

Descending colon is 25 cm long and extends from the left colic flexure to the sigmoid colon, vertically running up to iliac crest and medially on the iliopsoas muscle; in the pelvic brim it continues as sigmoid colon. Descending colon is retroperitoneal; it is rare to have a mesocolon. Behind it is related to transverse abdominis, quadratus lumborum, iliopsoas, iliohypogastric, ilioinguinal, lateral cutaneous, femoral and genitofemoral nerves, iliac branches of the iliolumbar vessels and testicular and external iliac vessels.

Sigmoid (pelvic) colon: It is about 35 cm in length extending from pelvic brim to 3rd piece of sacrum to continue as rectum. It is suspended with sigmoid mesocolon. Iliac part of the sigmoid is fixed one; pelvic part is mobile one with sigmoid mesentery. Left ureter passes





Figs 24-4A and B: Splenic ligaments and relations of the splenic flexure of the colon. These relations are important in left sided colectomy.

through the sigmoid colon through intersigmoid recess. Summit of the sigmoid is towards right iliac fossa. Pelvic mesocolon is inverted 'V' shaped; it has got two limbs—left limb is attached to brim of the left side pelvis; right limb is attached from apex to 3rd piece of the sacrum. Pelvic mesocolon carries superior rectal vessels; its apex is related to left ureter **(Figs 24-5A to C)**.

Rectosigmoid junction is actually not a precise point as it is variable; it is marked by a distinct flexure. If the lesion is below the promontory it is called as rectal; rectosigmoid is 15 cm above the anal verge on sigmoidoscopy.

Colon does not have mucosal villi; its longitudinal muscularis externa has three discrete bands (taeniae). Appendices epiploicae are fat appendages attached to the surface of the colon; it is the site of infarction, torsion and site for diverticulae formation. While removing these appendages they should not be pulled out to avoid injury to the vessel underneath.

Blood Supply

Arterial Supply

Ileocolic, right colic, and middle colic arteries which are branches of superior mesenteric artery supply the colon from caecum to splenic flexure. Left colic, sigmoid, superior rectal arteries which are branches of inferior mesenteric artery supply the descending and sigmoid colon. The anastomotic arcade formed between the branches of superior and inferior mesenteric arteries is called '*arc of Riolan.*'

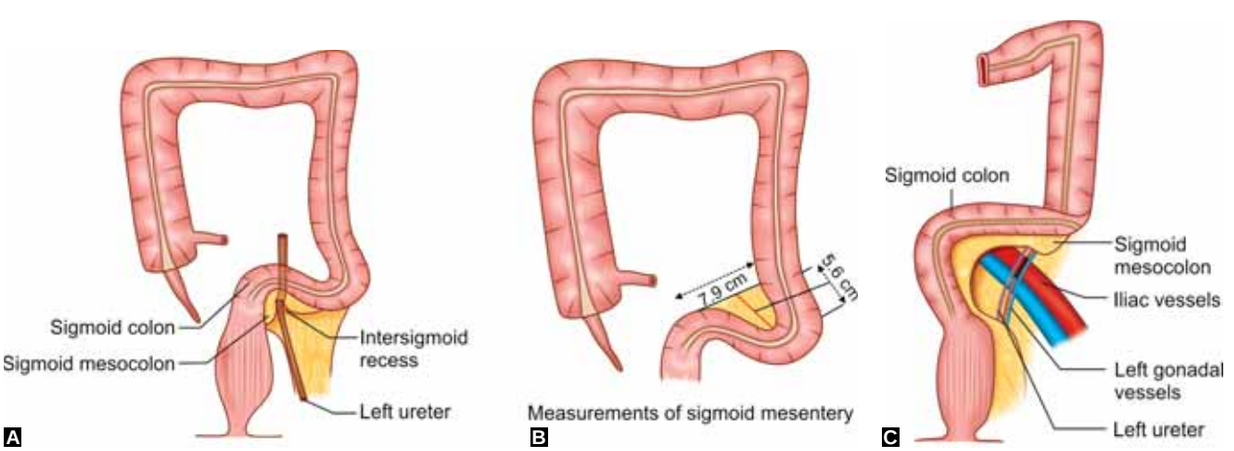
Ileocolic, right colic, middle colic (branches of superior mesenteric artery) and left colic artery and sigmoid branches supply the colon. Marginal artery connects branches of superior mesenteric and inferior mesenteric arteries. Marginal artery may be absent in 2% of individuals. Right colic artery may be absent in 12%; middle colic in 4% cases. Right (8%) and middle colic arteries (6%) or both (0.5%) may be often multiple. Atherosclerosis of the inferior mesenteric artery makes marginal artery poorer and unsuitable for colonic conduit. There is no marginal vein on the right side colon and it is said that anastomotic leak in 25% of right sided colonic conduit substitute is due to venous congestion rather than arterial.

Superior mesenteric artery (SMA) (artery of midgut) arises from the front of the abdominal aorta behind the body of pancreas at L1 vertebral level 1 cm below the coeliac trunk; it runs in front of the uncinate process crossing the 3rd part of the duodenum entering the mesentery to run in between its two layers. It ends at right iliac fossa by anastomosing with branch of ileocolic artery. Posteriorly above the root of the mesentery it is related to aorta, left renal vein, uncinate process and 3rd part of the duodenum; in the root of the mesentery it crosses the IVC, right ureter, right psoas muscle. SMV is at its right side; it is surrounded by superior mesenteric plexus of nerves. *Towards right side* it gives inferior pancreaticoduodenal, middle colic, right colic and ileocolic arterial branches. Middle colic artery arises just below the pancreas running downwards and forwards in the transverse mesocolon; its right branch communicates with right colic artery and its left branch with left colic artery. Right colic artery arises from SMA or as a common trunk with either middle colic or ileocolic arteries. It runs towards the upper part of the ascending colon; its descending branch anastomose with ileocolic artery and its ascending branch with middle colic artery. Ileocolic artery arises from SMA running downwards and towards right dividing into superior branch which anastomose with right colic artery and inferior branch which anastomose with terminal branch of the SMA. Inferior branch gives ascending colic branch, anterior and posterior coecal branches, appendicular artery and an ileal branch (terminal part of the ileum). Jejunal and ileal branches of SMA arise from its left side (fifteen in number) runs between two layers of the mesentery supplying the jejunum and ileum except terminal part of the ileum which is supplied by the ileal branch of the ileocolic artery. Jejunal vasa recta are longer and less numerous; ileal vasa recta are shorter and more in number.

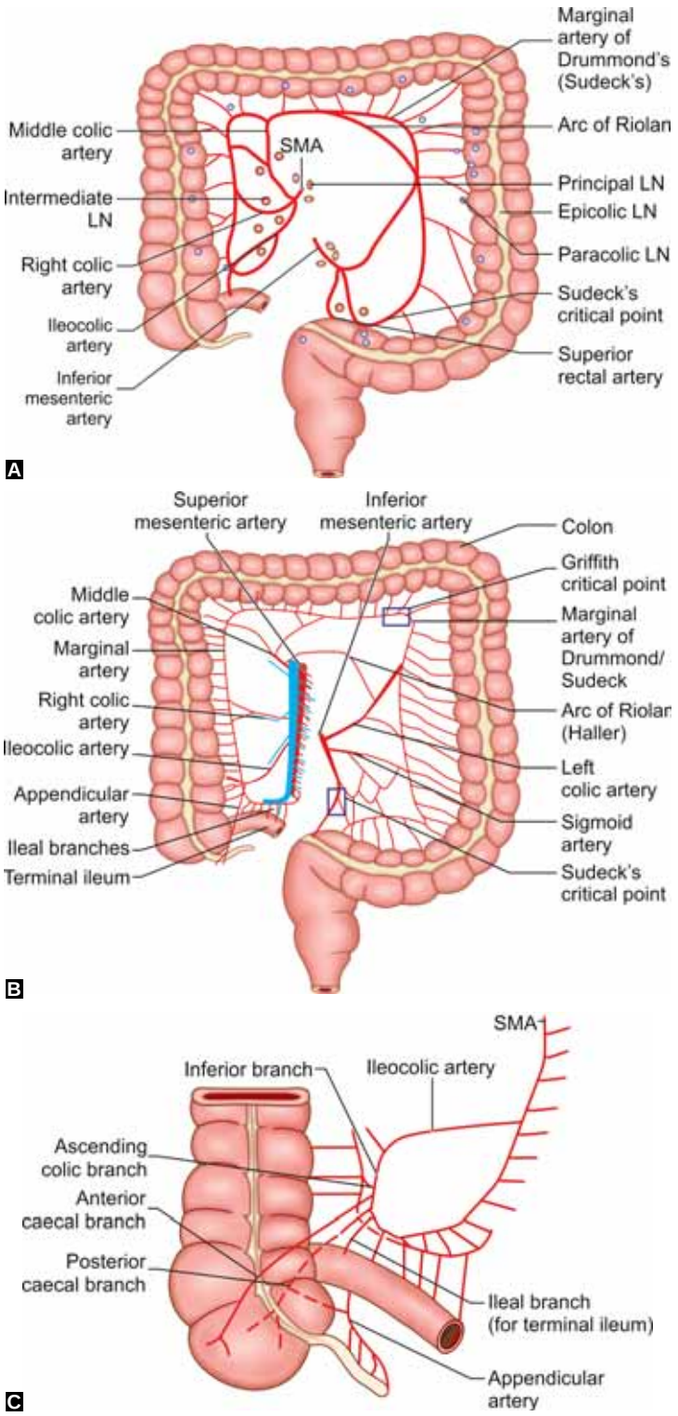
The marginal artery of the colon, also known as the *marginal artery of Drummond* (Sir David Drummond (1852-1932) an English physician), is an anastomotic branch connects the IMA and SMA. It is sometimes absent as an anatomical variant. The Marginal Artery of Drummond runs in the mesentery close to the bowel as part of the vascular arcade that connects the SMA and IMA. This artery is almost always present and its absence should be considered a variant.

The Arc of Riolan (Riolan's arcade, Haller's anastomosis, 1803), also known as the 'meandering mesenteric artery' or central anastomotic mesenteric artery, is another inconstant vascular arcade present in the colonic mesentery that connects the proximal middle colic artery with a branch of the left colic artery. This artery is found low in the mesentery, near the root. Rarely, it can arise from SMA **(Figs 24-6A to C)**.

Inferior mesenteric artery (artery of hindgut) (IMA) supplies colorectoanal region from left 1/3rd of the transverse colon to anal canal above the dentate line. IMA arises from front of the aorta 4 cm above the bifurcation of the aorta behind the 3rd part of the duodenum at L3



Figs 24-5A to C: Relations and features of the sigmoid colon.



Figs 24-6A to C: Blood supply and lymphatics of the colon.

vertebral level. It descends downwards and left crossing the common iliac artery medial to the left ureter; in the sigmoid mesocolon it continues as superior rectal artery. *Left colic artery* is the 1st branch of IMA, runs upwards and left ends by dividing into ascending and descending branch. The ascending branch enters the transverse mesocolon and anastomoses with branch of middle colic artery. Descending branch anastomoses with 1st sigmoid artery. Left colic artery may be absent in 6% of cases. Sigmoid branches are 2-4 in number forms lowermost part of the marginal artery. Lowermost branch anastomose with superior rectal artery. *Sudeck's critical point* at the rectosigmoid junction is described as the point of origin of the last sigmoid arterial branch, originating from the inferior mesenteric artery (IMA). The Sudeck's critical point refers to a specific location in the arterial supply of the rectosigmoid junction, namely the origin of the last sigmoid arterial branch from the IMA. This arterial branch usually forms an anastomosis with a branch of the superior rectal artery. The anastomosis is small and often only singular. Sudeck's point has particular relevance in colorectal surgery and also forms a site of watershed susceptible to ischaemia. Superior rectal artery is the continuation of the IMA beyond the root of the sigmoid mesocolon. Opposite 3rd sacral vertebra it divides into right and left branches; each pierces the muscular coat of the rectum to supply rectum and anal canal communicating with middle and inferior rectal arteries. Right branch divides into anterior and posterior branches. Often a branch from proximal part of the left colic artery joins a branch from proximal middle colic artery to form arc of Riolan. IMA can be ligated and blood supply can be maintained through marginal artery (via SMA and through branches from internal iliac arteries). Marginal artery is weaker and less consistent in the splenic flexure and often absent in splenic flexure level and this point in splenic flexure is called as *Griffith critical point*.

Venous Drainage

Venous drainage occurs into superior mesenteric vein (which joins the splenic vein to form the portal vein) and inferior mesenteric vein (drains into the splenic vein). Venous drainage is similar to arterial supply. Marginal vein is often absent on the right side; but on left side marginal vein will be always present. So venous congestion can occur in right sided colon after surgery which may lead into venous infarction.

LYMPHATIC DRAINAGE

Mucosa contains no lymph channels, so mucosal cancers rarely metastasize. Nodes are *epicolic* (located in the colonic wall), *paracolic* (located along the inner margin), *intermediate* (located near the mesenteric vessels), *and principal* (located near main mesenteric vessels). Nodes situated along the main blood vessels like SMA, middle colic, right colic, ileocolic, IMA, left colic, sigmoid, superior rectal are called as proximal nodes; nodes along the next level branches are called as intermediate nodes, nodes in the colonic wall and its inner margin are called as distal nodes.

NERVE SUPPLY

Colonic motility is under control of autonomic nervous system; parasympathetic via vagi and pelvic nerves, sympathetic via superior and inferior mesenteric ganglia. The effect of meal on colonic activity is termed as *gastrocolic reflex*.

PRINCIPLES IN COLONIC SURGERY

Colonoscopy is essential in all colonic diseases prior to surgical intervention unless it is a surgical emergency. Proper preoperative staging using CT scan of abdomen and chest, endosonography is needed for staging. Carcinoembryonic antigen (CEA) is of no use for diagnosis; however, it is done to get a base line level so as to be utilised during follow up for comparison.

Preoperative preparation (of the bowel)—Principle behind bowel preparation—Colon contains large amount of bacteria up to 10^9/mL of faeces. Commonest anaerobe is bacteroides; commonest aerobe is *E Coli*; *Pseudomonas*, *Enterococcus*, *Proteus*, *Klebsiella*, *Streptococcus* are other organisms. Bowel preparation is done to clear this bacterial load to reduce postoperative complications. ***Methods used are***—*Mechanical bowel preparation* using PEG or sodium phosphate**.** *Polyethylene glycol (PEG)* is a non-absorbed sodium sulphate solution, 2-3 litres of which is asked to drink by the patient along with plenty of additional fluids orally. It cleans the bowel by passing loose stool for 10-15 times in 12 hours. It acts by its hygroscopic action. *Side effects* are—nausea, vomiting, and abdominal cramps. Antiemetics are often needed. It is ideal in renal failure, ascites, cirrhosis, CCF. *Sodium phosphate* is an alternative to PEG as smaller volume is sufficient to take. But it causes electrolyte imbalance. Its efficacy is similar to PEG. But patient compliance and cost is better acceptable. It can cause hyponatraemia, hypokalaemia, hypocalcaemia and hypophosphataemia in case of renal dysfunction. In such patients, it is contraindicated. *Other methods*—(A) *Total gut irrigation* daily using 200 mL of *oral mannitol* or through nasogastric tube for 3 days prior to surgery; (B) *Bowel wash* daily for 3 days prior to surgery using 2 litres of normal saline (not water as it will cause water intoxication); it cleans entire large bowel; (C) Senna, castor oil, bisacodyl; (D) Repeated enemas. *PEG or sodium phosphate has taken over all this methods*. *Contraindications* for mechanical bowel preparation: Complete bowel obstruction and perforation. *Antibiotics parenteral and as bowel antiseptics, oral neomycin* (gentamycin, streptomycins were used in olden days) 1 gram, *erythromycin* 1 gram, is used 3 days prior to surgery. Alternatively *ciprofloxacin and metronidazole* are used. IV fluids should be given in addition to these patients to maintain hydration adequately. *IV antibiotics* given *4 hours before* making incision, reduces the incidence of sepsis (no clear evidence). Usually cephalosporins are given. ***Controversies—***There is doubt about the advantages of preoperative mechanical bowel preparation even though it practiced universally. Oral antibiotics used to reduce the bacterial load in the colon are also controversial. However, preoperative single dose parenteral antibiotic improves the result and reduces the sepsis.

Turnball no touch technique with ligation of pedicle at its origin prior to mobilising the colon and tumour reduces the chances of tumour spread. Avoiding breaching the colonic wall, negative proximal, distal and radial margins are absolute need. Intraoperative frozen section biopsy of resected margin should be taken. Lymphovascular clearance is a must in colectomies for carcinomas.

Controversies still exist about the duration of nasogastric tube and beginning of oral feeding. Proponents of late oral feeding after 7 days believe that colonic stomal tensile strength and ability to withstand disruptive force takes 7 days and so oral feeding started after 7 days. Initially oral liquid then gradually solid food is started. Proponents of early feeding believe once bowel sounds is heard and patient has passed flatus without abdominal distension, feeding can be started; it is also believed that by them that gradual feeding from oral liquid to solid is not necessary.

In colectomy for benign diseases initially colon is mobilized by opening the peritoneum along the paracolic gutter, and then vessels are ligated close to the bowel wall at its inner margin. There is no need to ligate vessels at its origin and no need to do lymphovascular clearance.

In *colonic perforation*—resection, creation of proximal stoma, closure of distal colon or creation of mucus fistula is better. Diversion may be loop ileostomy if perforation is in the right colon or proximal (right sided) colostomy if perforation is in left colon.

In colonic obstruction as general condition of the patient will not be good it is better to do resection and diversion.

Intestinal decompression can be done by doing a colotomy at the proximal site. On table colonic lavage as antegrade irrigation cleans the colon mechanically facilitating the one stage resection and primary anastomosis without diversion.

Meticulous anastomotic technique is important to avoid anastomotic dehiscence. Pulsatile arterial blood flow at the cut edge of the mesentery adjacent to the cut edge of the bowel is the deciding factor along with the bleeding from bowel cut edge and pink, soft and pliable bowel. Haematoma in the bowel wall, haematoma in the mesentery may reduce the blood supply. Single layer interrupted sutures using 3-0 silk is adequate. At every 3-5 mm sutures should be placed. Posterior layer knots are kept inside; anterior layer knots are placed outside. Two layers can be done with inner full thickness continuous or interrupted 3-0 vicryl sutures; outer interrupted seromuscular silk sutures. *Submucosa is strongest* layer and so bites should be taken through it during seromuscular sutures.

Different methods of anastomosis are used. ***Open method*** is commonly advocated. It can be single layer interrupted anastomosis or two layered anastomosis. ***Single layer*** has the advantages as it is easier, it maintains blood supply at the cut edges and prevents necrosis of the cut edges. Single layer bites can be *simple seromucosal full thickness sutures* or *mattress full thickness seromucosal* or *simple serosubmucosal sutures (mucosal bite is not taken here)* depending on the surgeons convenience and need of the patient. Whenever ***two layer anastomosis*** is done, inner continuous or interrupted full thickness sutures with outer seromuscular interrupted silk sutures are used. Usually 3-0 suture material is sufficient. Cut ends should be made of equal size by Cheatle's cut; occlusion clamps should be in place; initially bites are taken from mesenteric corner, antimesenteric corner and later bites are taken on either side. All suture bites should be ideally taken first and knots are tied later. Knots are placed inside in posterior layer and outside in anterior layer **(Figs 24-7 to 24-9)**.

In closed method crushing clamps are placed on each side of the bowel; *serosubmucosal interrupted bites* are taken posteriorly; once all posterior bites are taken knots are tied outside. Then anterior serosubmucosal bites are taken and knots are tied outside. Once all knots are tied then only crushing clamps are released. With thumb and finger crushed inner parts of the cut ends of the bowel are separated properly (which are inside the lumen) and surgeon should confirm that lumen is made patent. Closed method prevents contamination; it is not commonly practiced. Still there are surgeons who advocate this method.

At least 1 cm of the bowel cuff is cleared of the fat, mesentery and epiploic appendices. Leak commonly occurs on the mesenteric side of the stoma. Mesenteric defect should be closed using interrupted or continuous sutures by absorbable (vicryl) or nonabsorbable (silk) sutures. Tension free anastomosis should be achieved. Flexures whenever needed should be adequately mobilised to achieve free mobility of the stoma. Contamination should be avoided by using occlusion clamps, irrigation, and decompression. Fluid collection like blood, serous fluid should be avoided. Possible distal obstruction should be identified. It should be corrected otherwise it will cause anastomotic dehiscence. Patient who had radiotherapy earlier or if patient who is on steroids for long time needs special attention as stomal dehiscence and leak is very common. Omental wrap may be used around the anastomotic stoma.

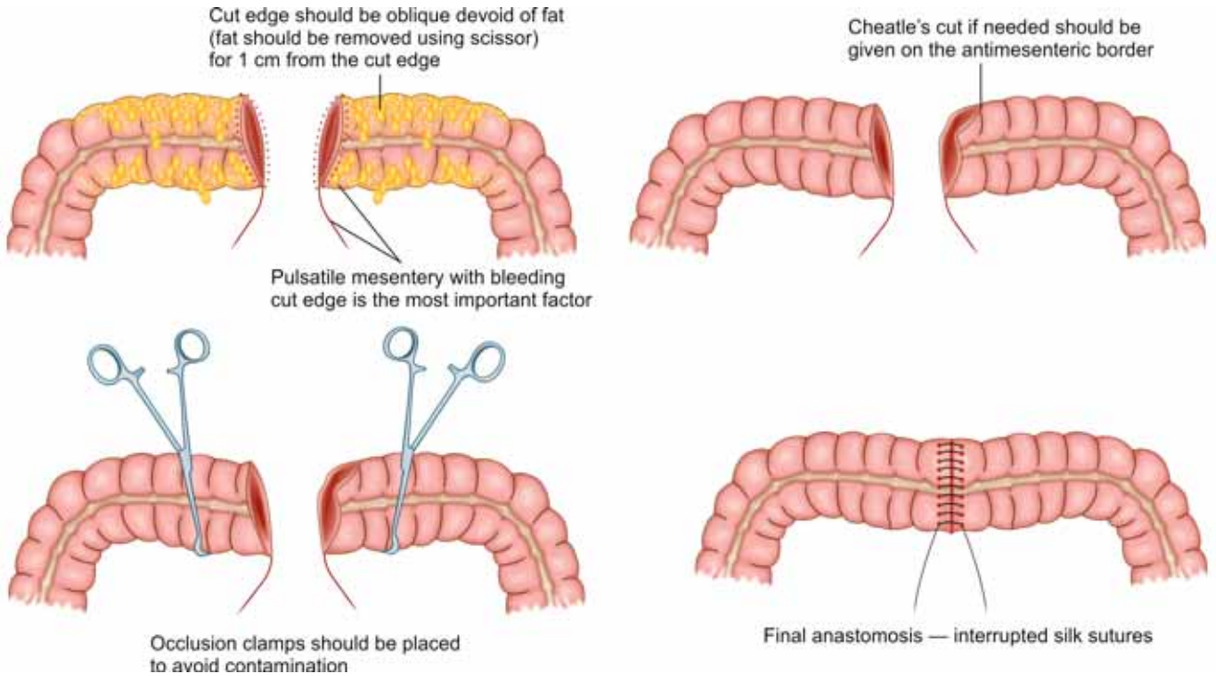
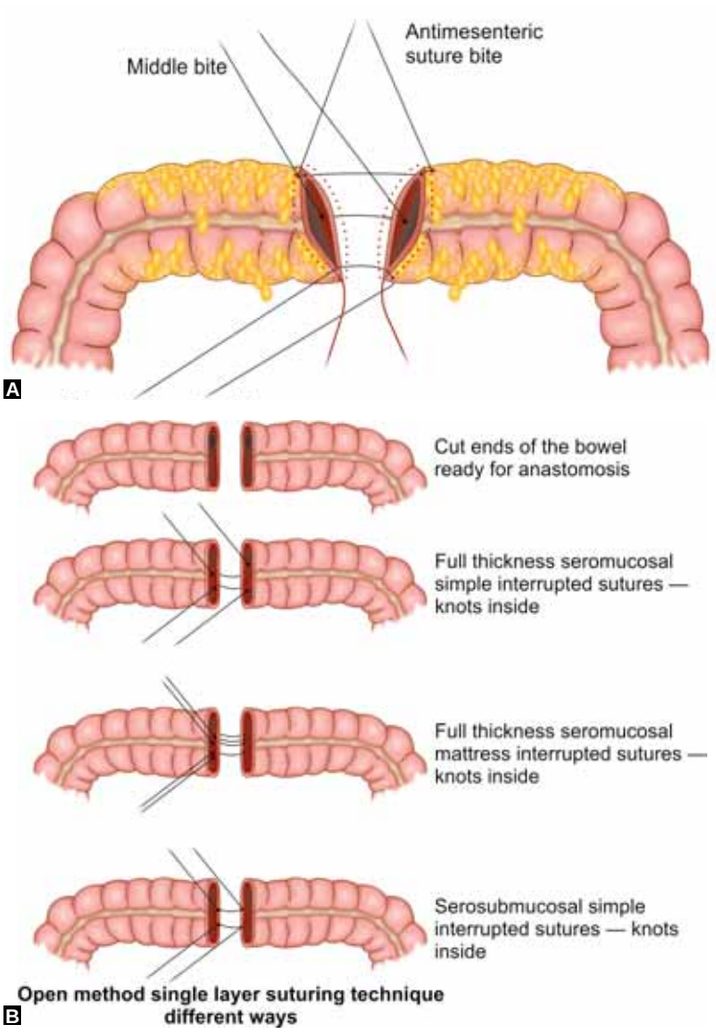

Cut edge should be oblique devoid of fat
(fat should be removed using scissor)
for 1 cm from the cut edge
Pulsatile mesentery with bleeding
cut edge is the most important factor
Occlusion clamps should be placed
to avoid contamination
Cheatle's cut if needed should be
given on the antimesenteric border
Final anastomosis — interrupted silk sutures

Fig. 24-7: Technique of colonic anastomosis.



Figs 24-8A and B: Suturing of the colon—different methods.

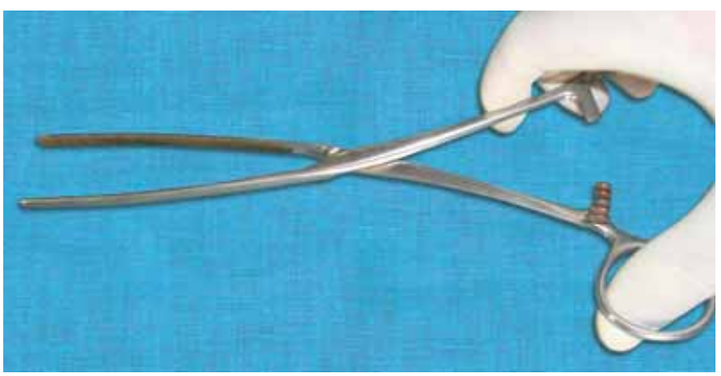


Fig. 24-9: Doyen's occlusion clamp is used during anastomosis as it is least traumatic.

Stapling is commonly used in colorectal surgery (Fig. 24-10)

Stoma (colostomy/enterostomy) when planned should be sited properly. End ileostomy should protrude 1.5 cm from the abdominal wall; end colostomy should protrude 1.0 cm from abdominal wall. Stoma care should be meticulously followed. Stoma closure in temporary stomas should be done only after 3 months not earlier; adequate time is needed to achieve stoma stability and develop proper nutritional and biochemical optimum in the body. In loop ileostomy, site should be 10 cm proximal to the ileocaecal valve so that closure will be easier later. Nowadays end ileostomy is also commonly used as temporary one as it is easier to construct and easier to close at a later period. In permanent ileostomy Kock's continent type is often done with a nipple valve which facilitates collection of ileal excretions. It needs a tube insertion into the continent pouch at regular intervals by patient himself to evacuate the content. Kock's continent avoids usage of the stoma appliances. But problem herein it needs re-surgery in up to 30% cases and complications are common. Permanent end ileostomy is needed in severe Crohn's disease where pouch is contraindicated or in ulcerative colitis wherein pouch has failed.

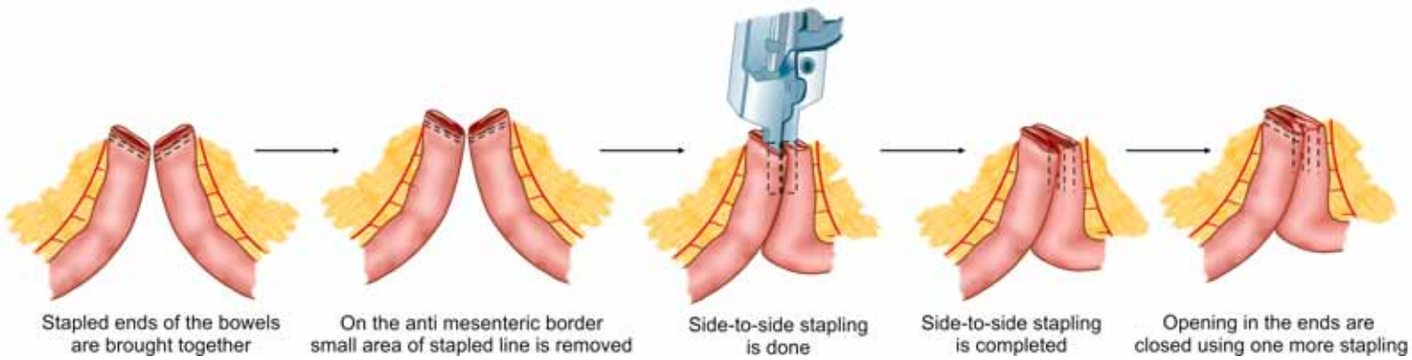

Stapled ends of the bowels are brought together
On the anti mesenteric border small area of stapled line is removed
Side-to-side stapling is done
Side-to-side stapling is completed
Opening in the ends are closed using one more stapling

Fig. 24-10: Stapling is also used for colonic anastomosis. For anterior resection circular stapler is used.

Ureter is very important structure which should be safeguarded on both sides. Stenting prior to surgery may be needed if obstruction is suspected or observed in imaging. On right side duodenum, SMV are also important.

Bowel wall oedema may trouble proper approximation. Interrupted sutures, stapler usage are helpful. Otherwise diversion should be done instead of forcing the sutures.

Laparoscopic colectomy has become popular and safer on both right and left. In left colectomy circular stapler makes anastomosis easier and precise.

CAECOPEXY

It is rarely done nowadays. It is used whenever caecum and ascending colon is mobile with higher chances of precipitating volvulus. It is done by fixing the caecum and ascending colon to the lateral abdominal wall. Bites should be taken from the taeniae of the caecum **(Fig. 24-11)**.

CAECOSTOMY

Caecostomy is often done in acute colonic conditions as diversion procedure after surgery distally like perforation closure and resection. It is useful in pseudo-obstruction. But it is not as popular as colostomy because it may not function adequately, may get displaced or blocked. But it is technically easier and usually done by doing appendicectomy and passing Malecot's tube through appendicular stump. Removal is easier without any surgical intervention. Foley's catheter no. 30 F can be used. Purse string suture is placed around the tube by taking seromuscular bites with 3-0 vicryl or silk suture. It is also fixed by 2-3 interrupted sutures taken between seromuscular part of the caecum very close to the tube and parietal peritoneum (abdominal wall).

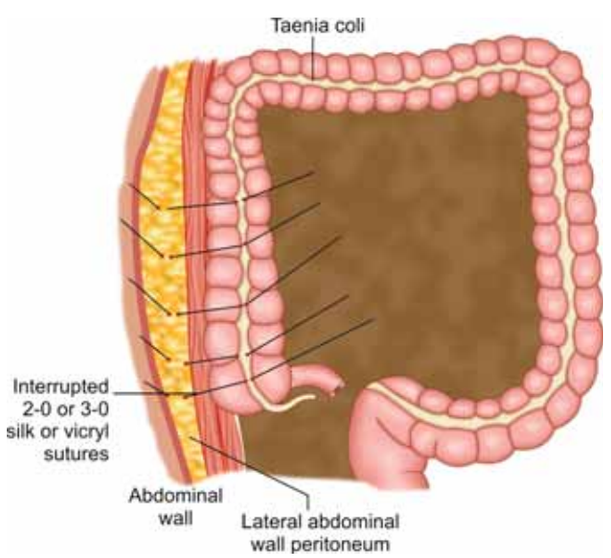


Fig. 24-11: Caecopexy technique.

It is often done along with other procedure during laparotomy. When only caecostomy is planned it is done through a oblique incision in right iliac fossa above the groin crease similar to Mc Burney's incision. Distended caecum is identified; an occlusion clamp is placed across the caecum; appendix removed with a purse string suture on the taeniae circumferentially. Appendix stump is not ligated; instead suction apparatus passed into that to suck the content to prevent spillage. No. 30 Foley's catheter is passed onto the caecum; purse string suture is ligated. Second purse string suture is placed. Appendicectomy should be performed even if caecostomy is done on the anterior part of the caecum through taenia.

Tip of the tube is directed toward hepatic flexure. Nonfunctioning, blockage, slippage, leak are the complications **(Figs 24-12A to D)**.

COLOSTOMY

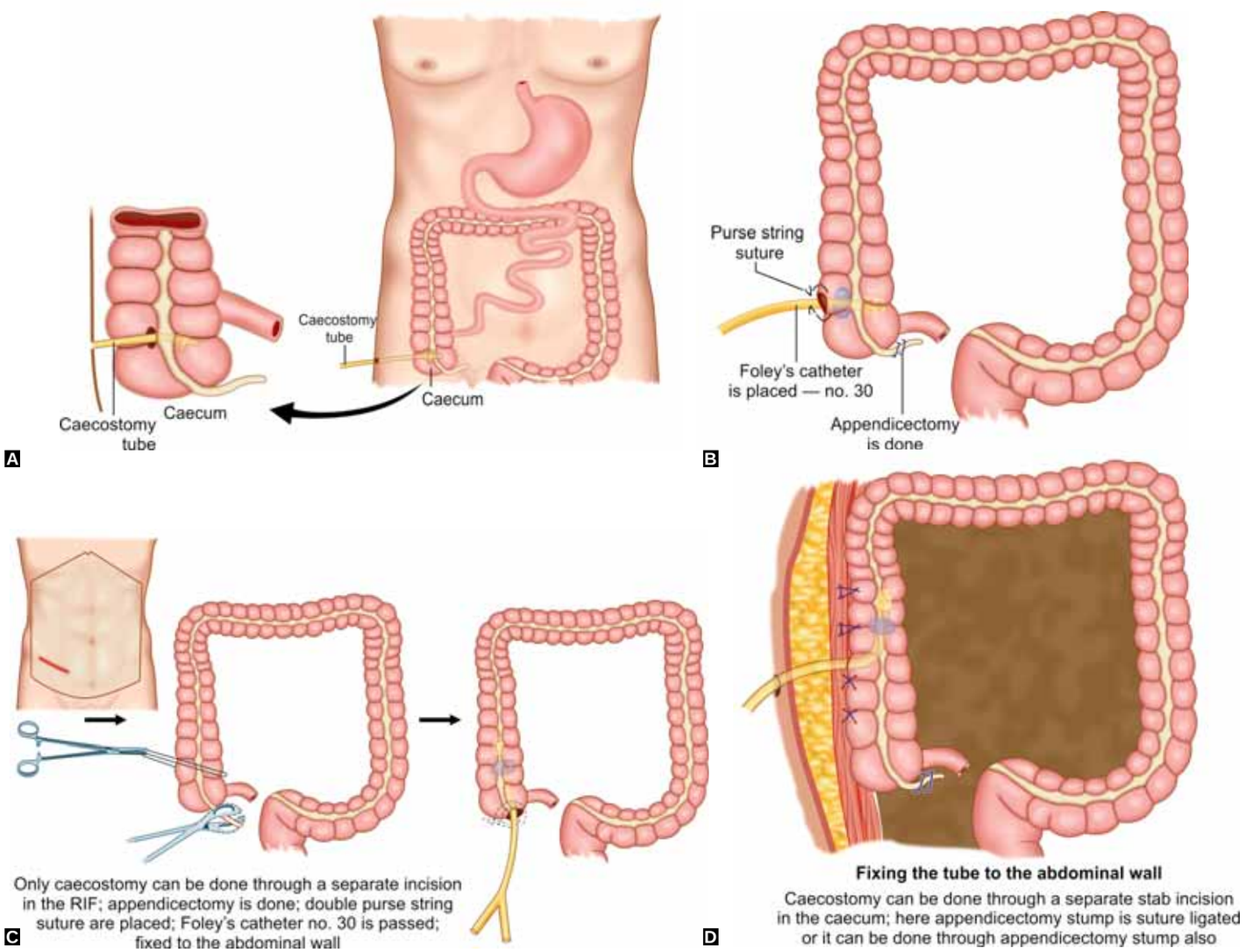
It is an artificial opening made in the colon to the exterior (skin) to divert faeces and flatus.

Types

1. ***Temporary:*** Is done in conditions wherein diversion is required to facilitate healing distally in the rectum or distal colon. And this is closed once the purpose is over. Site of temporary colostomy is usually right hypochondrium and left iliac fossa.
2. ***Permanent*** colostomy is always *end/terminal colostomy* placed in left iliac fossa, 6 cm above and medial to the anterior superior iliac spine.

Colostomy Can be

Diversion colostomy: It is done when there is breach in bowel wall, trauma, destruction, sphincter injuries, Crohn's, carcinoma rectosigmoid. It is usually brought out as an end colostomy with a mucus fistula or with a Hartmann's resection. It can be at sigmoid, descending and transverse colon. ***Decompression colostomy:*** It is done for obstructive lesions in rectosigmoid, toxic megacolon. Types—(1) *Blow hole* procedure is done as a single or multiple small stomas onto the skin to decompress colon in acutely ill patients with massively dilated or impending perforation of colon. Problems


Caecostomy tube
Caecum
Caecostomy tube
Caecum
A
Purse string suture
Foley's catheter is placed — no. 30
Appendicectomy is done
B
Only caecostomy can be done through a separate incision in the RIF; appendicectomy is done; double purse string suture are placed; Foley's catheter no. 30 is passed; fixed to the abdominal wall
C
Fixing the tube to the abdominal wall
Caecostomy can be done through a separate stab incision in the caecum; here appendicectomy stump is suture ligated or it can be done through appendicectomy stump also
D

Figs 24-12A to D: Caecostomy technique.

are—remaining possible ischaemic parts of the colon is not identified risking perforation; peristomal skin complications and mucosal prolapse is common. (2) *Tube caecostomy*—It is technically easier without much complications; but tube getting blocked limits its use regularly. (3) *Loop transverse colostomy*—It serves as decompressing and diverting long stoma without getting blocked. It is done only in mobile colon. *Irrigation colostomy:* It avoids need for appliance wear; reduces the passage of uncontrolled gas with less leak of stools. But it is time consuming with chance of water intoxication due to excess water absorption during irrigation.

Colostomy Can be

Loop colostomy *or double barrelled colostomy or* ***Devine's divided double-barrel colostomy*** (wherein there is a gap of skin between the two openings of colostomy which prevents spillage into the distal loop).

Loop colostomy is done temporarily to divert the stool. It is presently done to defunction distal anastomosis or in high fistulas or perianal traumas. It can be done at sigmoid colon at the junction of the sigmoid and descending colon as descending colon is fixed it, prevents colostomy prolapse. It can also be done more proximally at transverse colon in right hypochondrium. It is easier to construct. But prolapse is much more with colostomy than ileostomy; marginal artery may get damaged causing problematic eventual closure. Double barrel colostomy was done in olden days in sigmoid volvulus as Paul Mikulicz operation wherein a spur was created between two limbs at antimesenteric border.

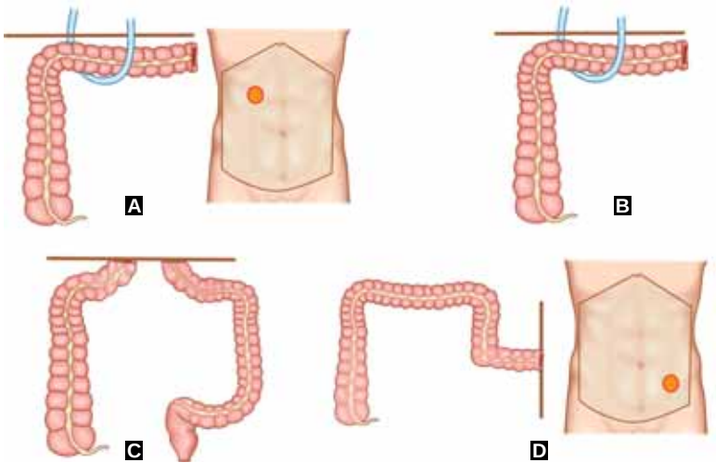
Indications

Temporary*:** Congenital megacolon. ***Permanent: AP-Resection; anorectal malformations; carcinoma anal canal; sigmoid volvulus after Hartmann's operation; perforation of left sided colon; left sided colonic growth; high anal fistula; trauma to left sided growth **(Figs 24-13 to 24-15)**.

Technique

Loop colostomy

It is ideally done under general anaesthesia; but can be done under spinal or local anaesthesia. It is done along with laparotomy for



Figs 24-13A to D: Types of Colostomy. (A) Temporary colostomy, (B) Loop colostomy, (C) Devine's double barrel colostomy, (D) Permanent colostomy.

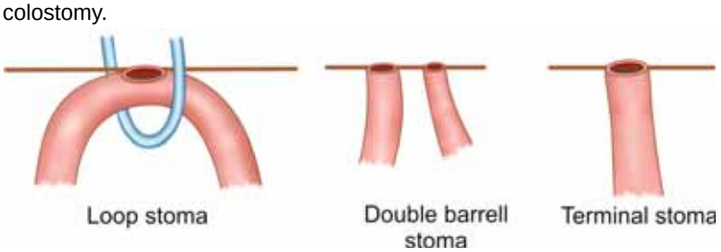


Fig. 24-14: Different types of stomas used in colostomy.

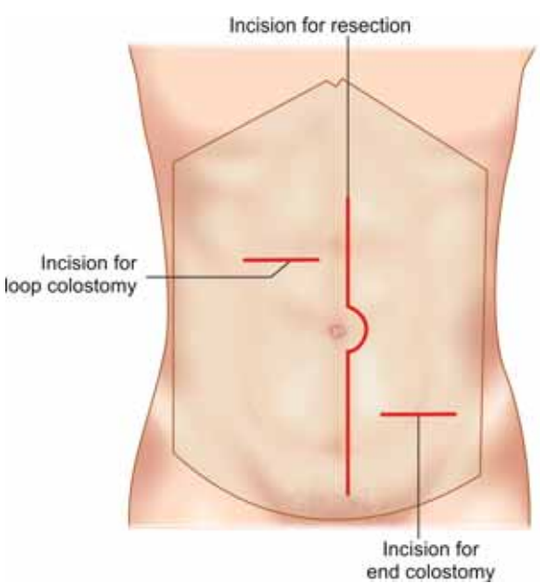


Fig. 24-15: Midline incision is used for resection. Incision in the right hypochondrium is used for loop colostomy (temporary). Permanent end colostomy is done after abdominoperineal resection (APR); here colostomy is sited at left iliac fossa.

definitive procedure or only loop colostomy at time and definitive procedure is done at a later period **(Fig. 24-16)**.

Incision is in the right hypochondrium midway between umbilicus and right costal margin, horizontally placed of about 6 cm in length, over the right rectus muscle with its right end ends just lateral to the lateral margin of right rectus abdominis muscle. Skin, two layers of superficial fascia and anterior rectus sheath is incised in the line of the skin incision. Rectus muscle is split vertically or horizontally cut; posterior rectus sheath and peritoneum are opened. Transverse colon is pulled out; omentum is detached from the colon for sufficient length—6 cm. Transverse mesocolon very close to the colonic wall is opened (window is created) in avascular plane and glass rod or stiff silastic tube/drain tube of 18 French size is passed across (which is usually removed in 8-10 days). Glass rod prevents retraction keeping colocutaneous suture line intact. But it is not mandatory to place a rod like this always; it is useful in obese patients. Glass rod often is brought out on either side by a separate stab incision which facilitated proper placement of sutures between colonic edge and skin. Colon is traditionally opened longitudinally along the taenia extending to both limbs of the loop. It is also practiced to open the colon horizontally which causes less damage to blood vessels. Both ways are accepted. After opening it is often practiced that few interrupted 2 zero vicryl sutures are placed between rectus sheath and seromuscular part of the colon away from the cut edge site. Usually 6 such sutures are placed. But it is again not mandatory to place such sutures in temporary colostomy. Interrupted sutures are placed between skin, subcutaneous and full thickness colonic cut edge. Many people use only subcuticular part of the skin for suturing instead of entire skin. Colostomy is ready for function. Stoma appliance is placed. Stoma should protrude outward at least 1-3 cm beyond skin margin **(Fig. 24-17)**.

Prasad end loop colostomy is often done along with laparotomy resection. Colostomy site is transected using stapler; proximal part is brought out through already created colostomy opening and is matured by releasing the stapler line; distal stapled colon is brought out adjacent to proximal loop. Proximal cut edge is sutured to skin using interrupted skin sutures. Distal loop stapled line is removed; it is partly sutured to skin; its inner part which is adjacent to proximal loop is anastomosed to it as side to side to create a modified loop colostomy.

End or Terminal Colostomy

End or terminal colostomy is done after abdominoperineal resection. It is permanent one. End colostomy site should be marked properly and a circular disc of skin is removed. Many do skin excision by holding the skin with a toothed forceps or Allis forceps and excising an elliptical skin but it is actually inadequate but accepted. Similarly same sized superficial fascia and rectus sheath is excised at corresponding level. Rectus muscle is split and peritoneum is incised. Two fingers should be passed through the wound without any difficulties. End of the cut colon is brought out by passing a Babcock's forceps inside through the opening for about 5 cm outside. If possible when colon is intraperitoneal lateral space between mesocolon and abdominal wall is closed using interrupted silk sutures. It prevents herniation. Otherwise colon end itself can be made extraperitoneal and brought out. One should ensure that there is no tension and good blood supply at the end of the colon. Few interrupted vicryl sutures may be placed between rectus sheath and seromuscular colon 1 cm proximal to the colon end. Interrupted skin sutures are placed between colonic full thickness edge and skin with subcutaneous fat. Many people take bites from seromuscular part of the colon avoiding the mucosa but it is practically not necessary. Even fixing to the rectus sheath is not mandatory even though commonly practiced.

When stapler is used for resection of the colon, stapler end is brought out and then later stapler line is excised. Other option is maturation is done at a later period postoperatively. But nowadays preferred one is doing maturation in the operation table only after closure of the main laparotomy wound.

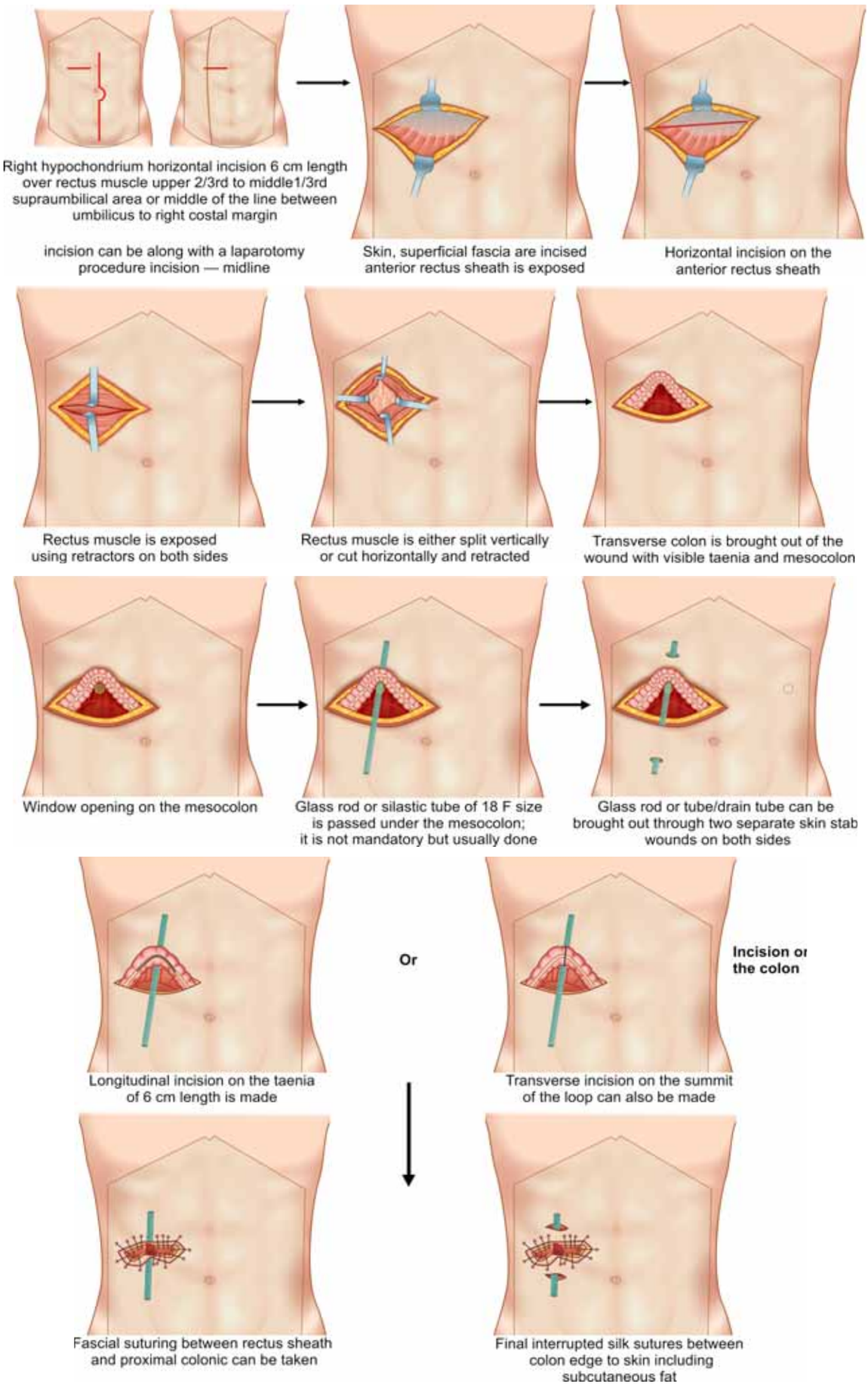

Right hypochondrium horizontal incision 6 cm length over rectus muscle upper 2/3rd to middle1/3rd supraumbilical area or middle of the line between umbilicus to right costal margin
incision can be along with a laparotomy procedure incision — midline
Skin, superficial fascia are incised anterior rectus sheath is exposed
Horizontal incision on the anterior rectus sheath
Rectus muscle is exposed using retractors on both sides
Rectus muscle is either split vertically or cut horizontally and retracted
Transverse colon is brought out of the wound with visible taenia and mesocolon
Window opening on the mesocolon
Glass rod or silastic tube of 18 F size is passed under the mesocolon; it is not mandatory but usually done
Glass rod or tube/drain tube can be brought out through two separate skin stab wounds on both sides
Or
Incision or the colon
Longitudinal incision on the taenia of 6 cm length is made
Transverse incision on the summit of the loop can also be made
Fascial suturing between rectus sheath and proximal colonic can be taken
Final interrupted silk sutures between colon edge to skin including subcutaneous fat

Fig. 24-16: Technique of loop colostomy.

Loop colostomy site at right hypochondrium
A window is created in the tr mesocolon through which tube is passed
Taeniae
Taenia at transverse colon is opened longitudinally to expose both proximal and distal lumens adequately
Protruded posterior wall of the transverse colon
Both lumens proximal and distal are felt
Edge of the colon is sutured to skin as full thickness interrupted skin sutures

Fig. 24-17: Loop colostomy is usually done in right hypochondrium. It is a temporary colostomy.

Complications of Colostomy

Prolapse of mucosa (prolapse of distal loop mucosa is common)—commonest complication; retraction; necrosis; stenosis; herniation; bleeding; diarrhoea; enteritis; skin excoriation. Necrosis of stoma can be just mucosal or full thickness.

Mucosal necrosis is treated conservatively. Full thickness necrosis needs reexploration and creation of new stoma.

Colostomy prolapse is common in loop than in end. It is initially treated conservatively; if troublesome then conversion into end colostomy and mucus fistula is safer. Mucus fistula is created at a separate opening.

Parastomal hernia is common in end colostomy. It is herniation of intestine on the side of bowel stoma—ileostomy/colostomy/other stomas. Incidence is 8%. *Classification (Devlin's)*: (1) Subcutaneous—Intestine herniates along the side of stoma to reach subcutaneous plane—commonest. (2) Interstitial—along the side of stoma intestine herniates into intermuscular plane. (3) Intrastomal – Bowel herniates between emerging and everted parts of the stoma. (4) Parastomal—Herniation occurs between the layers of the prolapsed stoma. Parastomal hernia can cause obstruction and strangulation. *Features:* Pain, features of obstruction, stomal malfunction, swelling which is tender, toxicity. If it is distressing it should be treated. Local repair with or without mesh can be done; otherwise closure of the stomal site with hernial repair using a mesh and redoing the colostomy at different location is the only choice. Mesh may be placed intraperitoneally or extraperitoneally. Rectus sheath which is closed often is supported with a local large Leslie skin flap.

Infection (enteritis / colitis), colostomy separation, skin excoriation, social problems, appliance problems are often difficult to manage **(Fig. 24-18)**.

Colostomy Care

It is similar to stoma care. Initially stoma bag should be transparent as content is liquid stool but later it can be opaque. Regular consultation with stoma therapist; care of the skin; training for managing colostomy, its care to prevent leak, odour, and discomfort. Educating the patient regarding the proper usage of colostomy bags and proper care of the colostomy is very essential.

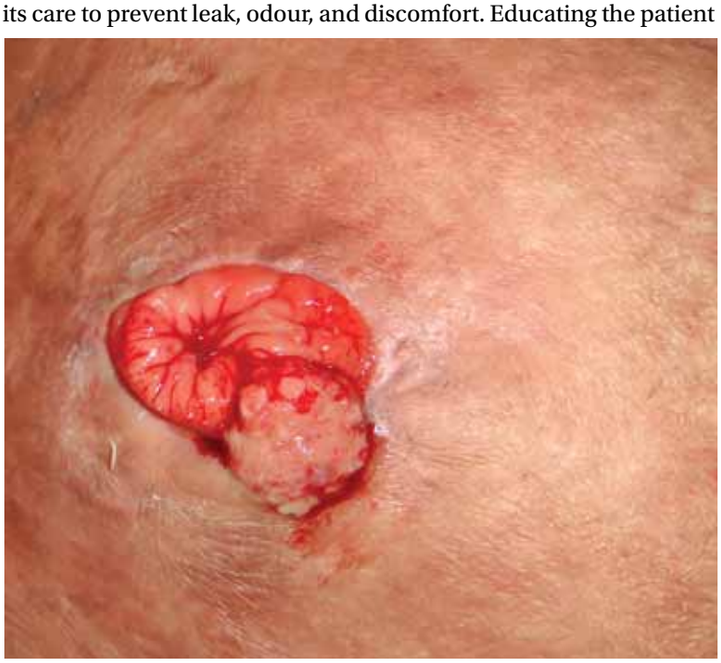


Fig. 24-18: Colostomy site recurrence of the carcinoma who has earlier undergone abdominoperineal resection.

CLOSURE OF COLOSTOMY

Criteria for temporary colostomy closure:

Integrity of distal colon should be normal and adequate; anorectal sphincter should be normal. Cause for construction of colostomy is cured completely without any suspicion of recurrence of same disease distally. When temporary colostomy is done, it is closed usually after 3 months. Closure of colostomy is done after proper bowel preparation, ideally under general anaesthesia. Colonoscopy is a must just prior to colostomy closure to confirm that distal colon is normal and without any obstruction and devoid of any disease.

Types of Colostomy Closure

Two types of closure are present - Extraperitoneal and intraperitoneal type. *Now intraperitoneal closure is done.*

Earlier extraperitoneal closure was done in loop colostomy by placing a spur in between and closing the antimesenteric part of the colon. It prevents the peritoneal contamination. But inadequate closure, leak, adhesions are the problems.

Intraperitoneal closure—commonly advocated technique now. It is done by placing series of 6-8 silk sutures around the skin margin to give traction while dissecting, separating and mobilising the colon using circumferential incision over the margin with 2 mm skin edge. Incision is deepened to enter the peritoneum and pull out the colostomy stoma. Adequate mobilisation is essential to prevent tension over the anastomotic site. Part adjacent to the skin is resected and anastomosed using silk/vicryl. Two layer anastomosis using interrupted sutures is usually practiced. If there is an unhealthy edge then it is better to mobilise the hepatic flexure completely and do a small colonic segment resection and anastomosis. Sutured bowel is placed into the peritoneal cavity. Drain is placed into the peritoneal cavity. Abdomen closed in layers.

Proper postoperative care is important. Patient should perform anal sphincter exercises to prevent sphincter atrophy and to maintain sphincter tone.

Complications of Colostomy Closure

Breakdown of anastomotic site and faecal fistula is the commonest complication; but it usually subsides unless there is distal obstruction. Distal anastomotic abscess formation, wound infection, wound dehiscence and later incisional hernia can develop.

TREATMENT FOR DIVERTICULAR DISEASE OF SIGMOID/COLON

Medical Treatment

High fibre diet; antibiotics; bulk purgatives; avoid constipation; regular follow-up of the progress of disease and onset of complications.

Abscess can be drained by CT guided aspiration or percutaneous drainage tube. *Guided aspiration* of the abscess is sufficient if abscess is small. Proper antibiotics are needed.

In acute stages, conservative treatment like bowel rest, antispasmodics, antibiotics are advised **(Fig. 24-19)**.

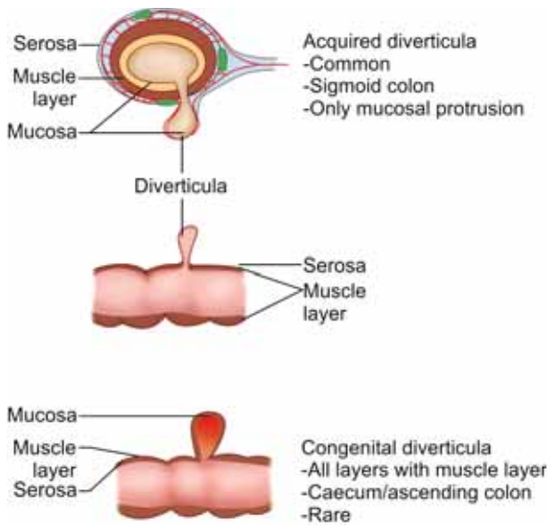


Fig. 24-19: Colonic diverticula – diagram.

Indications for Surgery

Recurrent diverticulitis; diverticulitis with complications.

Surgery required is—*Resection of sigmoid colon and anastomosis (colorectal). Laparoscopic sigmoid resection can also be done* **(Fig. 24-20)**.

If colon is loaded with faecal matter, initially a transverse colostomy is done. Then resection and anastomosis; later colostomy closure is done as a staged procedure **(Fig. 24-21)**.

In case of perforation, proximal colostomy and exteriorization of the affected bowel with later resection and anastomosis is done as it has high mortality **(Fig. 24-22)**.

Occasionally, Hartmann's procedure (combination of sigmoidectomy, end colostomy and closure of rectal stump) is better and life saving **(Fig. 24-23)**.

Fistulas are treated by resection of the diseased bowel and closure of the fistula along with diversion procedures like colostomy, cystostomy, ureterostomy.

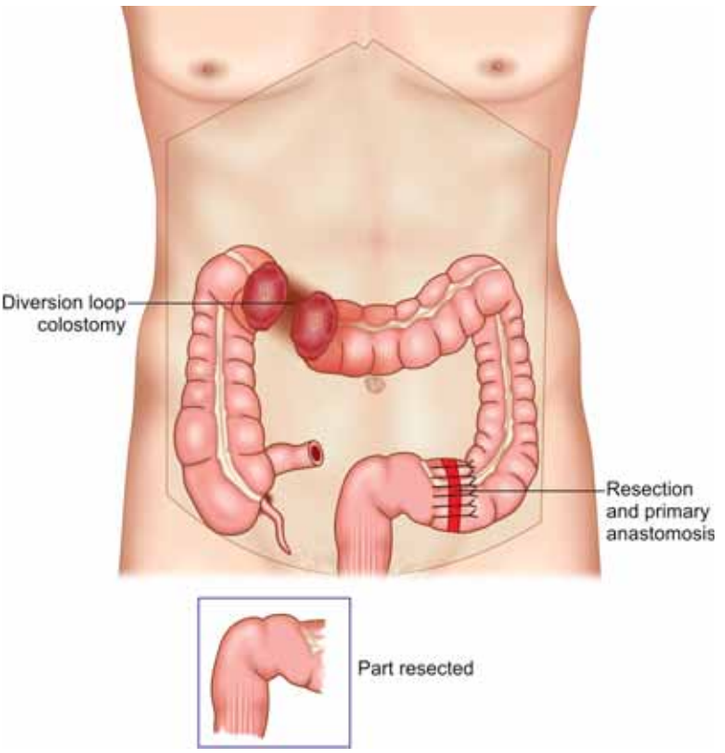


Fig. 24-21: Resection of sigmoid colon for sigmoid diverticula with primary anastomosis and defunctioning diversion colostomy.

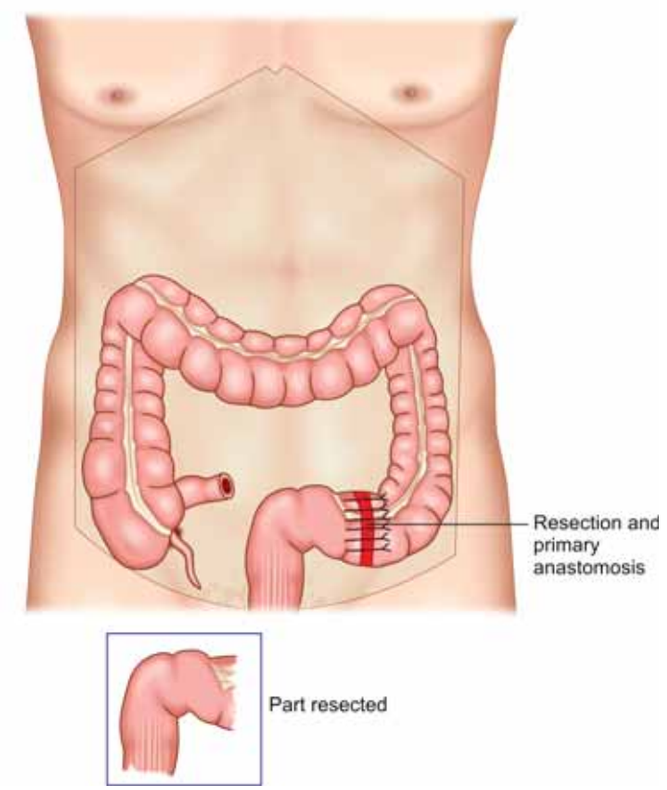


Fig. 24-20: Resection and primary anastomosis can be done in sigmoid diverticula after proper bowel preparation electively.

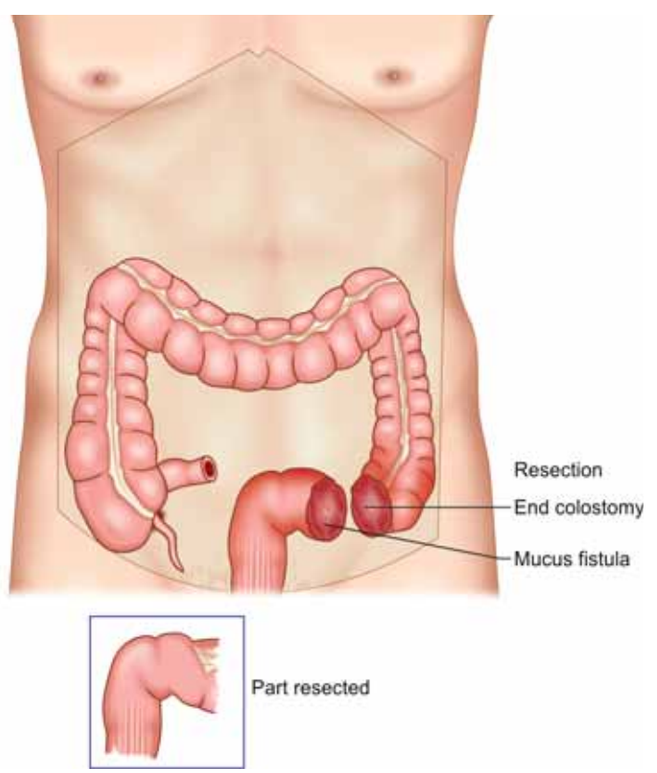


Fig. 24-22: Resection and formation of end colostomy and mucus fistula for acute sigmoid diverticulitis.

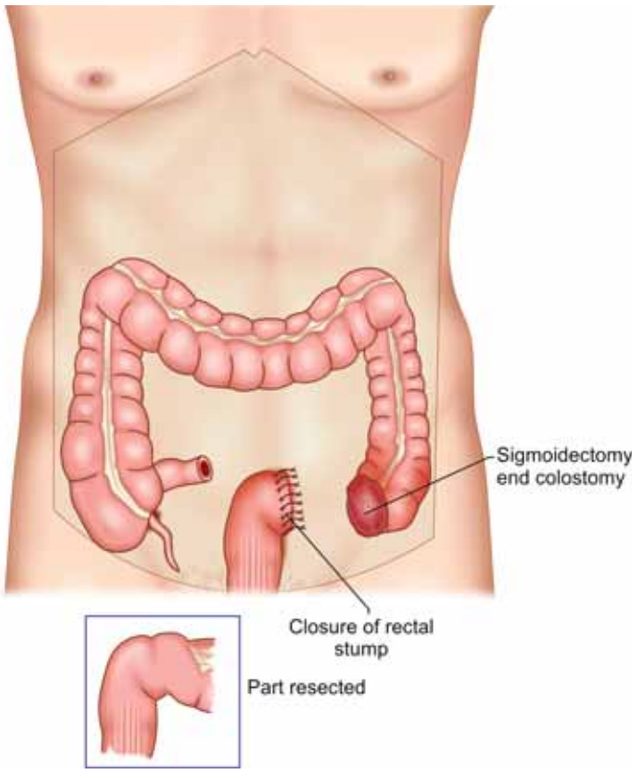


Fig. 24-23: Hartmanns operation for acute diverticulitis with sepsis/perforation/peritonitis. Here, after resection proximal colon is exteriorised as end colostomy. Distal rectal stump is closed.

In certain cases of diverticulosis, a longitudinal incision through the taenia and muscular layer without opening the mucosa is sufficient (like Heller's/Ramstedt's myotomy)— *Reilly's sigmoid myotomy*.

***Note*:** It is basically **a benign condition**, therefore the prognosis is good. High fibre diet is advised. Complications like *perforations, fistulas are dangerous and life-threatening*. Right sided diverticulum in the caecum and ascending colon is usually solitary and congenital.

Myotomy

- Heller's myotomy—achalasia cardia
- Ramstedt's myotomy—congenital pyloric stenosis
- Reilly's myotomy—diverticulosis

TREATMENT FOR ULCERATIVE COLITIS

General: Correction of anaemia; fluid and electrolyte supplementation; nutrition (high protein, carbohydrate, vitamin, but low fat diet), TPN; sedatives and tranquillisers; psychological counselling.

Drugs: In active disease, drugs are used to *induce remission*. Later drugs also should be given for *maintenance* of remission and to prevent relapses. Salazopyrine/sulphasalazine splits into 5 amino-salicylic acid and sulphapyridine in colon. It is used as *first line therapy*. Its dose is 2-4 gm/day. It is mainly used to induce remission. It suppresses PGE1 and PGE2 to reduce the inflammation, inhibits proteolytic enzymes and also causes immunosuppression. 5 ASA is the most active ingredient. Side effects are skin rashes, bone marrow suppression, folic acid deficiency, haemolysis in glucose-6-phosphate dehydrogenase deficiency patients, temporary fertility problems in men. 5 ASA (Mesalamine) is also used in active disease as *first line therapy*. It is used with an azo bond to prevent its absorption in small bowel. Its induction of remission is same as sulphasalazine. Idiosyncrasy and temporary infertility is not present in mesalamine. Its *oral* dose is 2-4 gm/day. It is also used as *retention enema* which is better than steroid enema in left sided ulcerative colitis/proctitis. But mesalamine enema (4 gm in 100 ml saline) is costly. Enema is combined with oral mesalamine or oral steroid in acute cases. Mesalamine 500 mg s*uppository* is also used in BID doses. Daily oral (1.6 gm) and topical 4 gm enema, twice weekly is often used for maintenance therapy. Headache, dyspepsia and myocarditis are the complications. Steroids are used in cases where salazopyrine fail to induce remission. It is a drug for *refractory cases*. Oral prednisolone 60 mg/day tapering in 4 weeks is the dose. Intravenous hydrocortisone 100 mg 8th hourly is used in acute cases. 100 mg hydrocortisone enema/40 mg methylprednisolone enema (steroid retention enema) are used for 2 weeks in acute active diseases. Most patients with moderate to severe disease need steroid therapy. *Budesonide* is a newer steroid hydrocortisone analogue is also equally effective with lesser side effects and less adrenal suppression. Immunomodulators are used often to induce remission and for maintenance. Azathioprine and 6-mercaptopurine are used. They act at DNA level (purine ribonucleotide) and inhibit lymphocyte function (of T cells). But this action is slow. Cyclosporin is used in refractory, fulminant severe ulcerative colitis as a reserve drug. Dose is 4 mg/kg/day IV. Mebeverine HCl and Tegaserod (6 mg) are the other drugs used in ulcerative colitis. Other measures are using sucralfate, short chain fatty acids, probiotics, anti-diarrhoeal drugs (diphenoxylate, loperamide, codeine), avoiding milk products, fibre, fruits. Anti-tumour necrosis factor alpha – *Infliximab* is also used selectively (in some studies). It is given intravenously at interval of 6 weeks. It shows 70% remission in ulcerative colitis. Newer drugs with a targeted delivery into the colon is used nowadays. *For example* Olsalazine (azobond); Balsalazine (4 aminobenzoyl carrier).

Indications for Surgery—30% Cases

Intractability—commonest indication; toxic dilatation; perforation; haemorrhage; risk of malignant transformation, dysplasia (DALM); onset at early age; chronic invalidism; progressive disease with stricture, abscess, fistulae; steroid dependency, persistent active disease; malignancy; severe extraintestinal manifestations; growth retardation in children.

Toxic megacolon: It is 1.5% in incidence; common in transverse colon; colon more than 6.5 cm in diametre in transverse colon and more than 10 cm in caecum is likely to be toxic; colon is like wet blotting paper; commonly seen in ulcerative colitis; can occur in bacterial colitis, pseudomembranous colitis, fulminant amoebic colitis; may be precipitated by antidiarrhoeal drugs. It is treated by—IV fluids, blood transfusion, antibiotics, steroids; it can be life threatening; plain X-ray abdomen is very useful; emergency surgery, colectomy, colostomy/ileostomy may be required. In olden days *blow hole procedure* was advocated for toxic megacolon, may be still useful in severe cases. Skin level transverse colostomy, sigmoid colostomy and a loop ileostomy is done to decompress entire small and large bowel. After many months (6-8 months) once patient recovers from acute illness, total proctocolectomy with ileal pouch anal anastomosis is done.

Surgeries

Total proctocolectomy with ileo-anal anastomosis with pouches as reservoir ("J', 'S', or "W' pouches). It is called as *restorative proctocolectomy with ileal pouch anal anastomosis (IPAA*). It is *ideal curative procedure* for ulcerative colitis. Anal sphincter complex is

preserved. An 30 cm ileal pouch is created either hand sewn or with stapler. Created ileal pouch reservoir is anastomosed just above the anal canal using end-to-end stapler. Diametre of the pouch should be twice the diametre of the ileum. Obstruction (25%), diarrhoea, *pouchitis (25%)*, leak, sepsis, incontinence are the complications.

Total proctocolectomy with ileostomy (permanent, continent Kock's ileostomy, with one way valve is done). It is used at present only *in revision surgery* when needed after restorative proctocolectomy.

Total proctocolectomy with end non-continent ileostomy was the earliest operation done for ulcerative colitis. It is now *reserved only* for ulcerative colitis complicated with carcinoma of rectum. *Ileostomy site* should be marked in standing and sitting position. Stoma should be within the right rectus abdominis muscle at the summit of infraumbilical fat, away from midline incision, bony prominences and umbilicus.

Total colectomy with ileorectal anastomosis can be done. Proper follow up at regular intervals by regular sigmoidoscopic evaluation should be done as rectum is also diseased and vulnerable for complications. It is *not commonly* practiced now.

Total colectomy with rectal mucosectomy and anastomosis above the dentate line on posterior aspect is also occasionally used.

TREATMENT CONCEPT IN CARCINOMA COLON

Mainly Surgical

Right Sided Early Growth

Right radical hemicolectomy with ileo transverse anastomosis is done. Structures removed are terminal 6 -15 cm of ileum, caecum and appendix, ascending colon, 1/3rd of transverse colon, lymph nodes (epicolic, paracolic, intermediate, principal).

In inoperable right sided growth, *ileo-transverse anastomosis* is done as a by-pass procedure.

In transverse colon and hepatic flexure growth—*An extended right hemicolectomy* is the procedure done for transverse colon growth which includes division of right colic, middle colic arteries at their origin, with removal of terminal 6 cm ileum, ascending and transverse colon; anastomosing terminal ileum and proximal part of the descending colon—*ileocolic*. Alternatively, in mid transverse colon growth only transverse colon with both flexures can be removed; anastomosing cut ends of ascending and descending colon—*colocolic*.

Left Sided Early Growth

Left radical hemicolectomy is done, where in left ½ of transverse colon and descending colon is removed along with lymph nodes.

Left sided stenosing type of growth can present with acute intestinal obstruction, in which case initially colostomy is done. Later, after 3-6 weeks, following proper preparation, required formal procedure is done, followed by colostomy closure after 8 weeks (*3 stage operation*). Presently it is done only in critically ill patient; otherwise it is proved that it is not necessary to do 3 stage procedures; instead primarily resection and anastomosis with a proximal diversion colostomy is an effective procedure.

Often growth in the transverse or left sided colon, which is stenosing or obstructive type, can cause *closed loop obstruction* because of the competent ileocaecal valve. As a result, pressure increases in the caecum eventually leading to its perforation. Perforation can also occur occasionally at the site of tumour. They need *emergency intervention*—caecostomy or colostomy, or ileostomy with resection and anastomosis. If severe peritonitis sets in, it may be life-threatening.

Left sided colon growth *with obstruction* can be treated with resection of tumour, saline lavage and cleaning the rest of the colon by passing a catheter through the appendix into the caecum followed by primary anastomosis thus avoiding colostomy.

Severely *obstructed sigmoid growths* are often treated alternatively by tumour resection with removal of entire proximal colon and continuity is maintained with ileo sigmoid/ileo rectal anastomosis. It also avoids diversion.

During exploration, presence of any synchronous growths has to be looked for. Now it is found that carcinoma colon can be *associated with tuberculosis or lymphoma of colon*. So this association is also looked for.

In acute left sided growths, *trans anal self-expanding metal stents* can be used instead of defunctioning colostomy.

Turnball's 'No touch technique': Here the vessels are ligated at its origin, at the beginning, in order to prevent the tumour spread—due to tumour handling. This medial to lateral oncological approach could be ideal in carcinomas. In laparoscopic colectomies, this medial to lateral approach is better as colon will be fixed laterally makeing dissection medially easier.

Abdominal total colectomy with ileorectal anastomosis is done if there are multiple primary tumours or in HNPCC. Significant chronic diarrhoea is the problem due to defective water absorption.

In Liver Secondaries

In solitary liver secondary, segmental hepatic resection is useful.

In case of multiple secondaries confined to one lobe of the liver, hemihepatectomy can be tried.

Metastasectomy—it is done in one secondary/one lobe secondaries/less than 3 metastases in both lobes/without any extrahepatic spread.

A 'Second Look Operation'

It is most often helpful in carcinoma of colon, to resect the residual or recurrent tumours (*Owen Wangensteen's Second look surgery). Relaparotomy is done after a stipulated period at regular intervals once colectomy is done for carcinoma.*

Synchronous Growths

If there are synchronous growths or growth with other area having multiple potential polyps, then total *colectomy with colorectal* anastomosis is done.

Recurrent Tumour

Recurrent tumour should be treated by re-exploration and resection with adjuvant chemotherapy of different regime.

Laparoscopic Approach

Laparoscopic evaluation and resection is becoming popular. Laparoscopic assisted colonic resection is also done [*Hand assisted laparoscopic surgery (HALS)*].

Note

- Caecum and ascending colon—right radical hemicolectomy (terminal ileum to mid-transverse colon); hepatic flexure and transverse colon—extended right radical hemicolectomy (terminal ileum to proximal descending colon); splenic flexure extended left radical hemicolectomy (hepatic flexure to rectosigmoid); descending colon and sigmoid—left radical hemicolectomy (splenic flexure to rectosigmoid).
- Minimum 5 cm margin clearance at colonic side/sides is needed; 6 cm terminal ileum clearance is sufficient in case of right sided growth.
- Duodenum, ureter, IVC, superior mesenteric vein should be taken care of during dissection in right hemicolectomy; spleen, stomach, tail of the pancreas should be taken care of in left hemicolectomy.
- It is ideal to mobilize both flexures adequately in all colonic surgeries to reduce the anastomotic tension.
- Bleeding at edges of anastomotic site should be adequate; in emergency obstructive situation, better to do temporary covering colostomy or ileostomy to prevent anastomotic leak whenever necessary.
- On table and postoperative hypoxia and hypotension should be prevented to minimize anastomotic leak.
- Preoperative mechanical bowel preparation is important in elective colonic resection using polyethylene glycol / mannitol, oral bowel antiseptics like neomycin and metronidaziole.
- Infiltration into adjacent local structures is not a contraindication for surgical resection.
- At least 12 nodes should be examined during histology after resection.
- Blood transfusion before or during surgery for colonic cancer may alter the immunological aspect of the colonic cancer and may increase the recurrence rate and so may alter the prognosis. It is presently not very well-proved. Reason thought is—Blood transfusion raises the level of suppressor T cells leading into immunosuppression. So autologous blood transfusion is better when in needed.
- Proper preoperative bowel preparation by mannitol/polyethylene glycolhypertonic saline/bowel wash/ bowel antiseptics (neomycin or gentamycin or streptomycin and metronidazole orally).
- Antibiotic prophylaxis; DVT prophylaxis by crepe bandage or stockings bandage, heparin or low molecular weight heparin; pulmonary function tests and pulmonary exercise preoperatively as well as postoperatively; urinary catheterisation, nasogastric tube placement—are always needed.
- Postoperative proper care with fluid, electrolyte, drain care, early mobilization, monitoring.
- Complications of surgery are leak (fecal fistula), bleeding, infection like intraperitoneal/pelvic abscess, respiratory problems, DVT, wound infection, burst abdomen.

RESECTION OF THE COLON

Colonic resection is a common condition surgeons will come across. It may be for benign diseases, acute conditions like obstruction, volvulus or perforation or diseases like severe ulcerative colitis, polyps of different type and cause, carcinoma at different levels. Technically even though colon resection is easier than biliopancreatic surgeries, to achieve an optimum result with least complications proper preoperative, operative and postoperative care should be undertaken.

Principles

Prior evaluation of the disease, extent, type of resection needed, and comorbid status should be evaluated by imaging, colonoscopy, biochemical and nutritional assessment, cardiac and respiratory evaluation. CT imaging is essential.

Need for diversion in obstruction and other acute conditions should be thought of. Diversion may be colostomy or ileostomy depending on the location of the pathology. Stoma appliances, stoma care should be planned.

Tumour may be closer to ureter or invading it; such situation warrants for ureteric stenting prior to surgery. Stent may be removed within 3 months.

Bowel preparation is routinely done with methods which surgeons are familiar. Bowel antiseptics, perioperative antibiotics are used. Nasogastric tube and urinary catheterization is needed.

Epidural with General Anaesthesia is Commonly Used

Different types of colectomies are performed depending on the need; these terminologies are used based on the extent of the colon resected. In benign conditions vascular ligations are done very close the colonic wall and conventional colectomies are done with colon being mobilized first from paracolic gutter inwards then vessel ligation followed by anastomosis. In carcinomas, resection begins with vascular ligation at its origin to achieve lymphovascular clearance. After ligation of the branch vessels at its origin then only colon mobilization is done from paracolic gutter to complete the resection – this is termed as radical resection of the colon. Hence usually *conventional colectomies* done for benign conditions with colonic mobilisation first; whereas in radical colectomies done for malignancies involves lymphovascular ligation first at the origin of the branch vessels. But one should remember that radical colectomies can be achieved through conventional approach after colon is mobilised vessels are ligated at its origin to clear nodes. Ligation of vessels at its origin is not done in colectomies for benign diseases.

Different types of colectomies are shown in the diagram—they are—ileocaecal resection; segmental ascending colon resection; right hemicolectomy; extended right hemicolectomy, transverse colectomy, left sided hemicolectomy; extended left sided hemicolectomy; sigmoid colectomy; subtotal colectomy; total colectomy; total proctocolectomy **(Figs 24-24 to 24-29)**.

RIGHT COLECTOMY

Conventional Right Hemicolectomy

Lengthy midline incision is used. Proper exploration is done – gall bladder, liver, pancreas, remaining parts of the bowel, pelvis, nodes should be assessed. Usually conventional right hemicolectomy is done for benign lesions. So lymph node clearance is not needed. But it is very well accepted that conventional colectomy can be used for malignancies but vessels should be ligated at its origin and lymphovascular clearance should be adequate and also gentle dissection and handling of the colon and tumour is needed. Self retaining retractor is placed. Surgeon can stand either on right side or on left side. Many prefer to stand on left side. Caecum, terminal ileum and ascending colon are gently retracted anteromedially. Posterolateral peritoneum (*Toldt's line*) gets stretched and is incised using cautery or scissor. As plane is natural and avascular gentle finger dissection using index finger will create a space underneath the peritoneum up to the hepatic flexure and peritoneum is incised to expose the psoas major muscle. If surgeon is holding the bowel assistant can incise the peritoneum otherwise assistant is made to hold the bowel. Ureter, gonadal vessels are identified and safeguarded. Near hepatic flexure duodenum is identified which is dissected and left in the retroperitoneum. Posteriorly Gerota's fascia with kidney

will be separated; Gerota's fascia is separated by dividing renocolic ligament. Gerota's should not be opened. Junction of the ascending colon and hepatic flexure is adherent to the gallbladder and should be released using scissor and finger dissection (division of *hepatocolic ligament*). Greater omentum is ligated and divided to achieve further mobilisation. In benign lesions omentum can be divided close to the colon at avascular plane. While mobilising hepatic flexure and right half of the transverse colon, mesocolon is related to SMV, middle colic vessels. Veins are friable here and gentle careful dissection under vision is needed to avoid unnecessary troublesome bleeding. If bleeding occurs it is better to keep a mop for a while and the bleeder is identified and caught with a haemostat and transfixation ligation is done using 3-0 vicryl or polypropylene. Firm pressure for few minutes controls most of the bleeding here. SMV is identified and care should be taken not

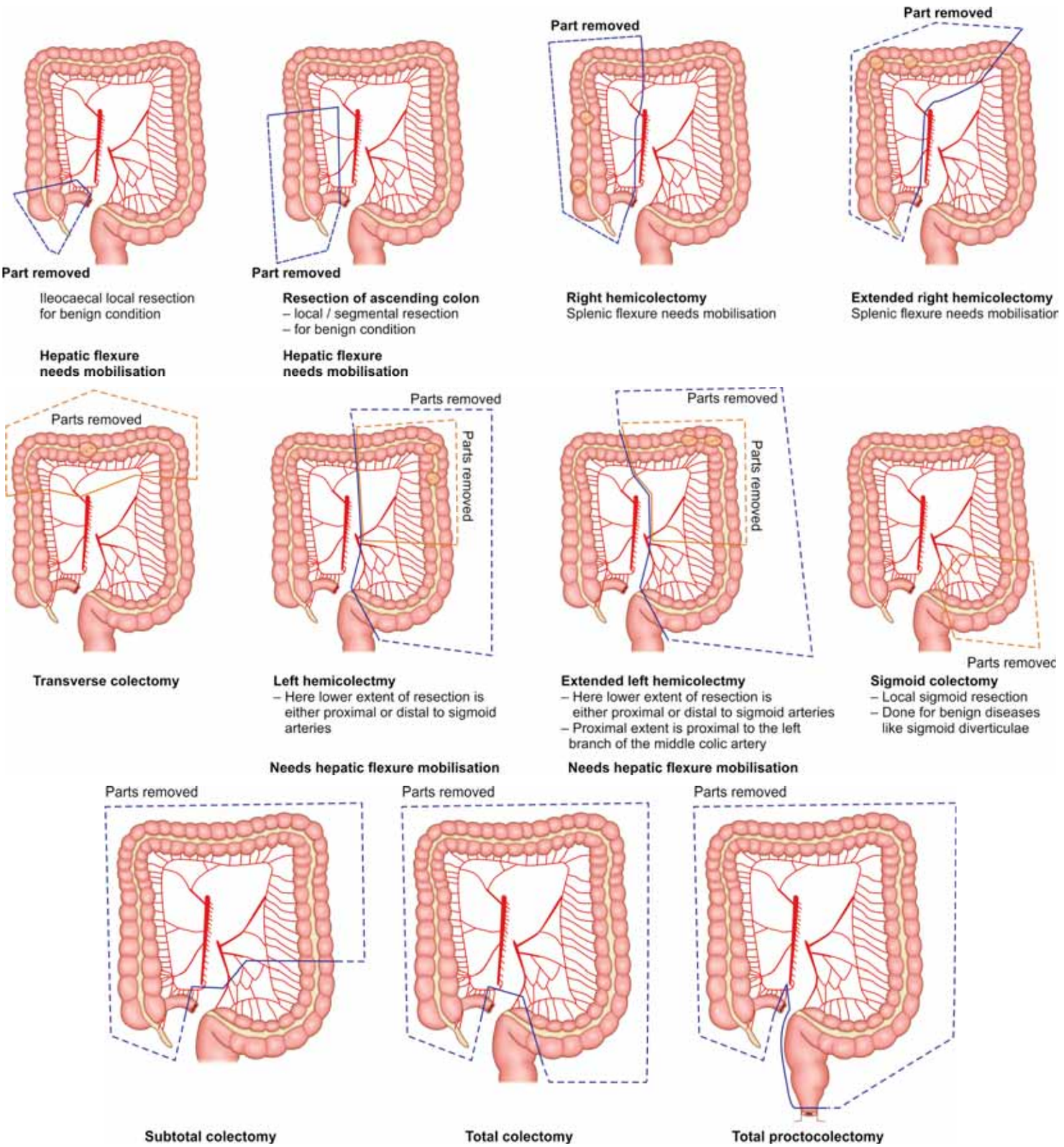
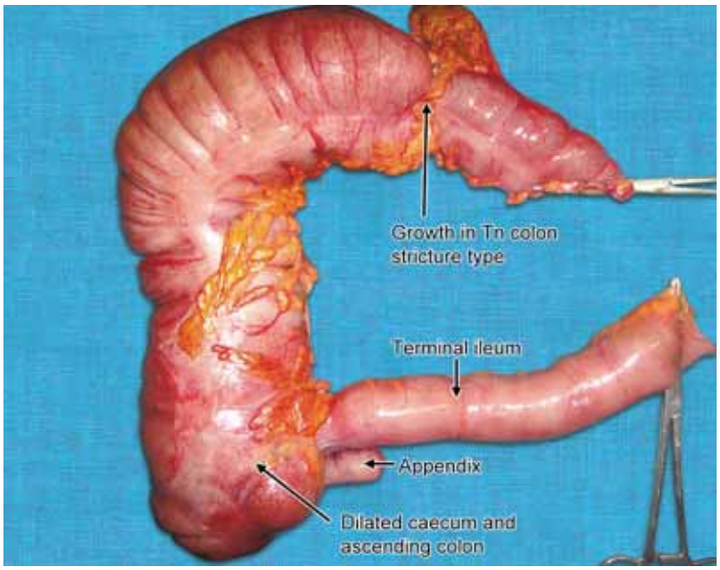


Fig. 24-24: Different types of colectomies with extents of resection.



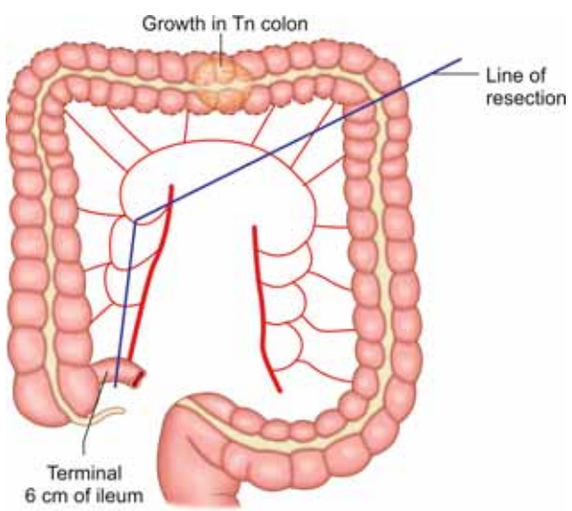


Fig. 24-25: Extended right hemicolectomy.

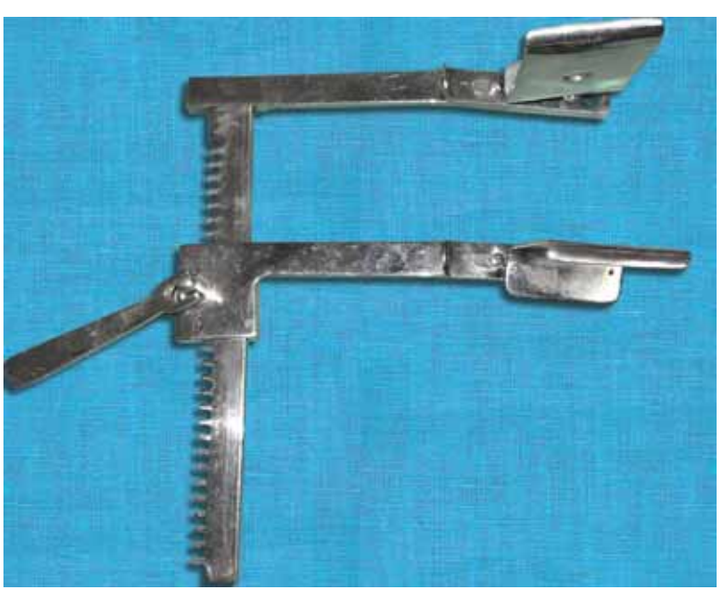


Fig. 24-26: Finochette retractor gives good exposure of the field keeping assistant's hands free for assisting.

to injure it. Peritoneum incision on the mesentery of the terminal 15 cm ileum is completed and that part of the ileum is also mobilised. Occlusion clamps are placed at the line of resection. Clamps are placed on the ileum obliquely; clamps should not extend onto the mesentery (only bowel part should be clamped). Another occlusion clamp is placed on the right 1/3rd to ½ of the transverse colon. Once right colon unit is completely mobilised, vessels are ligated. In benign diseases vessels are ligated very close to the bowel without intervening the main branch vessels. Often there will be fat in the mesentery which obviates the proper ligation; it is better to take short width of the mesentery of 1 cm for ligation; proximal double ligation or transfixation is needed and is safer. Vessels are identified through transillumination. In malignancy main vessels are ligated at its origin. Prior to ligation of the vessels one should confirm that ureter, gonadals, duodenum are kept away from the site of resection. Once mesenteric ligation is done within the area between the occlusion clamps; crushing or Kocher's clamps are applied on the specimen side. Ileum is cut using no. 15 blade from inside mesenteric point to outside antimesenteric part; similarly colon is cut between clamps to retrieve the specimen. Occlusion clamps should be placed oblique outwards to maintain the blood supply of the colon at its antimesenteric part. In practice occlusion clamps are placed 10 mm from the cut edges of the ileum and transverse colon; but ideally clamps should be placed 10 cm from the cut edges even though it is not practiced by most of the surgeons. Bleeding from the cut edge should be confirmed as well as pulsatile mesenteric edge. Fat should be removed from the colon for 1 cm from the cut edges to prevent fat interposition during anastomosis. For anastomosis, single layer interrupted full thickness 3-0 silk sutures or two layered interrupted full thickness vicryl sutures and outer interrupted seromuscular 3-0 silk sutures can be used. Cheatle's cut may be needed on the antimesenteric border of the ileum. Mesenteric rent is closed using continuous or interrupted 3-0 vicryl or silk sutures.

Conventional right hemicolectomy

Midline laparotomy
↓
Exploration
↓
Mobilisation of the colon from paracolic gutter through avascular plane of *Toldt*
↓
Safeguarding the ureter, gonadals
↓
Ascending colon and hepatic flexure is released from gall bladder by dividing hepatocolic ligament
↓
Mobilisation from the duodenum and Gerota's fascia
↓
Greater omentum is separated by ligation and division
↓
Care should be taken about SMV and its branches and bleeding
↓
Ligation of the vessels close to the colon in case of benign conditions; ligation of their branches at their origin from middle colic vessels to ileocolic vessels in case of malignancy to clear nodes
↓
Division of the terminal ileum and transverse colon between clamps
↓
Constructing a safe ileocolic anastomosis
↓
Closure of the mesenteric defect
↓
Suction tube drain and closure of the abdomen

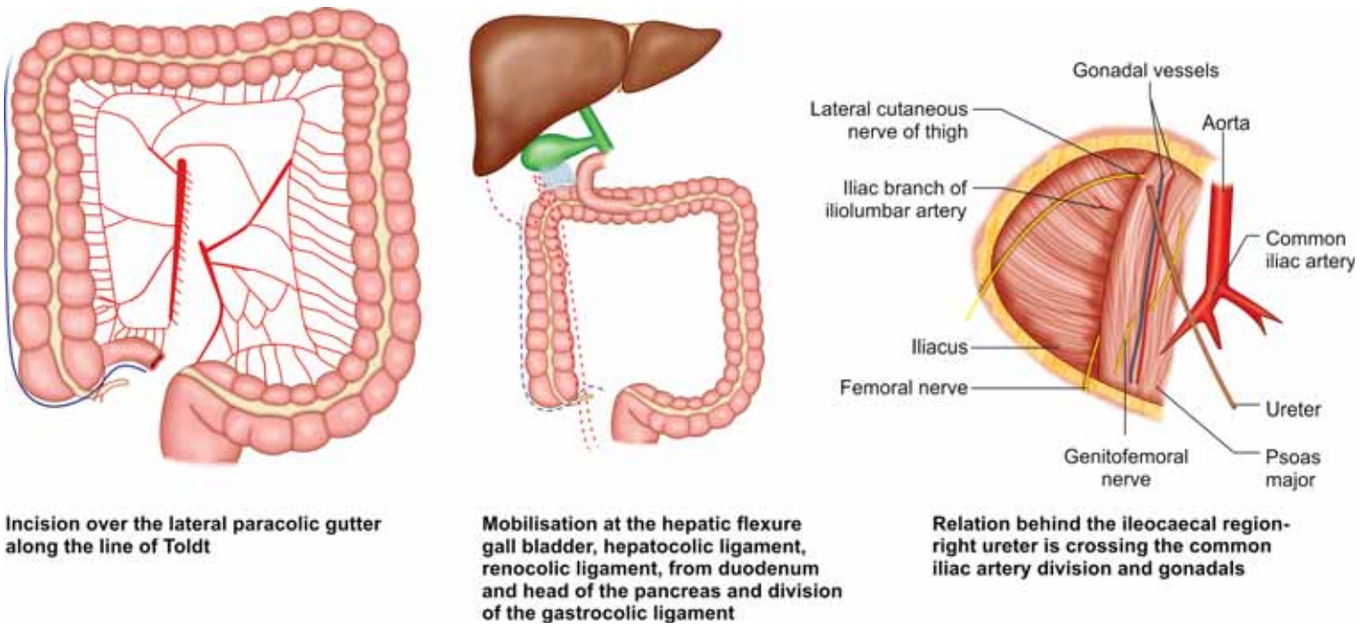

Gonadal vessels
Lateral cutaneous nerve of thigh
Aorta
Iliac branch of iliolumbar artery
Common iliac artery
Iliacus
Femoral nerve
Ureter
Genitofemoral nerve
Psoas major
Incision over the lateral paracolic gutter along the line of Toldt
Mobilisation at the hepatic flexure gall bladder, hepatocolic ligament, renocolic ligament, from duodenum and head of the pancreas and division of the gastrocolic ligament
Relation behind the ileocaecal region- right ureter is crossing the common iliac artery division and gonadals

Fig. 24-27: Relations, structures which will come across while doing right hemicolectomy.

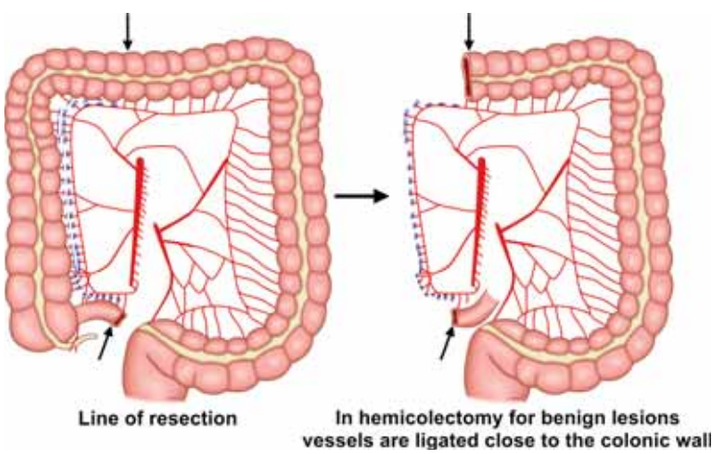


Fig. 24-28: In benign lesions, while doing hemicolectomy lateral to medial (conventional) approach is used with ligating the vessels close to the colonic wall without any lymphovascular clearance.

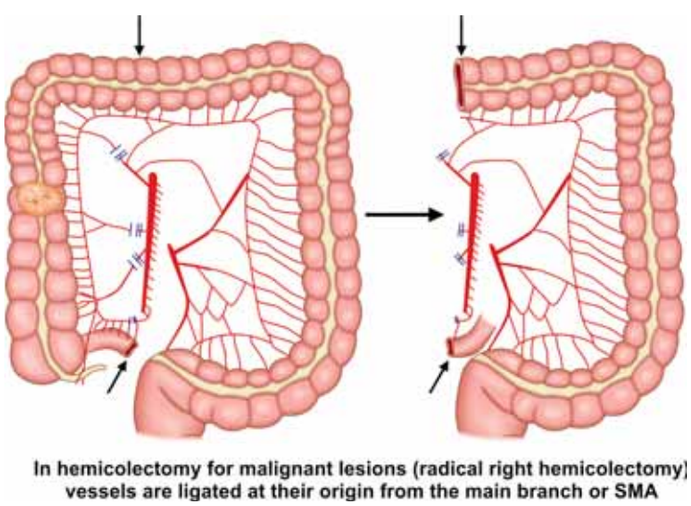

In hemicolectomy for malignant lesions (radical right hemicolectomy) vessels are ligated at their origin from the main branch or SMA

Fig. 24-29: In malignancy, medial to lateral approach (oncological) is used with proper lymphovascular clearance. Here vessels are ligated at their origin.

Radical Right Hemicolectomy

It is done commonly from medial to lateral with vessels ligated at its origin to clear the lymphovascular area. It clears the drainage lymph nodes properly in carcinomas. It also prevents spillage, avoids manipulation of the tumour area prior to vascular ligation—based on '*Turnball's no touch technique*'. Advantages of this medial to lateral technique are—it facilitates the early ligation of the main branches of the SMA and SMV and so prevents possible eventual trauma of superior mesenteric vessels while mobilising the colon; field will be clean and so anatomical variations are better identified. Early lymphovascular dissection achieves more precise dissection and clearance. Even though it is oncologically not very much proved, technically it is more precise. But surgeon should remember that radical hemicolectomy can also be done through conventional approach wherein after complete mobilisation of the colon, vessels are ligated at its origin to clear lymphovascular area.

Through transillumination vascular arcade is studied; site of division is decided in the ileum and transverse colon. After creating a small window at the mesenteric sides of these two points umbilical tapes or fine infant feeding tubes or two wet roller gauzes are passed one on each point (at terminal ileal and transverse colon sides) and tied firmly. Omentum (in malignancy) is detached from the stomach by ligation and divisions or harmonic scalpel can be used. First right branch of the middle colic artery is ligated at its origin (in carcinoma caecum and ascending colon); usually double ligation is needed proximally. In extended right radical hemicolectomy (carcinoma hepatic flexure and transverse colon), middle colic artery is ligated at its origin (at the level of the lower border of the pancreas) as colon division is far away at splenic flexure and remaining descending colon has its blood supply from left colic artery. Both middle colic artery and vein are ligated; inferior pancreaticoduodenal vein is very close and during dissection of the middle colic vessels this vein may get torn by avulsion causing torrential haemorrhage. Transverse colon is lifted upwards; right mesocolon is already opened while ligating the middle colic vessels; index finger is passed underneath to do gentle finger dissection; pulsation of the ileocolic trunk is felt. It is dissected from

surrounding areolar tissue; ileocolic vein is also located adjacent to the artery which should not be injured. SMA pulsation is also felt and is identified. SMA pulsation should not be mistaken for ileocolic arterial pulsation. Ileocolic artery and vein are individually ligated doubly using silk 1 cm distal to the SMA. Ileocolic vessels are divided. Ileal mesentery is divided for 10-15 cm (length of ileum removed depends on the location of the primary tumour). It is divided between ligatures.

Now right paracolic gutter is incised at avascular plane of Toldt from terminal ileum to hepatic flexure level using blunt finger and sharp scissor dissection. Ureter, gonadals, Gerota's fascia, duodenum is dissected using bipolar cautery and sharp scissor dissection. Blunt dissection here may injure these structures or can cause bleeding. Gerota's fascia is separated by dividing renocolic ligament. Omentum is separated from the greater curvature of the stomach (partial omentectomy) up to the level of transection of the transverse colon. Ureter is easily identified by its tubular shining nature with good peristalsis. Ureter crosses common iliac artery where bifurcates into external and internal iliac arteries. Reflected peritoneum may be having attached ureter and so should be inspected and felt carefully in the peritoneum.

Ileum and colon is divided similarly like mentioned earlier in conventional method above. Anastomosis is done. Stapler transection can be done at both ends; later completion with side-to-side stapler anastomosis **(Fig. 24-30)**.

Radical right hemicolectomy – medial to lateral vessel first hemicolectomy (Turnball no touch method)

Midline incision, exploration, self-retaining retractor
↓
Umbilical tape or fine infant feeding tube or wet roller gauze is tied around the ileum and transverse colon at their line of resection
↓
Transverse colon is lifted up
↓
Middle colic vessels are identified
↓
In right radical hemicolectomy, right branch of the middle colic vessel at its origin is ligated (in caecal and ascending colon growth). Origin of the middle colic vessels at the lower border of the pancreas is dissected and double ligated in hepatic flexure and right side transverse colon growth (extended). Double ligation should be ligated.
↓
Right colic vessels are ligated (may be absent also)
↓
Larger ileocolic artery is identified, dissected and doubly ligated (should not get confused for SMA)
↓
Terminal ileal vessels (terminal 10-15 cm) are ligated
↓
Now colonic mobilisation is done along the paracolic gutter through the line of *Toldt*
↓
Ureter, gonadals, duodenum, Gerota's fascia are identified and dissected away from right colon
↓
Ascending colon and hepatic flexure is mobilized by separating from gall bladder, duodenum and by cutting the renocolic ligament using scissor and gentle finger dissection; partial omentectomy is done by dividing the omentum adjacent to greater curvature of the stomach
↓
Once complete mobilization is over; specimen is divided between clamps on both sides. Fat at the colonic cut edges is freed for 1 cm;
↓
End to end hand sewn or side to side stapler ileo colic anastomosis is done
↓
Mesenteric defect is closed; suction tube drain is placed; abdomen is closed in layers

Stapler anastomosis can be done as side to side. Few stapler area in the antimesenteric borders of each ends which are brought together are removed just sufficient enough to pass the arms of the stapler. Arms are passed through this across the antimesenteric border and stapler is fired to create the anastomosis as side to side. Now stapled ends of the each part are having a defect at heir antimesenteric border which is closed by another linear stapling device.

Postoperative Care

Nasogastric tube is removed once bowel sounds appears; patient passes flatus; no distension in the abdomen. Drain is removed in 5 days. Oral fluid started in 3-5 days. Antibiotics are given. Fluid and electrolyte management is done judiciously.

Complications

Infection, subphrenic and pelvic abscess formation can occur. It is identified by CT imaging; initially can be treated with antibiotics conservatively but if persists or progress then US/CT guided pigtail catheter drainage or occasionally open drainage is done.

*Anastomotic disru*ption is dangerous complication. It causes leak from drain site or main abdominal wound. If leak is significant then re-exploration and re-anastomosis are done; commonly re-anastomosis is difficult due to friable inflamed oedematous bowel; ileostomy for diversion is best in such situation. If leak is less and patient is passing stool per anally then conservative treatment settles the leak. TPN, antibiotics, control of sepsis and observation, repeated imaging is the needed management.

Abdominal dehiscence is not uncommon; it needs resuturing of the rectus sheath, control of infection.

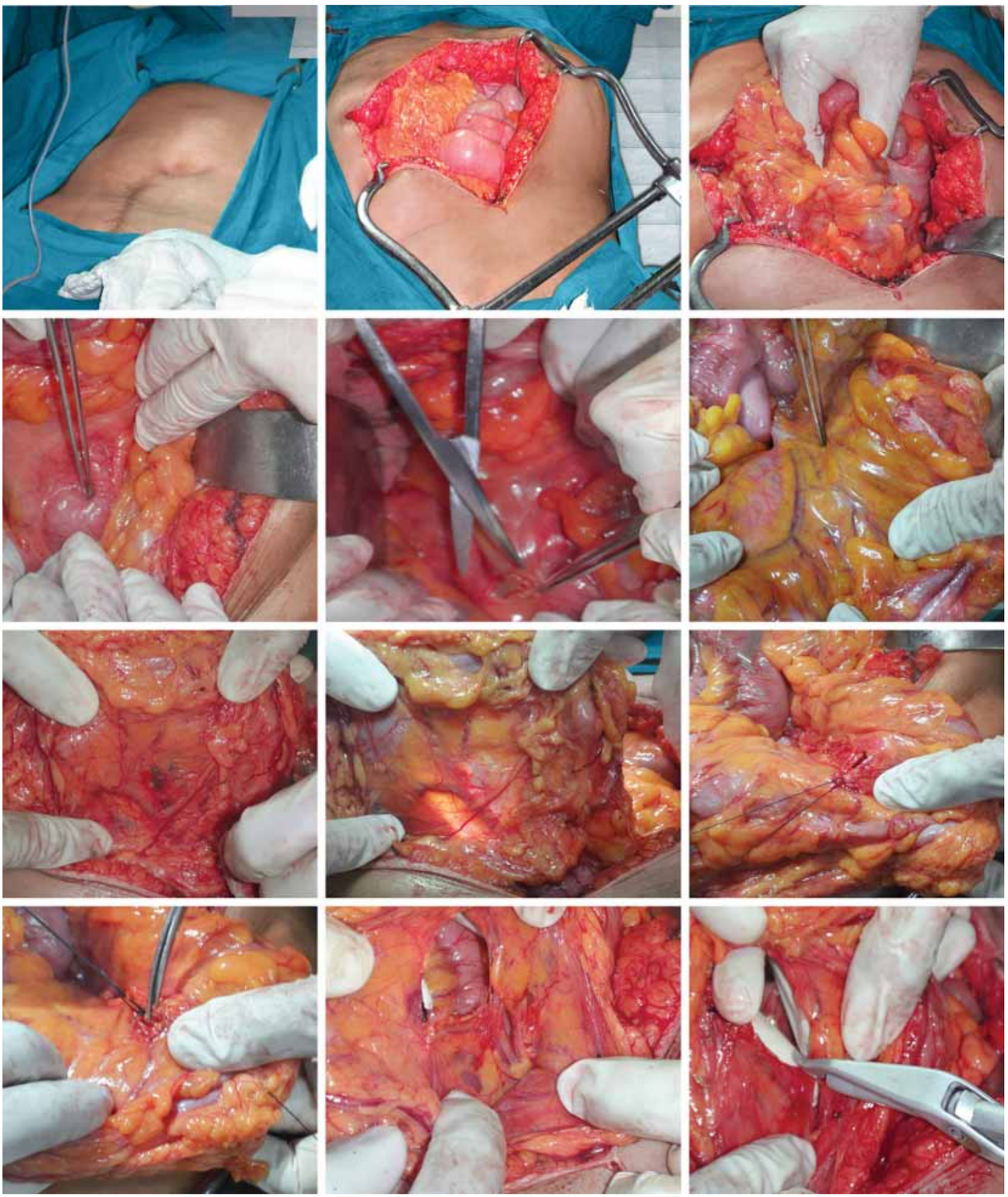
Injury to right ureter, duodenum can occur. Duodenal injury is sutured if it is small otherwise duodenostomy through a T tube should be done. Ureter injury on table when identified is sutured using interrupted 3-0 vicryl sutures. J stent should be placed in the ureter which is removed in 6-12 weeks.

LEFT COLECTOMY

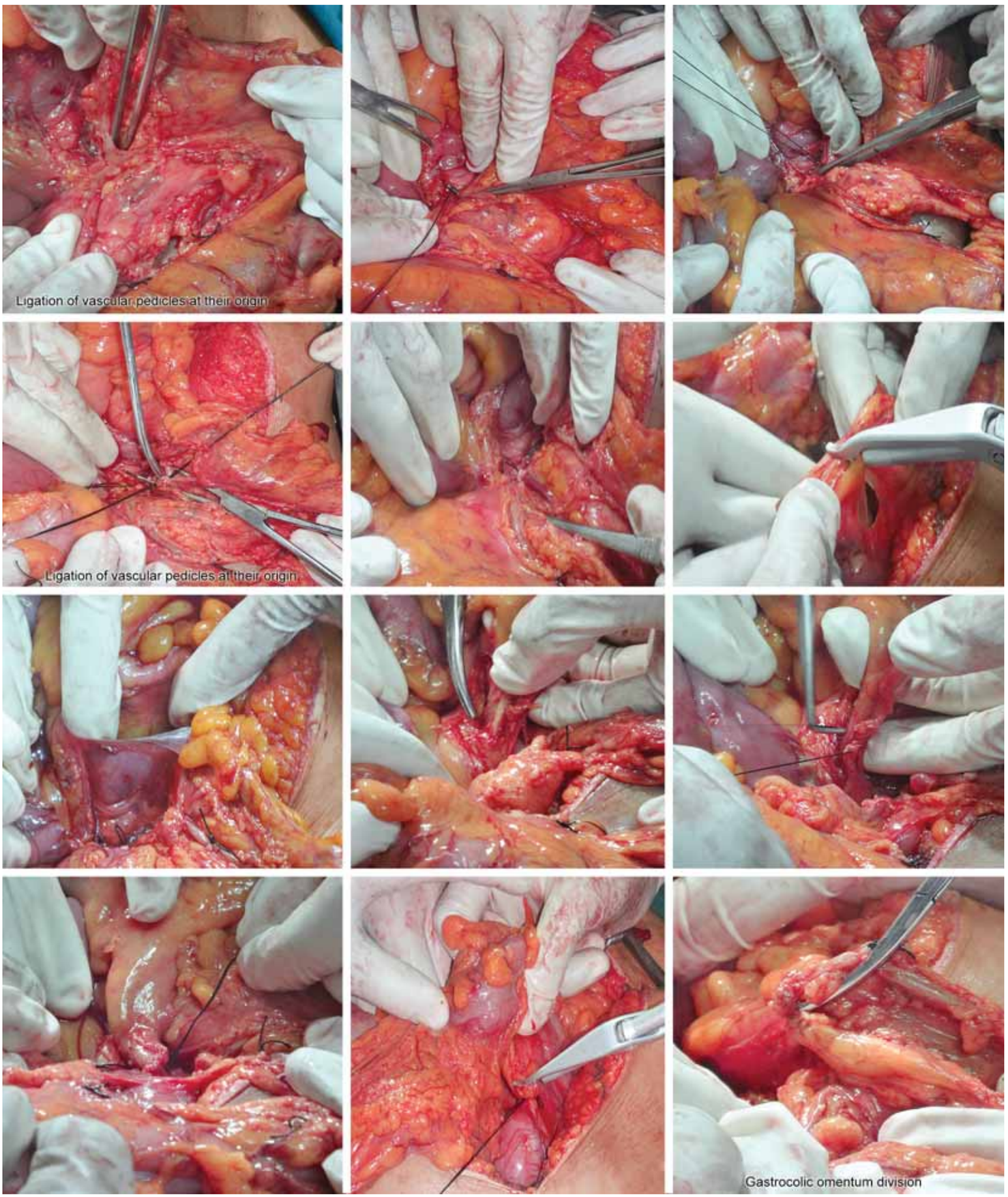
Left hemicolectomy is done for both benign and malignant diseases. Principles are almost similar as right hemicolectomy. But no touch technique is difficult to apply to left-sided colectomy. Marginal artery should be retained in all these patients especially in malignancies to maintain the blood supply retained to colon and anastomotic site. Left branch of the middle colic artery when retained is adequate enough to maintain the blood supply. Inferior mesenteric artery is ligated and divided at its origin from the aorta and inferior mesenteric vein is divided at lower border of the pancreas. Even most of the sigmoid if needs resection, blood supply of the anastomotic site can be achieved from middle rectal and inferior rectal arteries along with marginal artery. In benign diseases vessels are not ligated at their origin but close to the colonic wall as lymphovascular clearance is not needed.

In no touch technique, inferior mesenteric vessels are ligated first with lymphovascular clearance (for carcinoma left side colon) then left colon mobilisation is done. In benign diseases first mobilisation of the left colon is done then vessels are ligated close the colonic wall.

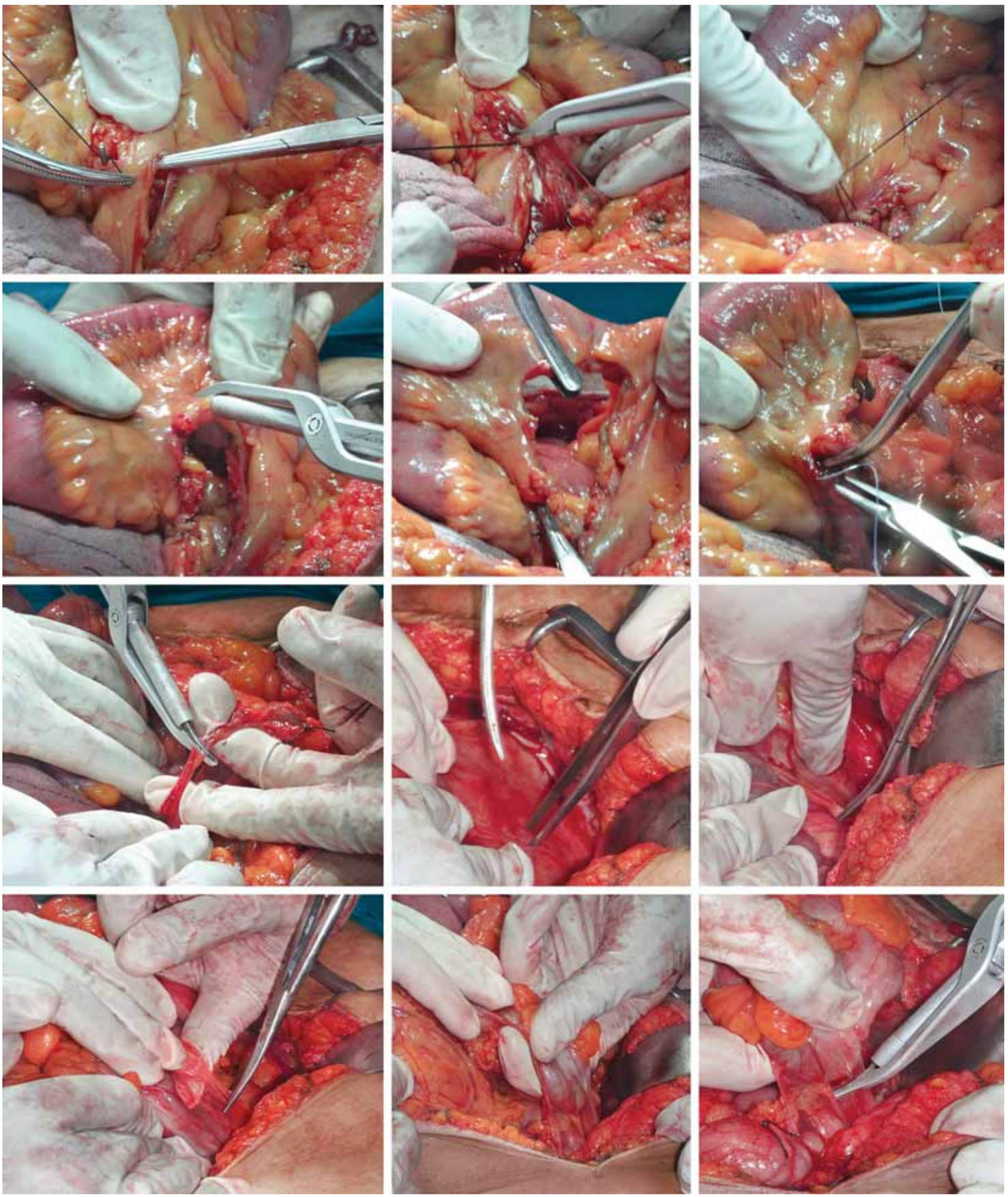
Splenic injury can occur while mobilizing the splenic flexure; alternatively spleen may get infiltrated by the splenic flexure growth which needs splenectomy. Gonadal vessels can be ligated if needed; but left ureter should be taken care of.



Figs 24-30(1)


Ligation of vascular pedicles at their origin
Ligation of vascular pedicles at their origin
Gastrocolic omentum division

Figs 24-30(2)



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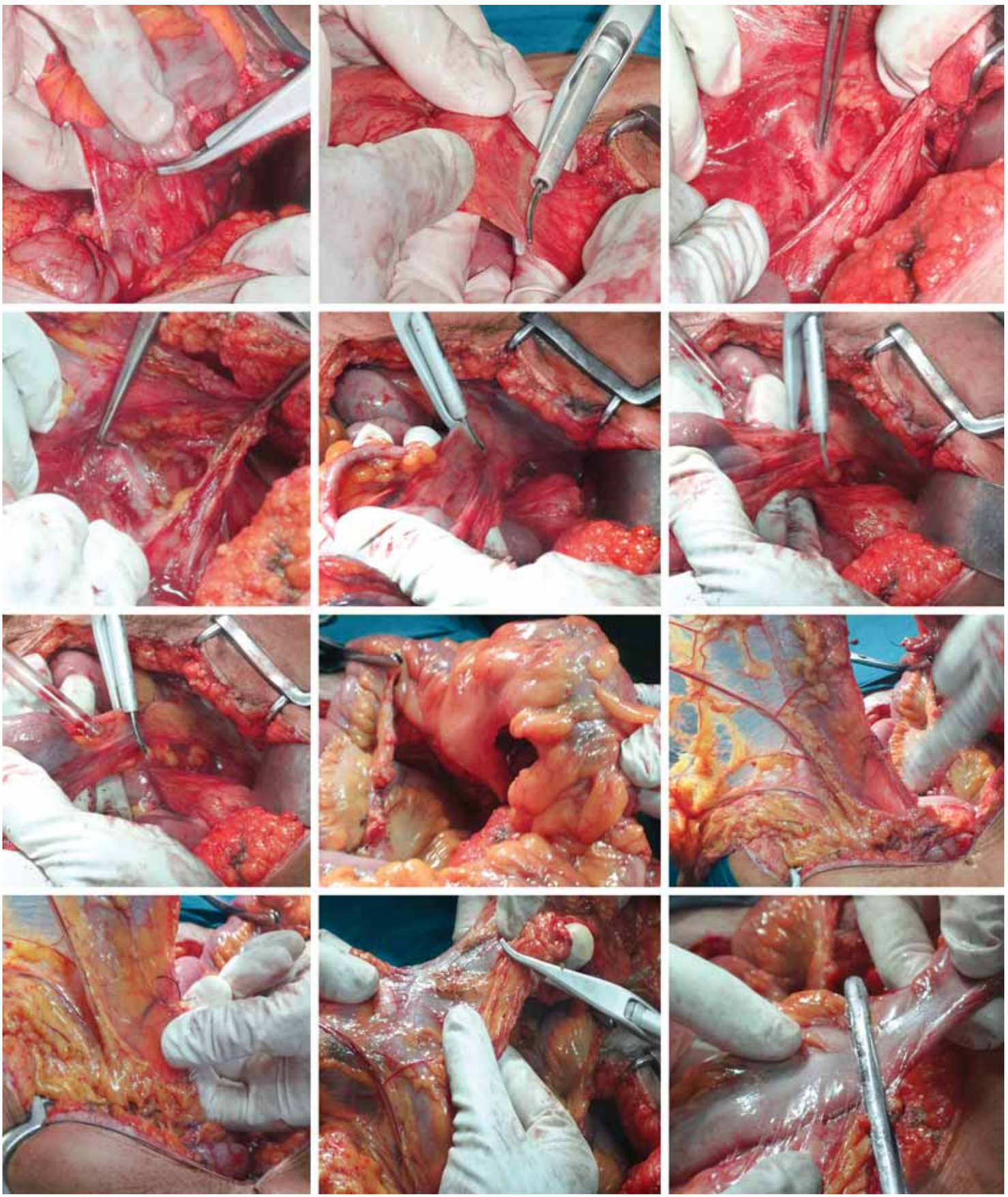

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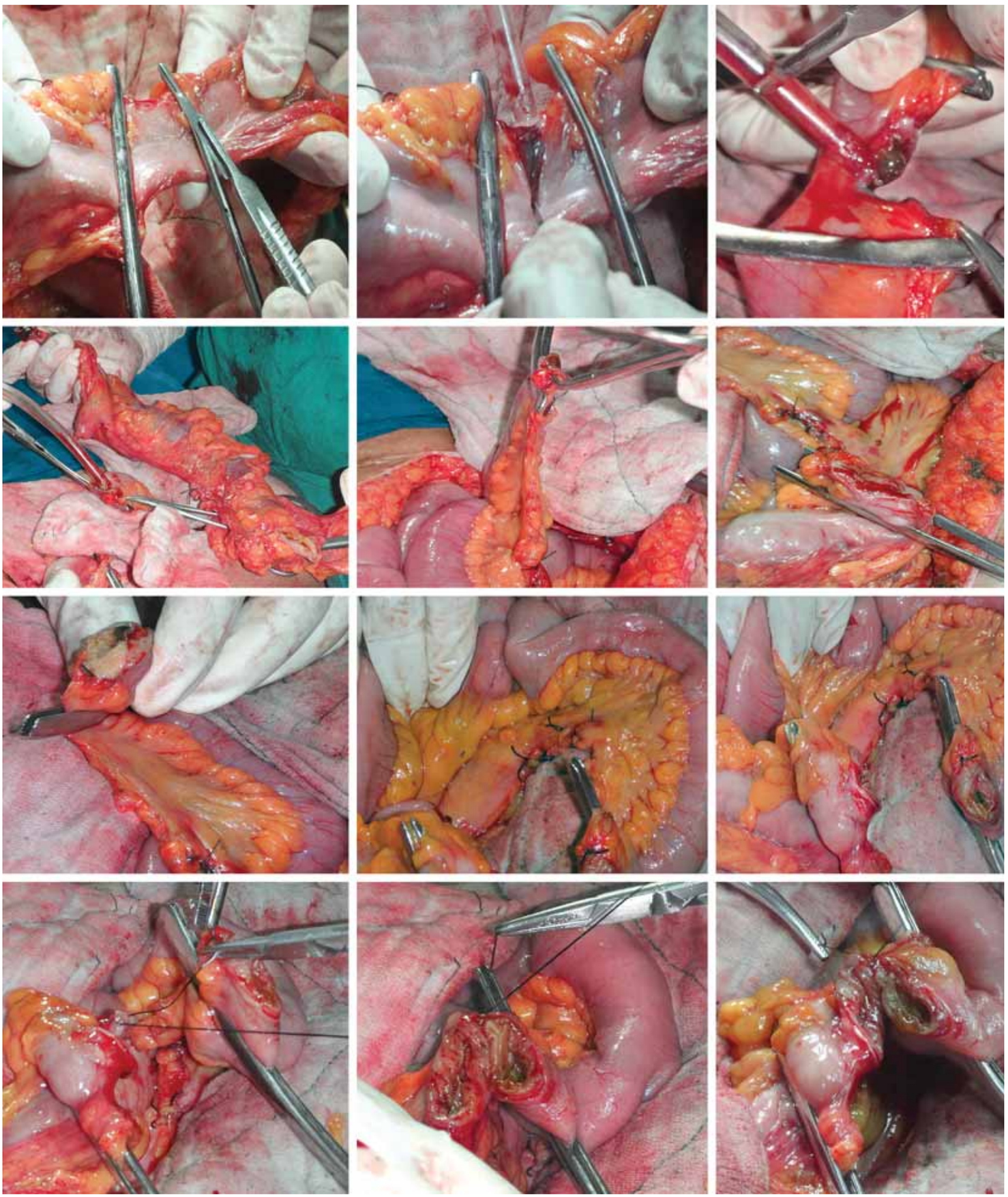

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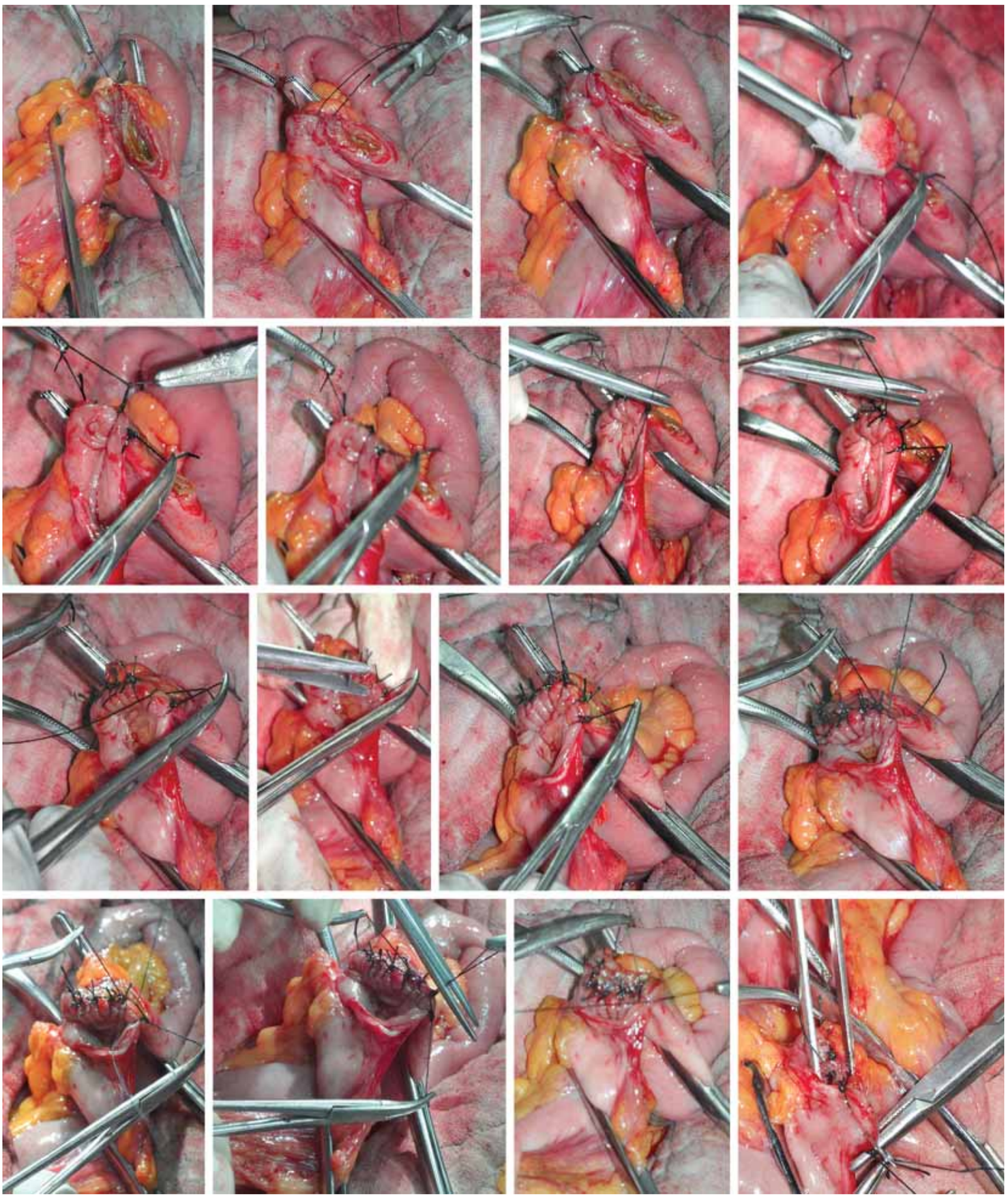

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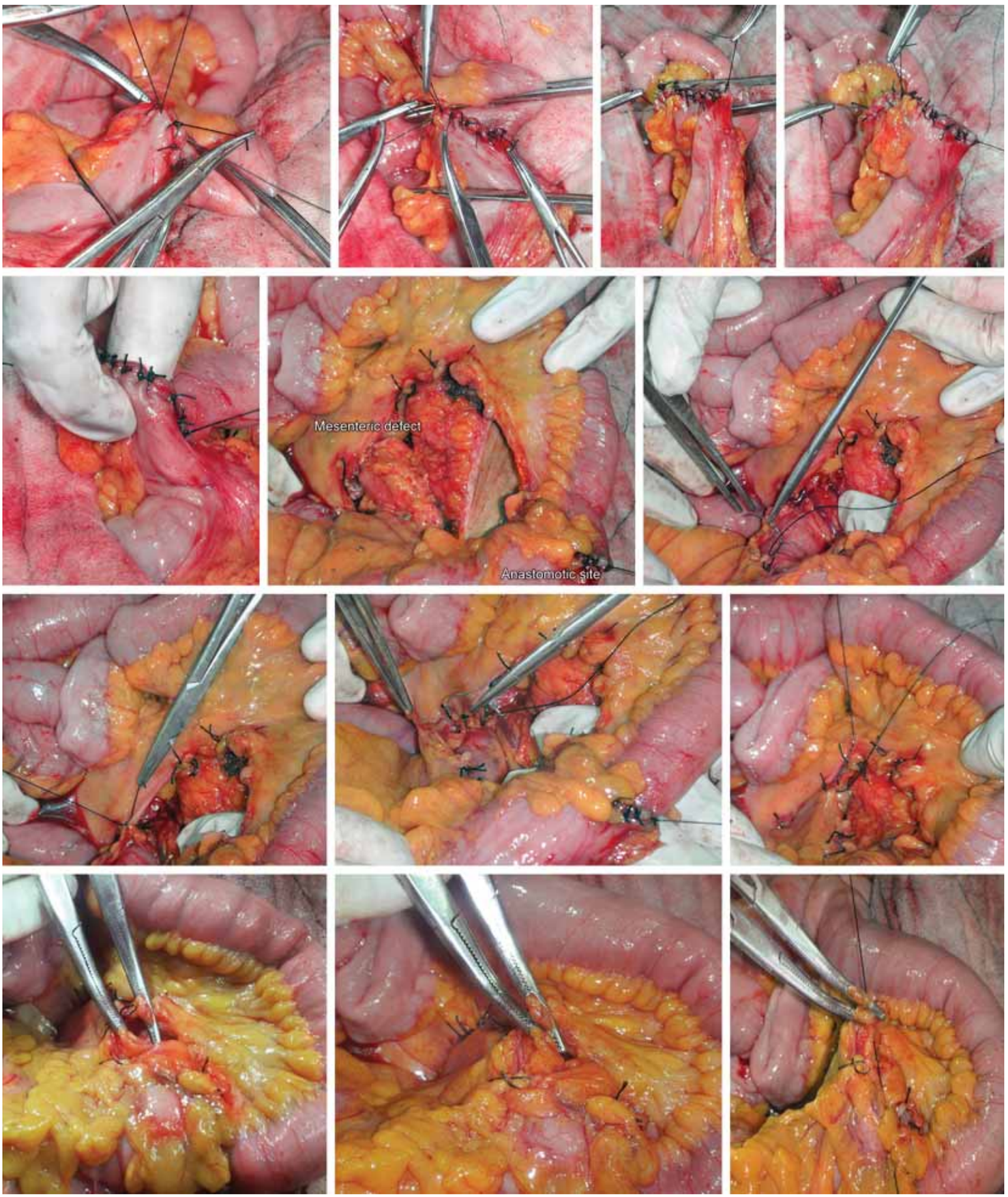
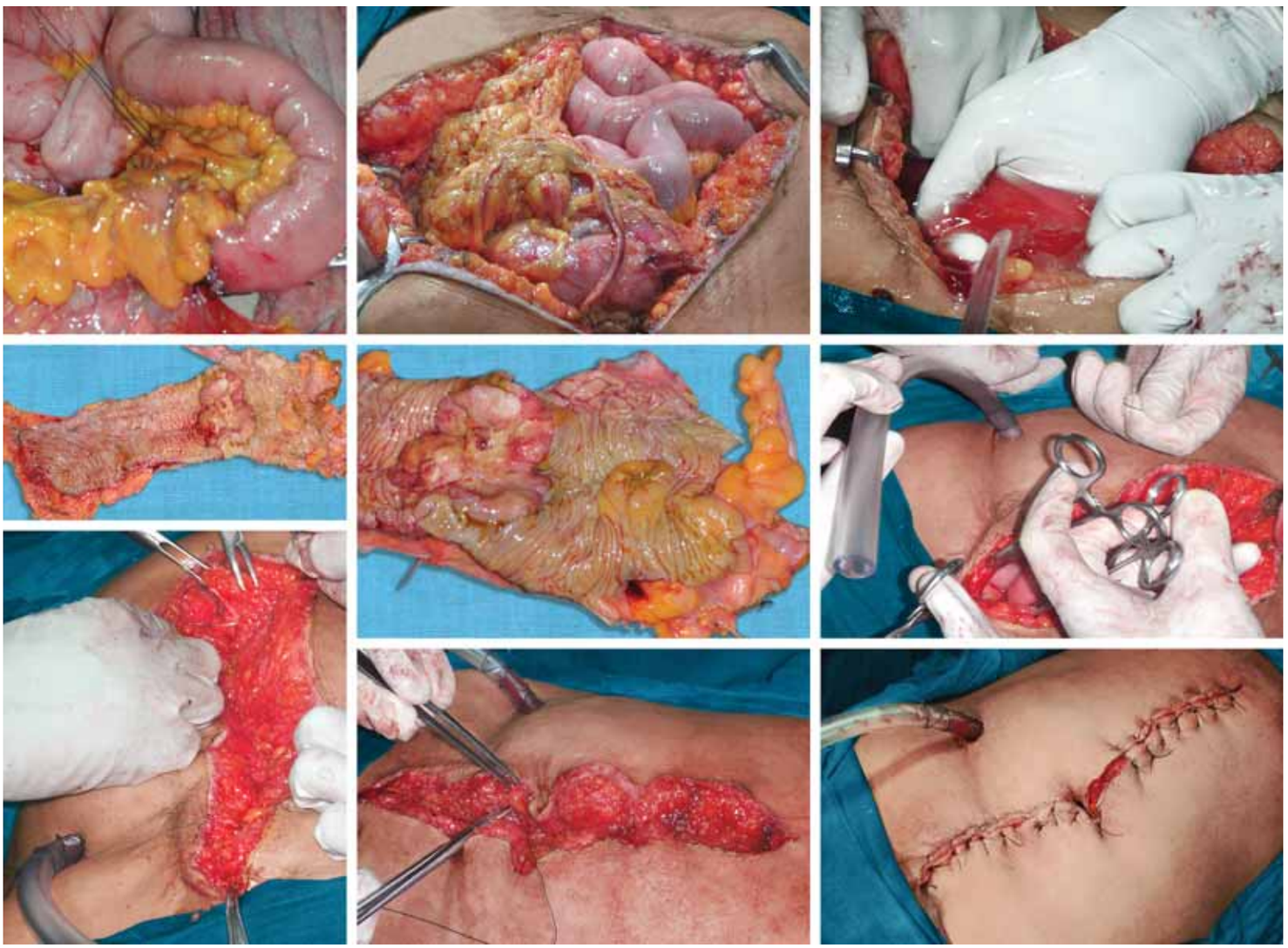


Figs 24-30(7)



Figs 24-30(8)

Figs 24-30(1 to 8): Right radical hemicolectomy with lymphovascular clearance with medial to lateral approach. Vessels are ligated near their origin.

Technique

Epidural and general anaesthesia are given. Nasogastric tube and urinary catheter are passed. After cleaning and draping lengthy midline incision is made. Head down position is better. If in sigmoid resection, when EEA stapler is used then low lithotomy position is better. Self retaining retractor like Finochette is used. Surgeon usually stands on the left side.

Sigmoid and descending colon is held towards right using a mop; peritoneum on the paracolic gutter is incised adjacent to sigmoid; left ureter and left gonadals are identified and safeguarded; incision is extended proximally towards splenic flexure; greater omentum attached to that part of the transverse colon close to the splenic flexure is divided between ligatures. Undue traction and blunt dissection should be avoided which may cause troublesome oozing. *Renocolic ligament* between capsule of left kidney and posterior part of the mesocolon is divided. *Lienocolic* (*splenocolic) ligament* is divided; *pancreaticocolic ligament* is divided to free the splenic flexure downwards. Appendices epiploicae of transverse colon may come across during dissection which when divided may cause bleeding; it needs proper ligation. While mobilising the splenic flexure adequate exposure is essential; undue traction on the colon may cause the avulsion on the omentum and bleeding; recognising the right plane and dissecting along that is needed; sharp scissor dissection with careful bipolar cautery fulguration is ideal rather than blunt dissection in splenic flexure mobilisation.

Duodenum 3rd and 4th part will be visualised here. Mesocolon on the medial aspect is incised from splenic flexure downwards towards the sacral promontory level. Inferior mesenteric artery is identified emerging from the aorta; its origin is visualised; 1-2 cm distal to its origin artery is double ligated and divided. This allows safe preservation of the hypogastric nerve plexus which are in front of the aorta. Preaortic areolar tissue with lymph nodes is swept medially to clear all lymphovascular tissues. Preaortic sympathetic plexus should not be injured to prevent development of sexual dysfunction. Inferior mesenteric vein is identified which runs upwards behind the duodenojejunal junction behind the pancreas to join splenic vein **(Fig. 24-31)**.

Rest of the mesocolon is divided down towards the sigmoid colon; here marginal artery is divided to complete the mesocolon and vascular dissection and mobilisation. If dissection is carried out downwards up to the rectosigmoid junction; proximal rectum

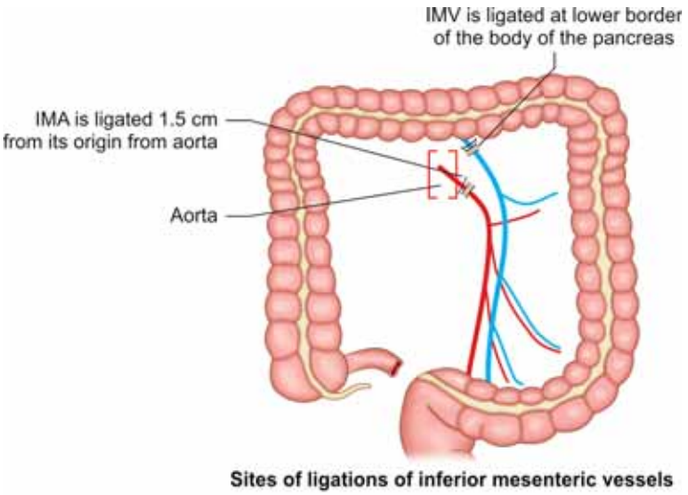

IMV is ligated at lower border of the body of the pancreas
IMA is ligated 1.5 cm from its origin from aorta
Aorta
Sites of ligations of inferior mesenteric vessels

Fig. 24-31: Ligation of inferior mesenteric vessels in radical left colectomy.

which is covered by peritoneum is dissected for 3 cm above the sacral promontory by ligating and dividing the vascular pararectal tissues. Autonomic nerve plexus lying on the posterior pelvic brim is preserved. Fat around the rectum for 1 cm should be cleared meticulously to achieve optimum anastomosis. Occlusion clamp is applied to the transverse colon proximal to the mobilised splenic flexure; crushing clamp is applied towards specimen side and divided in between using cautery or ideally no. 15 blade. Proximal cut edge should bleed adequately for safe anastomosis. Distally proximal to the mobilised and dissected proximal rectum another curved crushing / Kocher's clamp is applied (towards specimen side); usually clamp is not placed on the rectal stump side; however a soft occlusion clamp can be used if necessity arises. Bleeders in cut edge of the rectum are ligated using fine 4-0 vicryl or bipolar cauterisation is done. Fat should be cleared from the cut both ends for 1 cm; bleeding cut edge should be confirmed. Proximal cut end of the transverse colon easily reaches the rectal stump at sacral promontory level. If tension is present then the hepatic flexure should be mobilised to make transverse colon tension free.

While anastomosing, the cut edges transverse mesocolon should come towards the right side of the rectum. Usually two layered anastomosis is done; but single layer interrupted silk sutures are sufficient. Surgeon should stand on the left side while doing anastomosis. Initially two posterior seromuscular 3 zero silk sutures are placed on the medial and lateral aspects; knots are not tied now and these sutures act as marker / stay sutures to identify the medial and lateral edges of the rectal end. Then remaining 4-6 seromuscular sutures are placed at 5 mm gap; once all sutures are placed they are tied; leaving medial and lateral tied stay sutures long remaining sutures are cut. 2nd posterior full thickness interrupted 3 zero vicryl sutures are placed at 5 mm gap; once all sutures are placed they are tied together. 3rd layer anterior full thickness interrupted 3 zero vicryl sutures are placed and tied together. Lastly anterior seromuscular interrupted 3 zero silk sutures are placed. Site is checked for tension free anastomosis with adequate lumen inside **(Fig. 24-32)**.

Many use continuous 3 zero vicryl sutures for 2nd and 3rd layer. It is also practiced that if apposing area can be rotated for 180° then anterior layer seromuscular sutures are placed first; rotated fully to visualize the posterior layer through which anterior full thickness, posterior full thickness and posterior seromuscular sutures are placed and colon is derotated back to its original position. *End to end (EEA)* stapler can be used to achieve proper anastomosis. *Linear stapling device* can be used to transect at transverse colon level as well as rectal level.

It is often used to pass a wide Foley's catheter (no. 22 F) per anally and gently to negotiate across the anastomotic site to keep it there for 48 hours. After insertion of the Foley's catheter before negotiating across, anastomotic field is filled with normal saline and air is pushed across the Foley's catheter to check air bubbles in the field; if air bubbles are present then few more interrupted silk sutures may be placed at the site of the leak. Again even though it is not mandatory many do anal sphincter dilatation presuming that it will prevent distal obstruction and so reducing the chances of anastomotic leak. Tube drain is placed in the pelvis. Abdomen is closed in layers.

Postoperative Care

Nasogastric tube is removed in 72 hours; oral liquid is started. Drain is removed in 7 days. Skin sutures are removed in 10 days.

Complications

Intraoperative – injury to left ureter; spleen, haemorrhage—adequate exposure and careful dissection will prevent this.

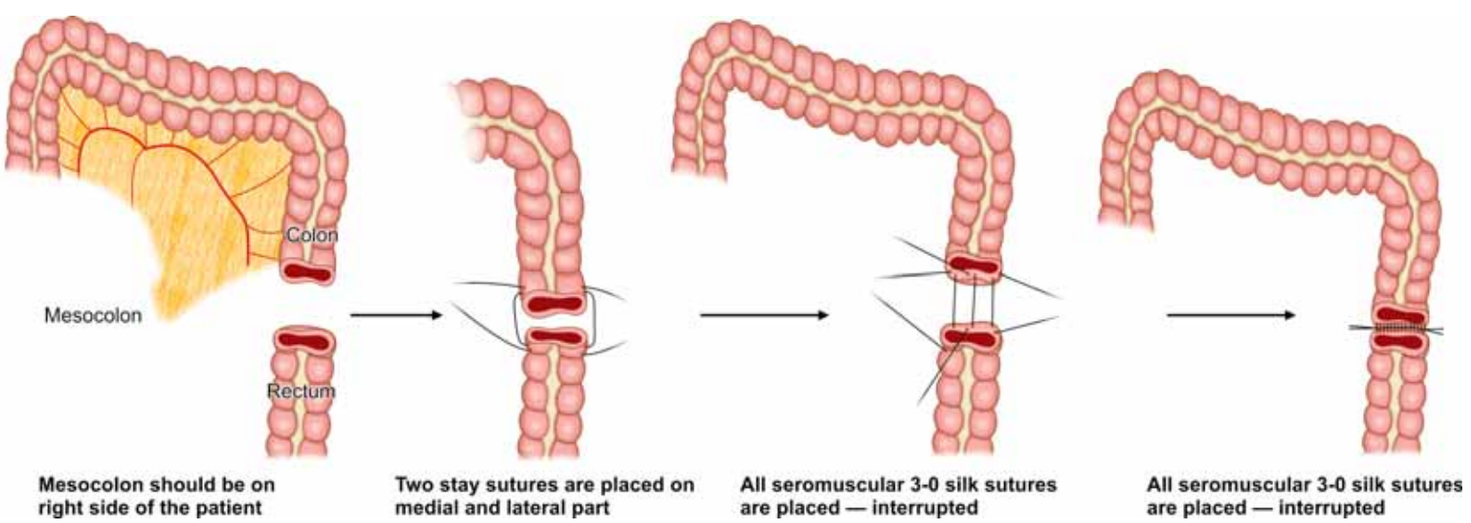

Colon
Mesocolon
Rectum
Mesocolon should be on right side of the patient
Two stay sutures are placed on medial and lateral part
All seromuscular 3-0 silk sutures are placed — interrupted
All seromuscular 3-0 silk sutures are placed — interrupted

Fig. 24-32: Placing seromuscular sutures in colorectal anastomosis.

Postoperative—anastomotic leak can occur; it is usually partial leak and subsides gradually. If significant high fistula persists then covering diversion proximal colostomy or ileostomy should be done. Often peritonitis may develop in such situation, anastomotic site is detached and proximal colonic part of anastomosis is brought out as colostomy; distal rectal stump is closed (Hartmann's) which is sutured to sacral promontory by 2-3 silk sutures to prevent it from getting retracted; once patient recovers from sepsis, only after 3 months resurgery should be done to maintain the continuity. Pelvic abscess, left sided subphrenic abscess are other complications which can occur.

LAPAROSCOPIC COLECTOMY

Laparoscopy for colectomy right or left is now well-accepted approach. There is lack of tactile sensation; dissection in more than one quadrant needs to change the camera in different ports during dissection. Contamination, bleeding, spillage of the content, port site recurrence, conversion, long time, cost are different problems. Still colectomy either totally laparoscopic or hand assisted are accepted universally. Principles and technique are same as open surgery. Identification and localization of the pathology, mobilisation of the needed part of the colon, devascularisation, restoration of the bowel continuity are essential steps of the colectomy. Different ports of different sizes, specialised instruments like bowel grasper and endostaplers are needed. Endostapler needs 12 mm port.

Different types of laparoscopic colectomies are practiced. In dissection facilitated laparoscopic colectomy, mobilisation of the colon is done through laparoscopy; and then through a small laparotomy incision, resection and anastomosis is done. In resection facilitated laparoscopic colectomy, dissection and resection is done through laparoscopy; specimen retrieval and anastomosis is done extracorporeally. In near total laparoscopic colectomy, dissection, resection and anastomosis is performed through laparoscopy; specimen retrieval and anvil of the circular stapler is passed through a small incision. In totally laparoscopic colectomy, dissection, resection, retrieval of the specimen and anastomosis are done through laparoscopy only; it is technically very demanding and time consuming.

Indications: Colonic malignancy, colonic tuberculosis, ileocolic Crohn's disease; diverticulitis, polyps which cannot be removed through the colonoscopy.

Contraindications: Faecal peritonitis, cirrhosis of liver, large abdominal aneurysm, pregnancy, cardiopulmonary problems, previous abdominal surgeries, blood dyscrasias.

Laparoscopic Right Hemicolectomy

Conventional lateral to medial approach and oncological medial to lateral approach are the two approaches. Former one is used in benign lesions and technically easier; latter one is used in malignancy wherein first vascular control is obtained prior to mobilisation. Nasogastric tube and urinary catheterisation are done. Under general anaesthesia, in supine position, cleaning and draping are done. Monitor is kept on the right side; surgeon stands on the left side; cameraman on the left of the surgeon; then scrub nurse.

Port positions: 10 mm umbilical port is created as open method (or closed Veress needle method can be used) which is used as right hand working port initially then later as camera port; suprapubic 10 mm port is used as camera port for mobilisation and later is used for retraction; left hand 5 mm working port is on the right iliac fossa; 10 mm epigastric port initially is used for retraction during hepatic flexure mobilization and later as right hand working port **(Fig. 24-33)**.

Medial to lateral oncological approach: Here during initial dissection of lymphovascular tissue, lateral peritoneal attachment of the ascending colon, which is yet to be divided acts as a natural retractor facilitating the vascular dissection easily. Camera telescope is passed through the suprapubic 10 mm port; terminal ileum is held upwards; peritoneum is opened behind the terminal ileum and caecum; retroperitoneal tunneling is created; right ureter and right gonadals are identified in this avascular plane; cranial dissection is done in front of the right ureter and right gonadals till 2nd part of the duodenum is visualised; Gerota's fascia is seen during this dissection which is not opened. Duodenum, head of the pancreas and IVC is visualised. Stretching of the mesentery facilitates the identification of the ileocolic and right colic vessels from below upwards. Ileo colic vessels are dissected close to their origin to SMV and SMA; fat and lymphatics are cleared off from its surface; ileocolic artery and vein are individually clipped or ligated and divided. Right colic vessels are also divided; often right colic vessels may be absent. Mesentery is divided using harmonic scalpel. Mesentery division continues on the transverse mesocolon until the right branch of the middle colic vessels are identified which are individually clipped and divided. Patient's position is changed to head-up position (reverse Trendelenburg). Right flexure of the colon is retracted downwards and medially; now umbilical port is used as camera port; epigastric port is used for right hand working. Lesser sac is entered by dividing the greater omentum between transverse colon and stomach. Dissection continues laterally by dividing the peritoneum between duodenum and pancreas and transverse colon. Hepatocolic ligament is divided to release the hepatic flexure. Middle colic vessels can be ligated at this juncture as proximal as towards its origin. This completes the devascularisation of the entire right colon; mesentery of the terminal ileum is divided using harmonic scalpel. At the end lateral attachment of the colon is divided using harmonic scalpel to complete the dissection and devascularisation. Intracorporeal resection is done using endo stapler; specimen is retrieved through a small subumbilical incision and anastomosis is done extracorporeally. Alternatively after dissection and mobilisation, mobilised part is exteriorised through a small subumbilical incision; resection is done; anastomosis is done using hand sewn or lineal stapler.

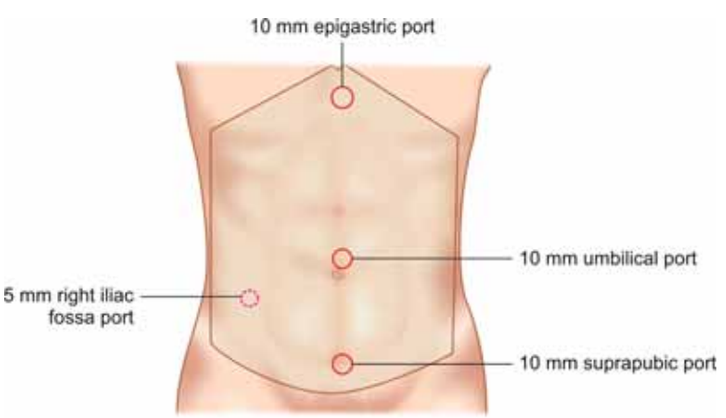


Fig. 24-33: Ports used for right laparoscopic colectomy.

Lateral to medial approach: It is conventional one wherein lateral peritoneal attachment (along the white line of Toldt) of caecum and ascending colon is incised and colon is mobilised; similarly hepatic flexure and transverse colon is mobilised using harmonic scalpel. Right ureter, vas deferens, gonadals and duodenum are identified. Gastrocolic ligament is divided. Subumbilical midline incision is done for 5 cm; mobilised colon is brought out; ileocolic, right colic and middle colic vessels are ligated and divided extracorporeally; in benign conditions vessels are ligated close to the colonic wall as there is no need to divide branch vessels at their origin. Resection and anastomosis is done extracorporeally; mesenteric defect is closed; anastomotic parts is placed back into the peritoneal cavity; minilaparotomy is closed in layers; again pneumoperitoneum is created; peritoneal cavity and anastomotic site is inspected; port area are closed in layers.

Laparoscopic Left Hemicolectomy

Patient is placed supine with semilithotomy position with thighs placed in semiflexed and hips flexed to only limited 15^0. Rotating table is a must to tilt the table as needed. Nasogastric tube insertion and urinary catheterisation is done. Monitor is placed on the left foot side. Wide area cleaning and draping is done; camera port (10 mm) is placed in supraumbilical position or right of the midline; 10 mm right hand working port is in the right iliac fossa; 5 mm left hand working port is in the right lumbar region; 10 mm colon retracting port is in the left lumbar area. Additional trocars may be added depending on need. Surgeon initially stands on the right side but changes the position to between legs for dissection of the splenic flexure and transverse colon on the left side. Head down with left upwards is the usual table tilt done to make small bowel to fall away from the pelvis.

Peritoneal cavity is explored including liver for initial assessment. Sacral promontory is identified; over the medial aspect of the mesosigmoid an incision is made; through the left lumbar midclavicular port sigmoid is grasped and retracted laterally. Avascular plane is reached by deepening the plane. Plane in front of the ureter, gonadals and inferior mesenteric vessels is dissected carefully. Ureter is safeguarded. Inferior mesenteric vessels are dissected and, ligated and divided individually using silk (intracorporeal sutures). Dissection in this plane is continued upwards towards the splenic flexure. Gerota's fascia is visualised and kept undisturbed.

Now sigmoid colon is gently retracted medially and lateral colonic peritoneal attachment is incised along the white line of Toldt. Surgeon should stand in between legs incision; monitor is shifted towards head end; table may be tilted according to need. Dissection over the lateral peritoneum is carried out upwards. Renocolic, splenocolic attachments are released; gastrocolic omentum is divided between stomach and transverse colon. Pancreaticocolic ligament is dissected to release the splenic flexure adequately downwards **(Fig. 24-34)**.

Surgeon returns back to right side position; monitor is shifted back to foot end. Rectal dissection is done through avascular plane between the layers of the pelvic fascia; mesorectum is divided up to the line of resection using harmonic scalpel. Colon can be transected using endostapler; otherwise through subumbilical incision colon is exteriorized; mobilized colon is resected; and end to end or stapler anastomosis is done. Sterile barrier (plastic) should be used while retrieving the specimen to avoid port site complications. Alternatively after resection using stapler; anvil of the EEA stapler is sutured to proximal end using nonabsorbable purse string suture; both ends are dropped into the peritoneal cavity. EEA stapler is gently negotiated per anally towards peritoneal cavity; its sharp point is made to perforate away from stapler line; it is connected to the anvil already present in the peritoneal cavity along with the proximal cut end of the bowel with purse string and locked. Stapler is fired to complete the anastomosis. Device is removed; doughnut is observed.

Complications and Problems with Laparoscopic Colectomy

Difficulty in dissection and mobilisation; injury to vital structures; multiquadrant dissection; problems related to laparoscopy itself; inability to feel the tumour; problems with the retrieval of the specimen; port site problems; increased operating time; anaesthesia complications; availability of the instruments; cost are different problems.

Complications specific to technique are—anastomotic leak; abscess formation (pelvic/subphrenic); anastomotic stenosis. In such situation proximal diversion or colostomy with mucus fistula formation or Hartmann's procedure may be required. Inadequate clearance in case of tumours, port site recurrences are other complications.

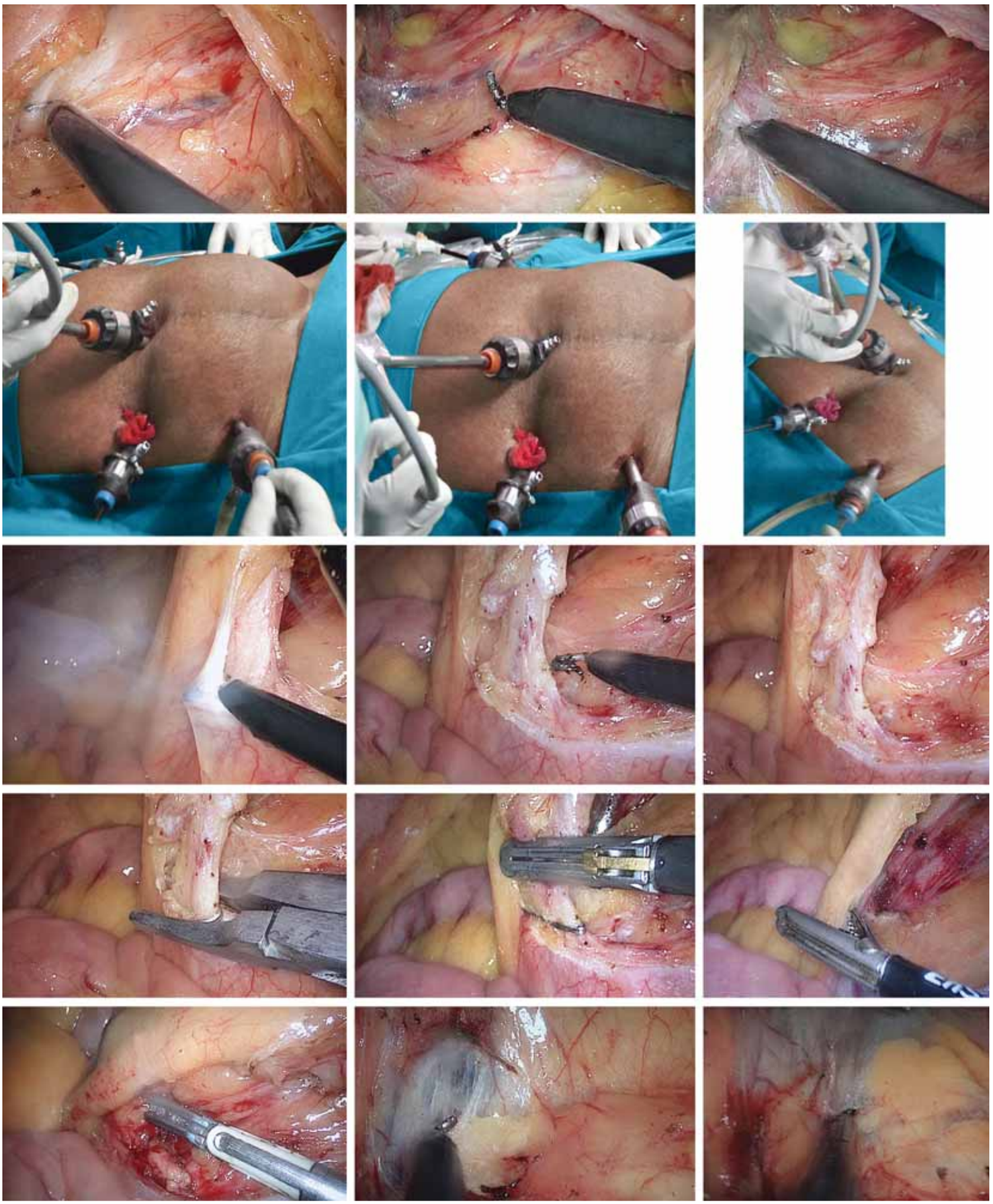
Laparoscopic Subtotal/Total Colectomy

It is demanding technique as it needs mobilisation of the colon in different quadrants as well as in pelvis. Tilting table is a must as position has to be changed depending on the site of mobilisation. With steep head-down (Trendelenburg) position (similar like for left colectomy) after placing adequate proper ports dissection begins at rectosigmoid. Dissection here is same as for left colectomy mentioned above. Inferior mesenteric vessel ligation; splenic flexure mobilisation remains the same. Transverse colon mobilisation is carried out as continuation of the splenic flexure mobilisation; gastrocolic omentum is divided using harmonic scalpel; transverse mesocolon is dissected to identify the middle colic artery which is ligated and divided. SMA should be identified and safeguarded without injuring it.

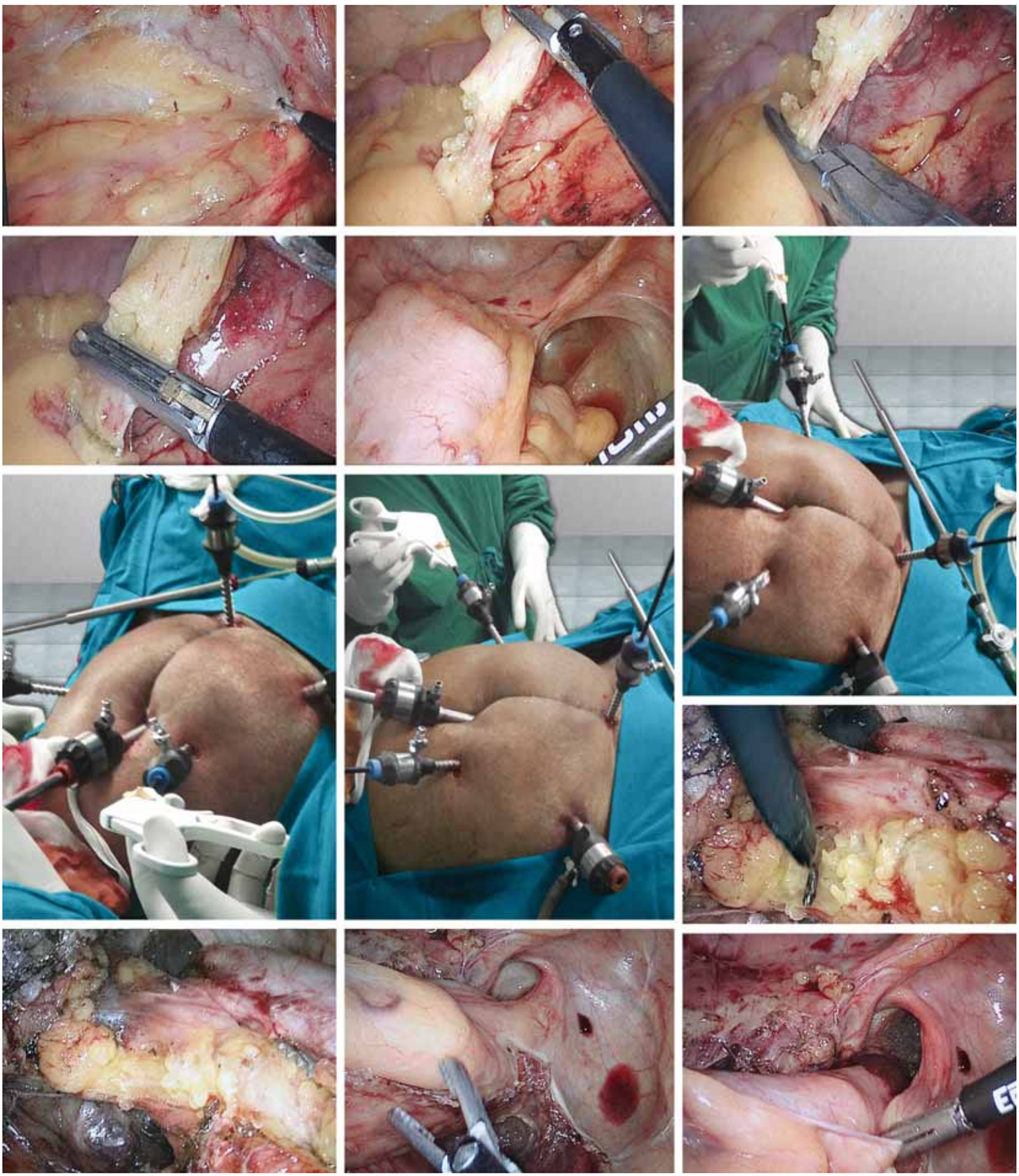
Right colon mobilisation is done with surgeon standing on the left side similar to right colectomy. It is done from medial to lateral approach. Retroperitoneal tunneling is created; right ureter, gonadals are identified; plane in front is dissected upwards; ileocolic vessels are ligated; then right colic artery. Once vascular divisions are complete, lateral peritoneal attachment is incised and divided along the Toldt's line. Terminal ileal vessels are divided using harmonic scalpel.

Rectum is further mobilised depending on the level of resection; injury to sympathetic nerves should be avoided to prevent sexual dysfunction. Injury to sacral plexus vessels will cause torrential haemorrhage; it is difficult to cauterise them as they retract into the sacral foramina.

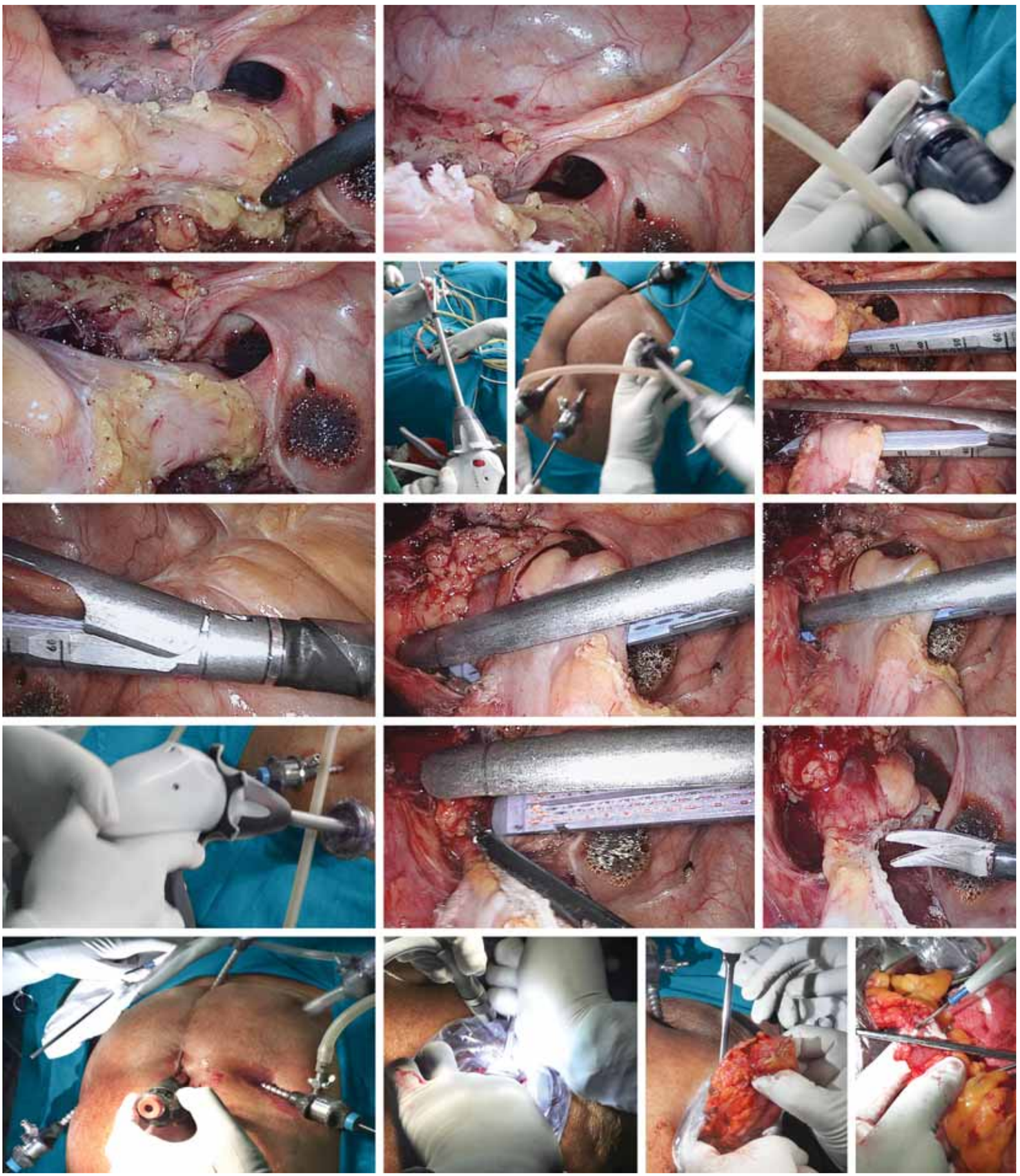
Rectosigmoid is divided using lineal stapler; minilaparotomy is done with a Pfannenstiel incision; protective plastic sheath is placed across the edge of the laparotomy; specimen is brought out; proximal part (terminal ileum) is transected. Ileo rectal continuity is achieved by intracorporeal suturing or if rectal end can be brought out to the wound it can be done using hand sewn technique; otherwise circular EEA stapler can be used to achieve continuity. Lower level resection decides the procedure as either subtotal or total colectomy.



Figs 24-34(1)

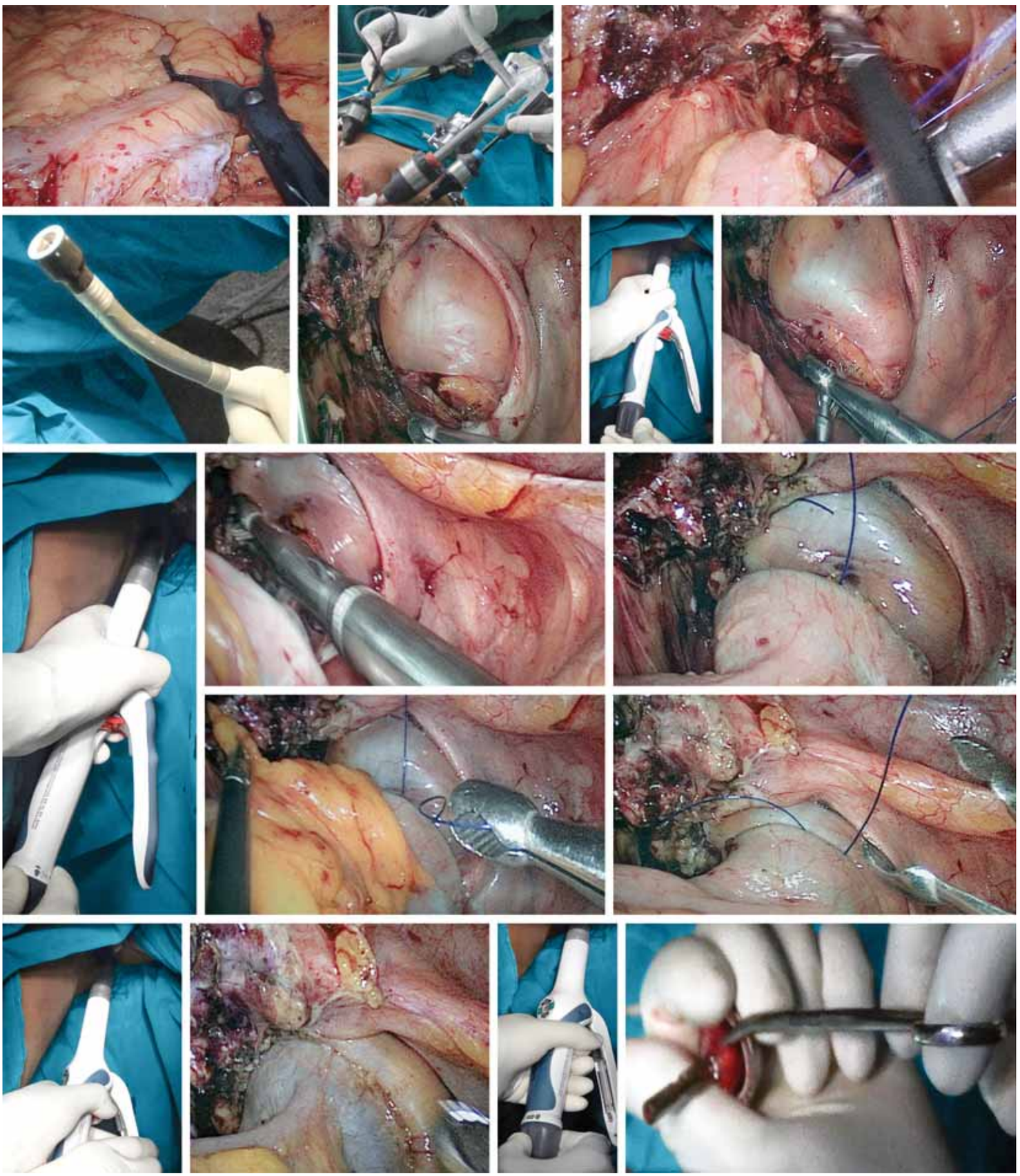


Figs 24-34(2)



Figs 24-34(3)

Figs 24-34(4)



Figs 24-34(5)

Figs 24-34(6)

Figs 24-34(1 to 6): Laparoscopic left colectomy. Note the angulated stapler used for transection. It needs 12 mm port. Note the patient position; port positions; steps; specimen retrieval; barrier plastic to the subumbilical minilaparotomy; anvil; placing purse string suture; circular stapler; firing the stapler; and other steps of dissection. Dissection here is done from medial to lateral. Main vessels (left colic) are clipped and divided using harmonic.

LOCALLY ADVANCED TUMOUR (INOPERABLE)

It is managed by colonoscopic decoring and stenting as a palliation. But it needs repetitive procedure. Alternatively bypass can be done either as ileo transverse anastomosis in case of hepatic *flexure* growth or colocolic anastomosis between transverse colon and descending colon in case of the left side advanced growth near or at splenic flexure **(Fig. 24-35)**.

Bowel proximal and distal are brought together confirming that there is no tension; if tension is there bowel mobilisation may be needed. Antimesenteric border of the ileum of 6 cm and antimesenteric border of the colon are incised at taenia at corresponding parts after placing occlusion clamps. Interrupted two layer anastomosis is done with inner full thickness and outer seromuscular sutures using 3 zero silk. Greater omentum may be wrapped around; clamps are removed. Usually drain is not required for bypass procedures unless there is contamination **(Fig. 24-36)**.

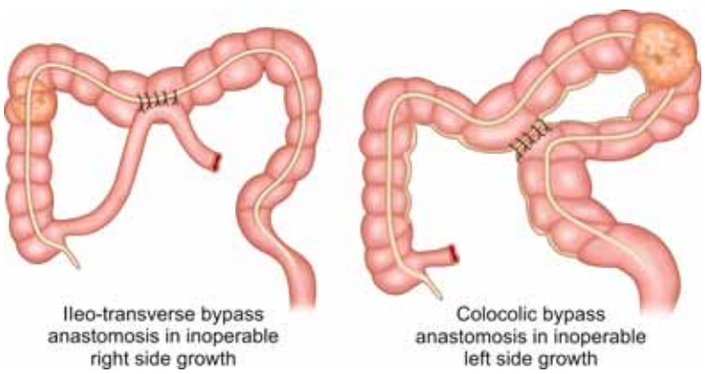

Ileo-transverse bypass anastomosis in inoperable right side growth
Colocolic bypass anastomosis in inoperable left side growth

Fig. 24-35: Bypass colonic procedures in advanced malignancies.

SURGICAL MANAGEMENT IN LARGE BOWEL OBSTRUCTION

Large bowel obstruction faces problems with sepsis, dehydration, contamination during surgery, electrolyte imbalance and nutritional deficiency.

Presently resection and primary anastomosis is done as a possibility. However, surgeon should finally decide about the factors like patient's general condition to obtain optimum recovery. Decision should be individualised rather than generalised. If needed after resection and anastomosis for right sided obstruction, covering loop ileostomy should be done which is closed after 3 months.

In left sided obstruction commonly due to growth, resection and anastomosis with right side diversion colostomy is the choice. It is often preferable to do on table colonic lavage to reduce the contamination and sepsis. It is done by passing a catheter through appendicectomy opening or a separate ileal stab opening which is secured by a purse string suture. Left sided growth/obstruction is identified; colon is transected between clamps above the obstruction; proximal end of the bowel is directed outside the surgical field to empty the content or connected to a lengthy tube (Savaage's decompressor). Warm normal saline is run through the proximal catheter distally across the colon towards distal end to empty; around 10 litres of fluid is needed to clean the bowel adequately **(Fig. 24-37)**.

Treatment of Sigmoid Volvulus

Initial treatment—nasogastric tube aspiration; IV fluids; catheterisation; antibiotics; *A flatus tube or sigmoidoscope* is passed in operation theatre (proper care is taken otherwise it leads to perforation). If it derotates, patient will pass flatus and faeces; and distension reduces **(Fig. 24-38)**.

If derotation does not occur, laparotomy through midline incision should be done. Dilated sigmoid colon is derotated manually and checked for viability. If viable, it can be fixed to the lateral wall of abdomen or pelvis—***Sigmoidopexy***.

If sigmoid colon is gangrenous, it is resected and proximal cut end is brought out as colostomy and distal end is brought out as mucus fistula, from the rectum *(Paul-Mikulicz Operation)*. Later after 6 weeks, continuity is maintained after proper preparation.

Resection of the gangrenous sigmoid done; proximal cut is brought out as end colostomy: distal end closed – *Hartmann's operation*. Later in 6-12 weeks colorectal anastomosis is maintained.

Primary resection and anastomosis is not advisable because of the contamination and anastomotic leak.

Mortality in sigmoid volvulus is due to *perforation, peritonitis and septicaemia* **(Fig. 24-39)**.

TREATMENT FOR HIRSCHSPRUNG'S DISEASE

Initially, colostomy is done either transverse or transitional, so to have normal bowel function, and nutritional supplementation. Once the child attains 10 kg of weight, definitive procedure is done, i.e. a. Excision of aganglionic segment (spasmodic segment); b. Maintenance of continuity by doing coloanal anastomosis; c. Closure of colostomy later.

Common procedures done are

Modified Duhamel operation: Resection of upper part of the rectum and a part of colon; anastomosis of colon to posterior part of the lower rectum and crushing the spurs to create the rectal pouch. It is *technically easier and a retro-rectal pull through*. New pouch is created by anterior part of the aganglionic rectum and by ganglionic proximal pulled down colon. Biopsy should be taken from proximal pulled down colon to look for evidence of ganglions. Pulled down proximal colon is sutured to full thickness posterior anal canal just above the dentate line. Spur between these two segments is crushed by Kocher's forceps or specialised instrument to create a single pouch **(Fig. 24-40)**.

Soave's mucosectomy and pull through operation: Through laparotomy approach rectum is mobilised deeply into the pelvis; circular myotomy is made on the rectal wall; submucosal plane is created up to the dentate line; denuded mucosa is excised; normal colon is brought down through this tube and coloanal anastomosis is done. In original Soave's technique, after telescoping the normal proximal colon through the rectal tube outside anus it is made to protrude outside for few cms which is not sutured and left like that to allow distal part to slough off to achieve continuity naturally.

Total proctocolectomy with ileo-anal anastomosis in case of total colonic Hirschsprung's disease.

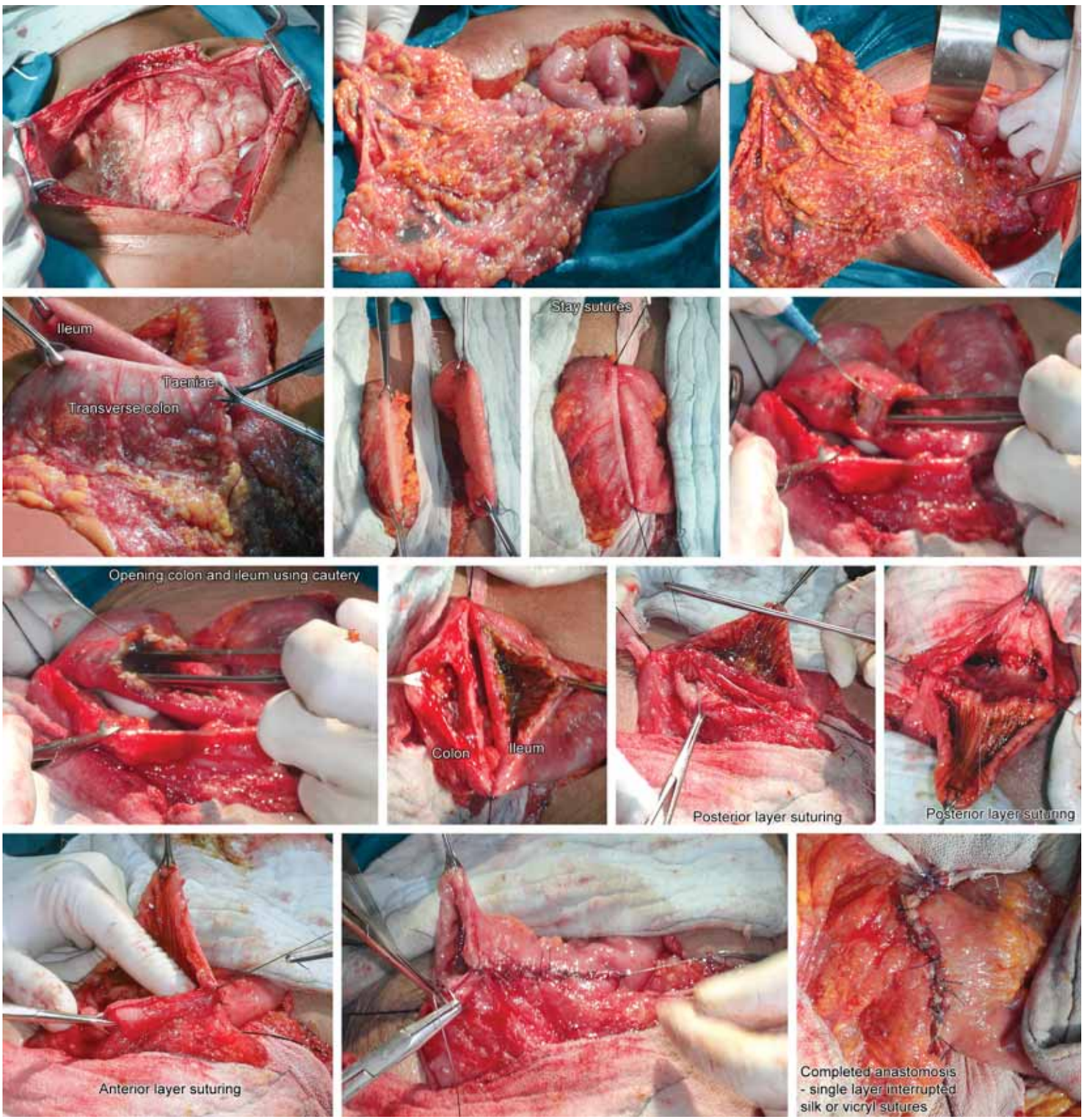


Fig. 24-36: Ileo-transverse anastomosis is done in a patient with obstruction at ileocaecal region. It is done here as patient had abdominal tuberculosis involving peritoneum and omentum; hence resection is not done with less aggressive bypass was done. Single layer interrupted sutures are placed—silk suture material.

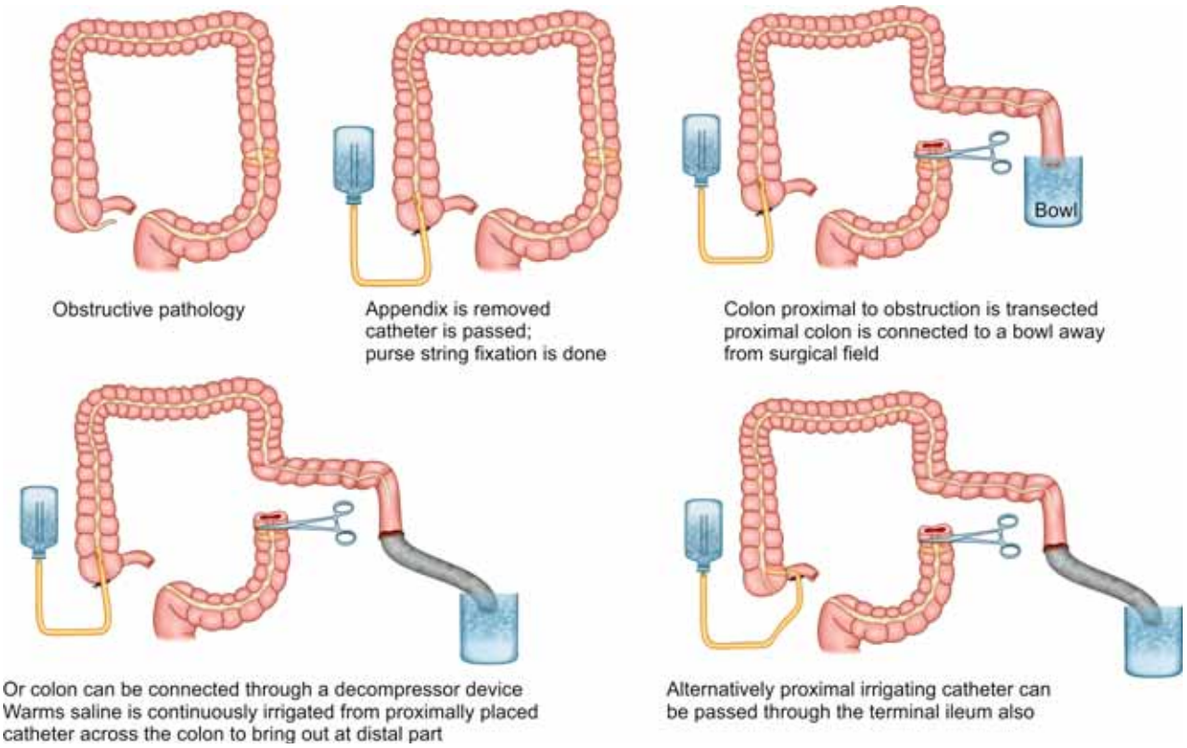

Obstructive pathology
Appendix is removed
catheter is passed;
purse string fixation is done
Bowl
Colon proximal to obstruction is transected
proximal colon is connected to a bowl away
from surgical field
Or colon can be connected through a decompressor device
Warms saline is continuously irrigated from proximally placed
catheter across the colon to bring out at distal part
Alternatively proximal irrigating catheter can
be passed through the terminal ileum also

Fig. 24-37: Technique of colonic decompression.

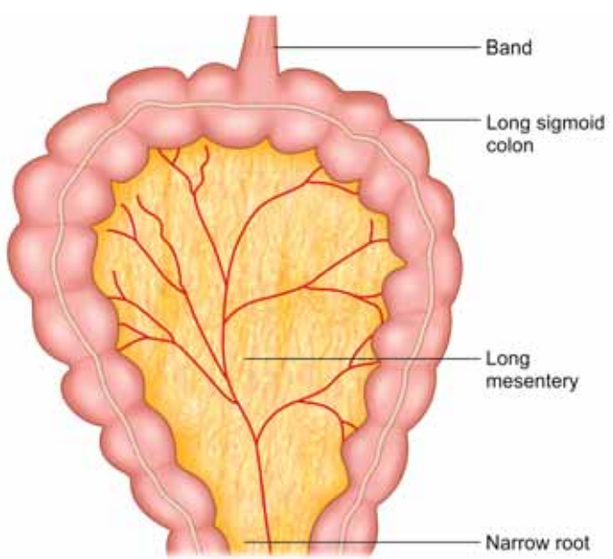


Fig. 24-38: Precipitating factors for sigmoid volvulus.

Swenson's operation: Through abdomino-anal approach, aganglionic segment of the rectum is mobilised including proximal normal bowel. Rectum above the pathological level is transected; lower segment is everted through the anus; normal proximal colon is brought out through the everted rectum; everted diseased rectum is resected just above the dentate line, anastomosis is done between brought out colon and cut end of the rectum just above the dentate line. Anastomotic site is repositioned back by gentle push.

Anorectal myectomy is found to be very useful for ultrashort segment and short-segment Hirschsprung's disease. Mucosa is incised horizontally 1 cm proximal to mucocutaneous junction. A strip of muscularis with part of internal sphincter is excised with both muscle layers of the rectum for about 6–10 cm length. Mucosa is sutured back. Complications are abscess formation and failure.

Complications of Surgeries

Severe colitis often distressing; faecal fistula due to disruption of the anastomotic site; stenosis at anastomotic site; stunted growth of the child due to deficiencies.

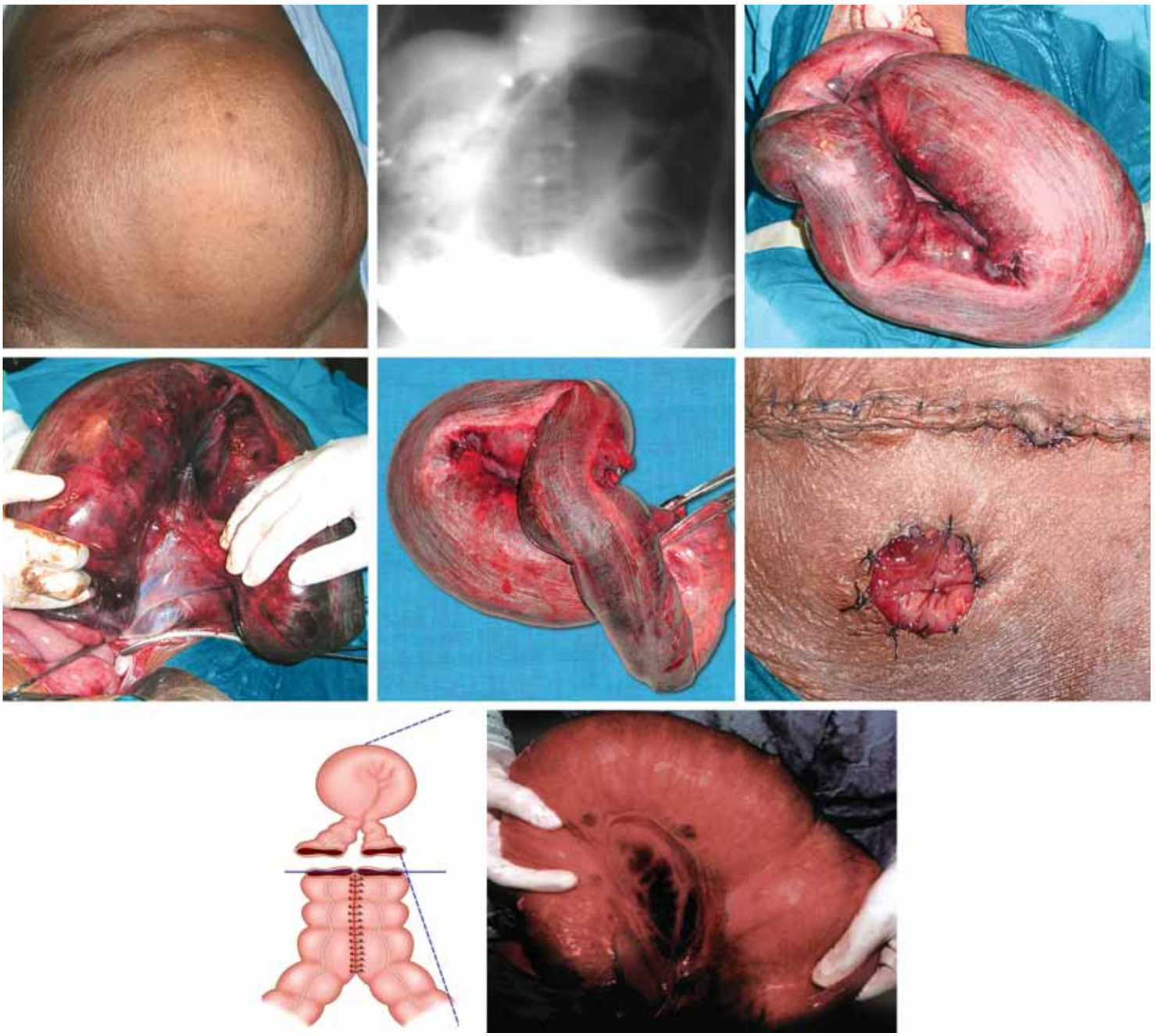


Fig. 24-39: Sigmoid volvulus: Note distended tympanic abdomen; X-ray showing typical sigmoid volvulus; on table gangrenous sigmoid volvulus; underwent resection with colostomy and mucus fistula (exteriorisation).

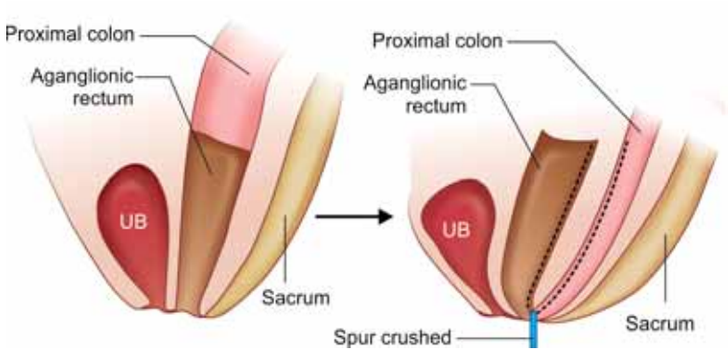


Fig. 24.40: Modified Duhamel operation. Normal colon is brought behind the aganglionic rectum and anastomosed just above the dentate line.

Chapter

25

Anorectal Surgeries

SURGICAL ANATOMY

Rectum

Rectum is connecting part between sigmoid colon above and anal canal. It is a misnomer as it is not straight; it has got curvatures anteroposteriorly and side to side. It is located in the posterior part of the lesser pelvis in front of the three sacral pieces and coccyx. It begins at 3rd sacral vertebra and ends at anorectal ring 2 cm in front and below the tip of coccyx at the apex of the prostate in males. It is 12 cm in length; proximally it has got same diameter as sigmoid colon; below it dilates to form rectal ampulla. Initially, it runs backwards and downwards then it runs forwards and downwards. In the sacrum and coccyx, it is concave in front; it bends backwards at the anorectal junction. It has got three lateral curves—upper lateral with convex towards right; middle lateral with convex towards left; lower lateral with convex towards right **(Fig. 25-1)**.

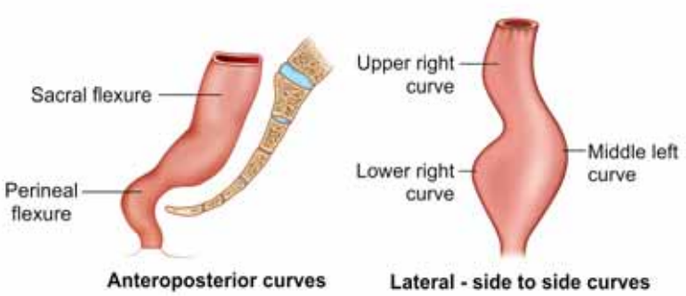


Fig. 25-1: Curvatures of the rectum.

The three cardinal features of large intestine (*sacculation, appendices epiploicae and taeniae*) are *absent* in the rectum.

Rectosigmoid junction implies a segment of bowel comprising the last seven centimeter of sigmoid colon and upper five centimeter of rectum. On sigmoidoscopic examination, it is taken as a point 15 cm from the anal verge. Taeniae of the sigmoid blends for about 8 cm to become longitudinal muscle coat of the rectum.

Relations of the Rectum

Upper 1/3rd is covered with peritoneum in front and sides; middle 1/3rd is covered by the peritoneum only in front; lower 1/3rd is not related to peritoneum but is dilated to form ampulla. Lower 1/3rd lies below the rectovesical pouch in males (pouch is 7.5 cm from the anus); below the rectouterine pouch (5.5 cm from the anus) in females. Upper 2/3rd in front in males is related to rectovesical pouch, intestines and sigmoid colon; in females rectouterine pouch, intestines and sigmoid. Lower 1/3rd in front in males it is related to base of the urinary bladder, ends of the ureters, seminal vesicles, vas deferens and prostate; in females it is related in front to lower part of the vagina **(Fig. 25-2)**.

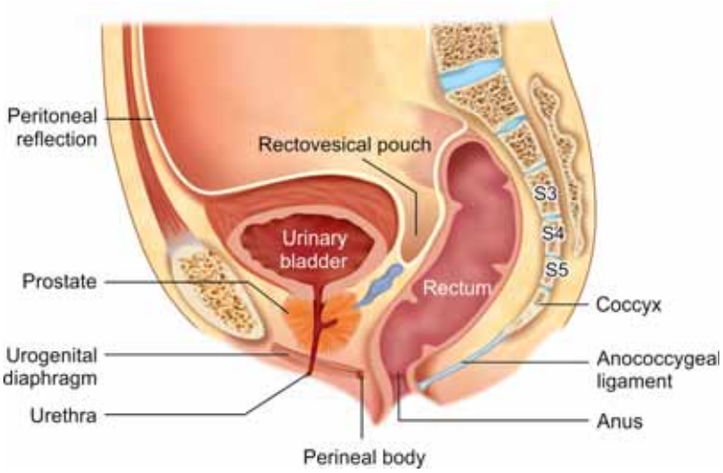


Fig. 25-2: Relations of the rectum.

Posteriorly rectum is related to lower three sacral pieces and coccyx, anococcygeal ligament, pyriformis muscle, coccygeus and levator ani, median sacral, superior rectal and lower lateral sacral vessels, sympathetic chain and ganglion impar, anterior primary rami of S3,4,5 and coccyx 1 nerves, pelvic splanchnic nerves, lymph nodes, lymphatics and fat.

Upper rectum contains 3 folds—left superior (12 cm from anal verge); right middle (10 cm from anal verge); left inferior (7 cm from the anal verge). These folds are called as valves of Houston.

Arterial Supply of the Rectum

Superior rectal artery, terminal branch of inferior mesenteric artery is the main artery of the rectum. It runs medial to left ureter at pelvic brim; opposite 3rd sacral vertebra it divides into right and left branches.

Each branch divides into smaller branches to pierce the muscle wall of the rectum to run in the anal columns up to anal valves to form anastomoses.

Middle rectal artery arises from anterior division of the internal iliac artery runs in the lateral ligament supplies muscles of the lower rectum.

Median sacral artery arises from the back of the lower most part of the aorta descending in the median plane supplying the posterior part of the anorectum **(Fig. 25-3)**.

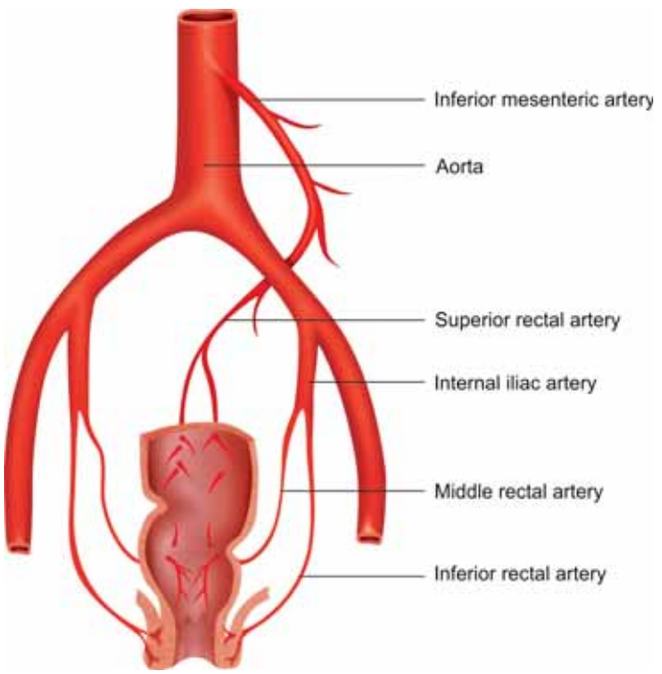


Fig. 25-3: Arterial supply of anorectum.

Venous Drainage

Superior rectal vein: Internal anal plexus forms about six tributaries which run upwards in the rectal submucosa; pierces the rectal muscular coat about 7.5 cm above the anus; join together to form superior rectal vein which eventually continues as inferior mesenteric vein.

Middle rectal veins drain from muscle coat of the rectum to end in internal iliac vein.

Submucous venous plexus drains into the venous plexus around the rectum, which communicates with the venous plexus in the base of the broad ligament in female and vesical plexus in male.

Lymphatic Drainage

Upper half of rectum drains along the superior rectal vessels drain into the inferior mesenteric nodes; from the lower half of the rectum drain along the middle rectal vessels into the internal iliac nodes.

Nerve Supply

Superior rectal, inferior mesenteric and inferior hypogastric plexus supply both sympathetic (L1,2) and parasympathetic (S2,3,4) components. Sympathetic nerve is vasoconstrictor, inhibits the rectal muscle, and constricts the internal sphincter. Parasympathetic nerve contracts the rectal muscle but inhibits the internal sphincter.

Supports of Rectum

Pelvic floor: It is formed by levator ani muscles.

Fascia of Waldeyer: It is the condensation of pelvic fascia behind rectum, contains superior rectal vessels and lymphatics. It attaches the lower part of the rectal ampulla to the sacrum. It is strong thick layer of parietal pelvic fascia adherent to sacrum and coccyx. Below it fuses with the rectum at anorectal junction. It is seen as a thick white fascial layer above the anococcygeal ligament. This Waldeyer fascia has to be divided to gain access to the retrorectal space; inadvertent dissection posterior to this fascia will injure sacral veins causing torrential haemorrhage.

Lateral ligaments of rectum: It is the condensation of pelvic fascia, attaches rectum to the postero-lateral wall of lesser pelvis. They enclose the middle rectal vessels and branches of the pelvic plexus. It is also called as rectal stalk, is a dense fibrous tissue running from the 3rd piece of sacrum to the rectal wall. It contains nervi erigentes. These ligaments have to be divided during abdominoperineal resection.

Denonvillier's fascia: It is the fascial condensation which separates rectum from prostate and seminal vesicles in males and vagina in females. It is densely adherent visceral pelvic fascia in front of extraperitoneal portion of the rectum extending above from upper peritoneal reflection below to urogenital diaphragm; laterally it continues with lateral ligaments. This fascia remains adherent to the posterior aspect of the prostate gland.

ANAL CANAL

Anal canal is 3.8 cm long extending from the anorectal ring to the anus directed downwards and backwards; it is situated below the level of pelvic brim; lying in the perineal anal triangle between right and left ischiorectal fossae. These fossae facilitate expansion of the anal canal during defaecation. Anal canal is surrounded by inner involuntary and outer voluntary sphincters. They keep the anal canal closed as an anteroposterior slit.

Anorectal junction is the junction where rectal ampulla narrows and pierces the pelvic diaphragm. It corresponds to the apex of the prostate. Anorectal junction is located 2 cm in front and just below the tip of the coccyx.

The anus is surface opening of the anal canal situated 4 cm below and in front of the tip of the coccyx. This has radial folds of the skin with pigmentation containing apocrine glands.

Relations: Anteriorly, it is related to perineal body; in males, membranous urethra and bulb of penis; in females, lower end of the vagina. Posteriorly, it is related to the anococcygeal ligament and coccyx. Laterally, it is related to the ischiorectal fossae. Sphincter muscles are around the anal canal.

Spaces Related to the Anal Canal

Ischiorectal fossa (pyramidal shape 5 cm depth and 2 cm width) lies between anal skin and levator ani. Right and left communicates with each other. Laterally, it is related to fascia covering obturator internus and ischial tuberosity; medially to levator ani and external sphincter; posteriorly sacrotuberous ligament and gluteus maximus; anteriorly urogenital diaphragm; below, the floor by skin. Above, it is related to lunate fascia and pudendal neurovascular bundle in pudendal canal

(*Alcock's canal*). There is no deep fascia under the skin in ischiorectal fossa. *Fascia lunata* (semilunar shaped hence the name) covers fascia on the levator ani medially, covers fascia on the obturator internus laterally (pudendal canal is located between obturator fascia and fascia lunata transmitting internal pudendal vessels and nerves); in front it fuses with urogenital diaphragm; above fascia is arched as tegmentum creating suprategmental space above **(Fig. 25-4)**.

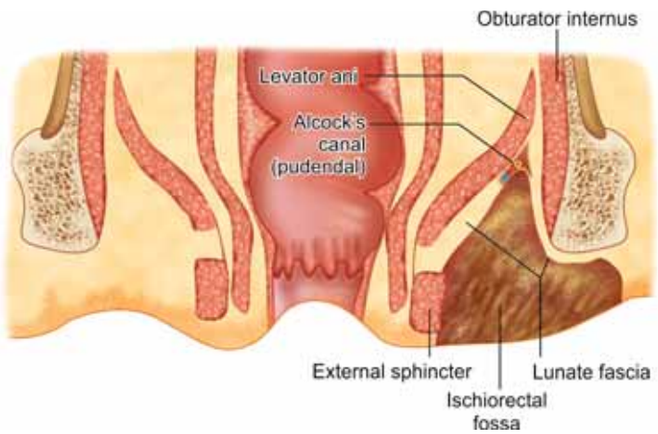


Fig. 25-4: Surgical anatomy of ischiorectal fossa.

The perianal space surrounds the anal canal below the white line. It contains subcutaneous external sphincter, external rectal venous plexus and the terminal branches of the inferior rectal vessels and nerves. Pus here spreads to white line or perianal skin but not into the ischiorectal space.

Submucous space lies above the white line between mucous membrane and internal sphincter, which contains internal venous plexus and lymphatics. Abscess here (submucous abscess) is not visible from outside; on rectal examination, it is felt as boggy tender swelling. It needs drainage under general anaesthesia.

Parts of the Anal Canal

Interior of the anal canal is divided into three parts **(Fig. 25-5)**.

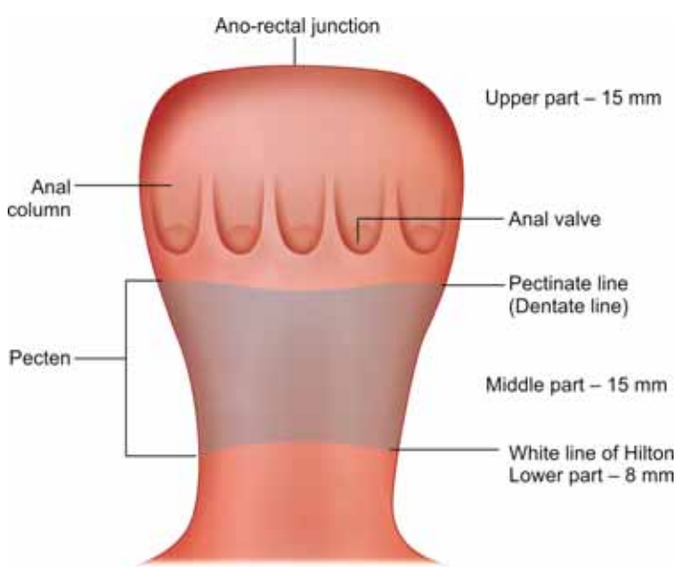


Fig. 25-5: Parts of the anal canal.

Upper part is 15 mm in length; lined by mucous membrane; endodermal origin. 6–10 vertical folds here are called as *anal columns of Morgagni*; lower ends of these columns joint together by transverse folds called as *anal valves*; depression above each valve is called as *anal sinus/anal crypt*. Anal glands about 5–10 in number opens into the anal crypts. Transverse line along the anal valves all around is called as *pectinate/dentate* line. Epithelial projections of the anal valve are called as anal papillae. Dentate line is situated opposite the middle of the internal sphincter.

Middle part of the anal canal is called as pectin or transition zone; is 15 mm in length; dense submucosal venous plexus makes it appear bluish; this part mucosa is less mobile. Lower portion of middle part is whitish and is called as white line of Hilton, which defines the gap between subcutaneous part of the external sphincter and lower border of the internal anal sphincter. Middle part is thin, pale, glossy and is lined by stratified squamous epithelium without sweat glands.

Lower part of the anal canal is 8 mm in length and is lined by sweat and sebaceous glands like a true skin.

Muscles of the Anal Canal

Internal anal sphincter is formed by thickened circular smooth muscle which is involuntary; extends and surrounds proximal 3 cm of the anal canal; below it ends at white line of Hilton. It is controlled by autonomic nervous system. Internal sphincter is light chicken meat coloured, firm structure which is well exposed during haemorrhoidectomy; its lower fibres are divided during sphincterotomy for fissure in ano. Under anaesthesia when anus is stretched, lower end of the internal sphincter is at a lower level than the lower end of the external sphincter **(Fig. 25-6)**.

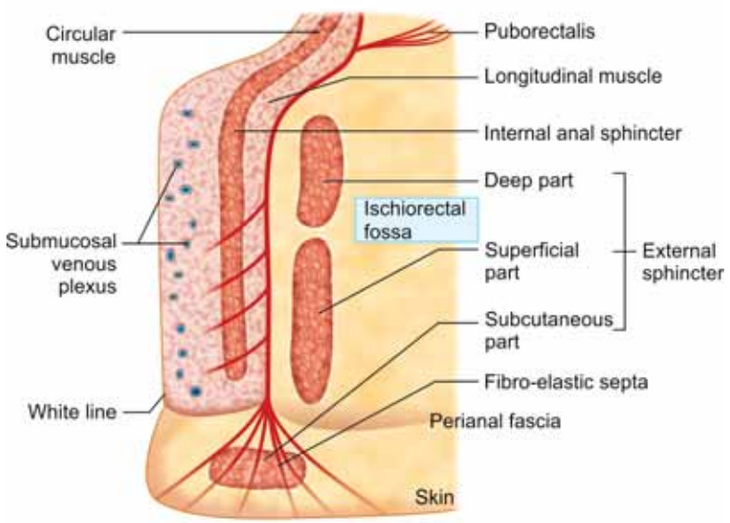


Fig. 25-6: Sphincters of the anal canal.

External anal sphincter is striated voluntary muscle which surrounds the entire length of the anal canal and has three parts—deep, superficial and subcutaneous. *Subcutaneous part* is below the level of the internal sphincter; it is flat band of 15 mm size, which does not have bony attachments. *Elliptical superficial part* arises from terminal coccygeal segment and anococcygeal ligament or raphe which after surrounding the lower part of the internal sphincter gets inserted into the perineal body. *Deep part* also does not have bony attachment;

it surrounds the upper part of the internal sphincter to fuse with puborectalis above. External sphincter is supplied by the inferior rectal nerve and branch of the 4th sacral nerve **(Fig. 25-7)**.

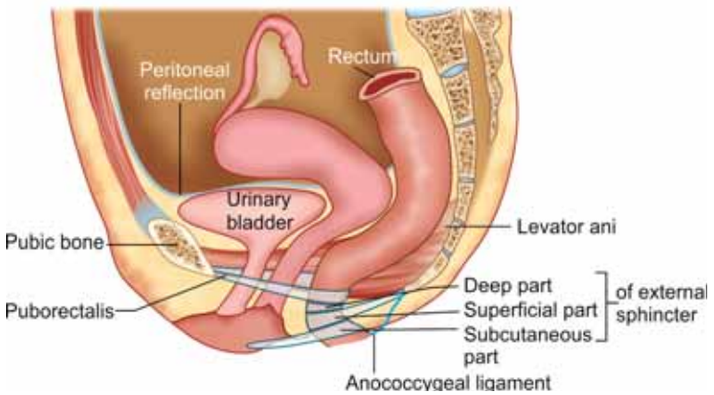


Fig. 25-7: External sphincter and puborectalis muscle. Deep part of the external sphincter fuses with the puborectalis above.

Conjoint longitudinal muscle coat is formed at the anorectal junction by the fusion of the puborectalis and longitudinal muscle coat of the rectum lying between external and internal sphincters. Below it forms fibroelastic band, which at the level of white line divides into many fibroelastic septa piercing the subcutaneous part of the external sphincter getting attached to the skin around anus. Lateral most septum is perianal fascia; anal intermuscular septum is most medial one.

Anorectal muscular ring is formed at the anorectal junction by the fusion of the puborectalis, deep external sphincter and internal sphincter. Ring is less prominent anteriorly as puborectalis fibres are absent anteriorly. Anorectal ring is palpable on digital examination of the rectum.

Arterial Supply of the Anal Canal

Part above the pectinate line is supplied by the superior rectal artery; part below is supplied by the inferior rectal artery.

Venous Drainage of Anal Canal

Internal rectal/haemorrhoidal venous plexus lies in the submucosa of the anal canal draining into the superior rectal vein and so inferior mesenteric vein; communicates freely with external venous plexus which drains into the middle (to internal iliac vein)and inferior rectal (to internal pudendal vein) veins—creating a porta systemic communication.

Lymphatic Drainage of Anal Canal

Lymphatics above the dentate line drains into internal iliac nodes; below the line drains into medial group of superficial inguinal nodes.

Nerve Supply of Anal Canal

Above the dentate line sympathetic by inferior hypogastric plexus L1,2 and parasympathetic by pelvic splanchnic nerve, S2,3,4; below the dentate line somatic inferior rectal nerve S2,3,4.

Internal sphincter contracts by sympathetic action; relaxes by parasympathetic action. External sphincter is supplied by the inferior rectal nerve and branch of 4th sacral nerve.

Muscles Related to the Anorectum

Levator ani: It is important muscle in the pelvic diaphragm. It has got two parts. **Pubococcygeus part**—*Anterior fibres* of the puborectalis originates from the medial surface of the pelvic surface of the body of the pubis which surrounds prostate in males as levator prostatae; in females surrounds the vagina as sphincter vaginae. *Middle fibres* arise from the lateral parts of the pelvic surface of the body of pubis as puborectalis which encroache the anorectum. The *posterior fibres* of the pubococcygeus originate from the anterior half of the white line of the obturator fascia getting attached posteriorly to anococcygeal ligament and tip of the coccyx. ***Iliococcygeus part*** arises from the posterior half of the white line of obturator fascia and pelvic surface of the ischial spine; inserted medially and behind to anococcygeal ligament and side of the last two pieces of coccyx. Levator ani is supplied by a branch from 4th sacral nerve and a branch from inferior rectal nerve or perineal division of the pudendal nerve **(Figs 25-8 and 25-9)**.

Coccygeus: It is triangular in shape which is partly muscle and partly tendinous; originates from pelvic surface of the ischial spine and sacrospinous ligament to insert into the side of the coccyx and 5th sacral vertebra. Coccygeus is supplied by a branch from 4th and 5th sacral nerves.

Pyriformis muscle: It originates from pelvic surface of 2nd, 3rd, 4th pieces of the sacrum, upper margin of the greater sciatic notch, adjoining sacroiliac joint and sacrotuberous ligament; inserted into the apex of the greater trochanter of the femur. It is supplied by ventral S1, 2 rami.

Obturator internus: It originates from pelvic surface of the obturator membrane, body of the ischium, ischial tuberosity, ischiopubic rami, ilium below the pelvic brim; it is inserted into the medial surface of the greater trochanter of the femur after passing through the lesser sciatic foramen running laterally. It is supplied by nerve to obturator internus—L5, S1, 2.

Vessels of the Pelvis

Internal iliac artery (IIA) begins as smaller terminal branch of common iliac artery which is 3.75 cm in length. IIA in fetus transmits blood to the placenta through the umbilical artery. CIA → IIA → umbilical artery → placenta in fetus. After birth, only proximal part of the umbilical artery persists as 1st part of the superior vesical artery;

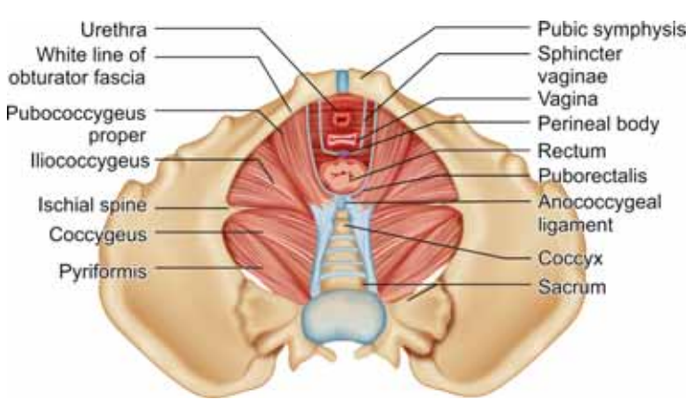


Fig. 25-8: Levator ani muscle.

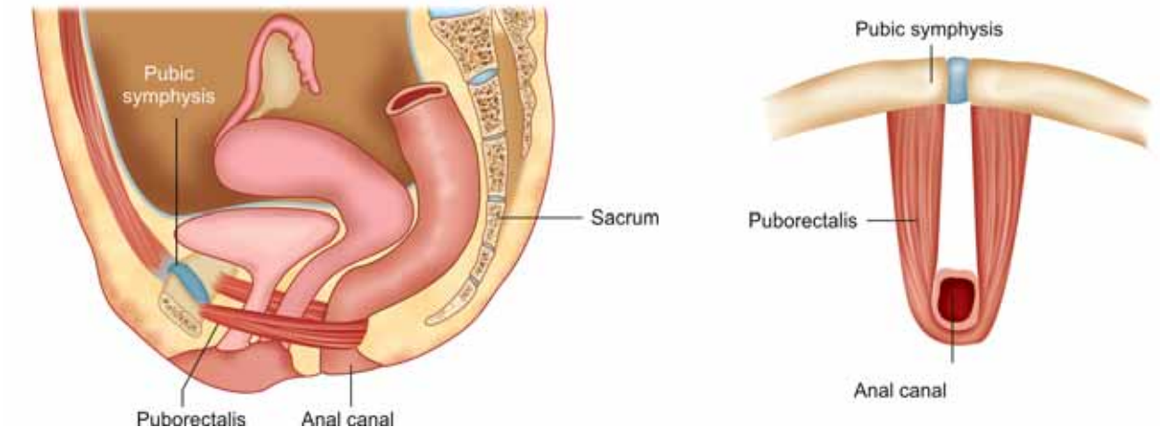


Fig. 25-9: Puborectalis sling.

remaining part of the umbilical artery obliterates as medial umbilical ligament. IIA begins in front of the sacroiliac joint at the level of disc between L5 and sacrum. It runs medial to psoas major downwards and backwards ending at the upper margin of the greater sciatic notch by dividing into *anterior and posterior divisions*. IIA is related in front to ureter, ovary and Fallopian tube in females; behind to internal iliac vein, lumbosacral trunk and sacroiliac joint; laterally to external iliac vein and obturator nerve; medially to peritoneum and small tributaries of IIV. IIA supplies all pelvic organs except those supplied by the superior rectal, ovarian and median sacral arteries; the perineum; greater part of the gluteal region; iliac fossa. *Branches* of anterior division are—superior vesical; obturator; middle rectal; inferior vesical; inferior gluteal (largest branch of anterior division) and internal pudendal. (In females, inferior vesical artery is replaced by vaginal artery; also uterine artery as an additional branch). *Posterior division branches are*—iliolumbar, two lateral sacral, superior gluteal arteries (runs above the 1st sacral nerve and enters the gluteal region by passing through the greater sciatic foramen above the pyriformis). Inferior gluteal and internal pudendal are terminal branches; in males there are six branches; in females seven branches (uterine artery is extra). Artery of vas arises from superior vesical artery **(Fig. 25-10)**.

Obturator artery runs in obturator fascia in between obturator vein (below) and nerve (above) enters the obturator foramen. It passes through the obturator foramen. It is crossed by ureter and vas deferens. It gives iliac, vesical branches and a pubic branch, which communicates with pubic branch of the inferior epigastric artery and with pubic branch of opposite side obturator artery.

Middle rectal artery originates with the inferior vesical artery; it supplies prostate, seminal vesicle and a little to muscle of the rectum; it may be absent in females.

Inferior gluteal artery is the largest branch of IIA running downwards in front of the sacral plexus and pyriformis and runs between pyriformis and coccygeus to enter lower part of the greater sciatic foramen to reach gluteal region. It gives muscular, fascial and vesical branches in the pelvis.

Internal pudendal artery is the main artery of the perineum and external genitalia. It is the smaller terminal branch of the anterior division of the IIA. In the pelvis, it runs on the pyriformis, sacral plexus, inferior gluteal artery enters the gluteal region by passing through the greater sciatic foramen; it runs for a short course in gluteal region; again through lesser sciatic foramen enters the pudendal canal. In the canal it is related to dorsal nerve and perineal nerve; gives inferior rectal artery posteriorly and perineal artery anteriorly; artery enters the deep perineal space as artery of penis or artery of clitoris. Artery of the penis divides just behind the arcuate pubic ligament as deep and dorsal arteries of the penis. Branches of the internal pudendal arteries are—*inferior rectal artery* that supplies skin and muscles of

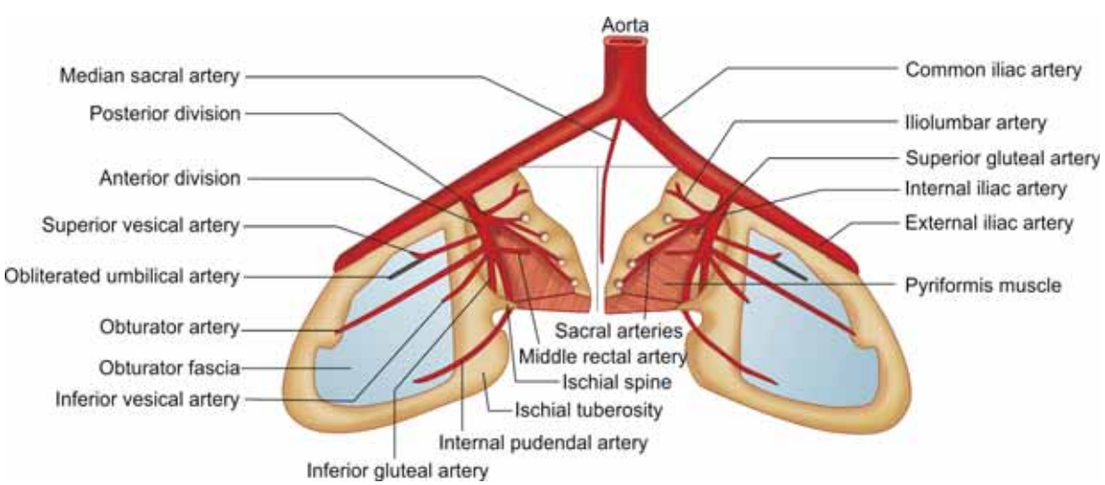


Fig. 25-10: Internal iliac artery and its branches in the pelvis.

the anal region. Perineal artery pierces the base of the perineal membrane to reach the superficial perineal space dividing into transverse perineal and posterior scrotal arteries. Artery of the penis runs in the deep perineal space gives artery of the bulb (supplies the bulb of penis and posterior urethra); urethral artery (supplies anterior urethra and corpus spongiosum); deep artery of the penis supplies the crus and corpus cavernosum; dorsal artery of the penis supplies the skin, fascia of the body of the penis and glans.

Internal iliac vein lies posteromedial to the IIA joins the external iliac vein to form common iliac vein at the pelvic brim, in front of the lower part of the pelvic brim.

Lymph Nodes of the Pelvis

Internal iliac nodes receive lymphatics from all pelvic organs, deeper parts of the perineum, muscles of the buttock and back of thigh; efferents enter the common iliac nodes. Sacral and obturator nodes drain to these nodes.

External iliac nodes receive lymphatics from inguinal nodes of infraumbilical deeper parts of the abdominal wall, membranous urethra, prostate, base of the urinary bladder, cervix of the uterus, part of the vagina. Inferior epigastric nodes and circumflex iliac nodes drain to these nodes.

Common iliac nodes are 4–6 in number receive lymphatics from external and internal iliac nodes; their efferents enter the lateral aortic nodes.

Nerves Related to Anorectum

During dissection of the rectum, hypogastric nerves should be retained. So proper anatomical knowledge of nervous system in the pelvis is essential to a surgeon.

Autonomic Nervous System of Abdomen

Sympathetic nerves are derived from coeliac plexus formed by splanchnic from thorax supplies all abdominal organs and gonads; the lumbar sympathetic trunk has got somatic branches to lower abdominal wall and lower limb; visceral branches supply pelvic organs. Coeliac ganglion is the largest ganglion in the body situated one on each side of the coeliac trunk. Coeliac/solar plexus is located in relation to coeliac ganglion on the aorta around coeliac trunk and root of SMA. Coeliac plexus extends above to crura of diaphragm; overlapped by IVC and pancreas. Its preganglionic fibres come from greater and lesser splanchnic nerves; preganglionic vagal fibres from right vagus mainly. Its branches are – plexuses of phrenic, hepatic, left gastric, suprarenal, renal, testicular/ovarian. Superior mesenteric plexus contains superior mesenteric ganglion. Abdominal aortic plexus is intermesenteric plexus formed by coeliac plexus and fibres from 1st and 2nd lumbar splanchnic nerves. Plexus is situated on the sides and in front of the aorta, between the origins of the superior and inferior mesenteric arteries with 6–12 intermesenteric nerves which are connected to each other. Above it is connected with coeliac plexus; below it continues as superior hypogastric plexus. Branches of this aortic plexus are—testicular, inferior mesenteric, iliac and superior hypogastric plexus.

Lumbar sympathetic chain: It is situated on both sides of the body of vertebrae. There are four ganglia as 1st and 2nd are usually fused together. It runs downwards closely related to psoas major and lumbar vessels; on right side it is covered by IVC; on left side by lateral aortic nodes. First ganglion is very closely related to crus of diaphragm. Lumbar sympathetic chain continuous below behind the common iliac vessels as sacral part of the sympathetic chain. Anterior primary rami of corresponding lumbar nerves send white rami communicans to corresponding ganglion. Lumbar nerves receive grey rami communicans from corresponding ganglia as their lateral branches. Their upper two medial branches join coeliac and aortic plexus; lower two join the superior hypogastric plexus.

Superior hypogastric plexus often is called as presacral nerve; is located in front of the abdominal aorta, left common iliac vein, median sacral vessels, body of 5th lumbar vertebra, sacral promontory, and between two common iliac arteries. Plexus is located more towards left side. It is having commonly multiple fibres. Plexus is formed by descending fibres of aortic plexus and 3rd and 4th lumbar splanchnic nerves. Above it gives branches to ureter, testis/ovary, and common iliac plexus branch; below it divides into right and left hypogastric nerves which on reaching the pelvis form inferior hypogastric plexus **(Fig. 25-11)**.

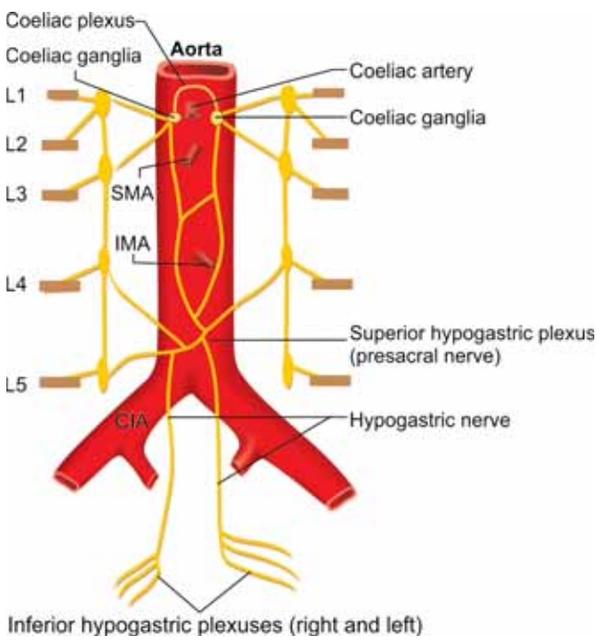


Fig. 25-11: Autonomic nervous system of the posterior abdominal wall and pelvis.

Inferior hypogastric plexuses are two—right and left. It is located in the pelvis extraperitoneally; lying on the side of rectum, seminal vesicle, prostate, posterior part of the urinary bladder in males; in females it lies on side of rectum, cervix and fornix and posterior part of the urinary bladder. In males, adjacent to prostate and seminal vesicle, in front of the Denonvillier's fascia nervi erigentes from pelvic splanchnic nerves join sympathetic branches to form a neurovascular bundle of Walsh. Inferior hypogastric plexus gives sympathetic and parasympathetic branches.

Parasympathetic nerves are derived from vagus, which joins coeliac ganglion; pelvic splanchnic nerves join inferior hypogastric plexus. Pelvic splanchnic nerves (nervi erigentes) are sacral outflow of parasympathetic system. Nerves arise from ventral rami of S2,3,4. They pass through the sacral foramina and join the inferior hypogastric plexus to supply the pelvis; few fibres run upwards along with hypogastric nerves to join superior hypogastric plexus.

Pelvic sympathetic chain runs medially over the body of the sacrum along the medial margins of the foramina, one on each side, two chains join in front of the coccyx as ganglion impar.

PRINCIPLES IN ANORECTAL SURGERIES

Lithotomy position is essential in most of the anorectal surgeries. Low lithotomy with legs at low position is better **(Fig. 25-12)**.

Entire abdomen, perineum should be cleaned and separately draped. Nasogastric tube and urinary catheterisation is needed in rectal surgeries and in selected anal surgeries. Head low position (reverse Trendelenburg/Fowler's) is also useful to keep small bowel upwards out of surgical field in the pelvis. Anatomical dissection in the rectum is difficult as it is a narrow compact area. Injury to sphincters will lead into incontinence. Buttocks should be abducted properly to facilitate the perineal dissection in abdominoperineal resection and also in anterior resection to negotiate the circular stapler across the anal canal.

Invasion of the tumor into the presacral nerves and prostate makes rectal cancer inoperable. Adherence to sacrum due to desmoplastic reaction is common and is not a contraindication for resection. In some patients with local invasion initial neoadjuvant chemotherapy or chemoradiation and later resection (APR) can be done probably after 3 cycles of chemotherapy.

Anastomotic leak can occur in rectal anastomosis. There is no serosa in the lower rectum and so barrier is not clear.

Nerves in the posterior plane may get injured which will cause impotence. Safeguarding the nerve is very important. Preaortic sympathetic nerves of the superior hypogastric plexus contribute to inferior pelvic hypogastric plexus; this plexus at sacral promontory forms two hypogastric nerves often each with many strands descends in the posterolateral wall of the pelvis close to IIA (hypogastric artery); injury to this will cause failure of ejaculation in males.

In carcinoma, achieving clearance circumferentially (CRM, circumferential resected margin) is important. Total mesorectal excision is ideal (TME) but technically it is demanding.

Disparity between diameter of rectal ampulla (6 cm) and colon needs correction. Otherwise anastomotic dehiscence can occur. Side to end anastomosis between the colon and rectum will correct this problem. Tension free anastomosis is very important. Mobilisation of the splenic flexure is a must in all rectal cancer surgeries.

Oozing in the presacral space during dissection is common; it is often difficult to reach the instruments into deep pelvis for control of haemorrhage and dissection especially in open approach. Laparoscopic approach facilitates the instruments into the place and visual dissection. Haematoma is common in this space which will lead into sepsis, disruption of the anastomosis. It is better to place a suction drain in the presacral space. Dissection in presacral space very close to the periosteum will injure the veins draining through the sacral foramina which get retracted into the foramina. It is impossible to control such haemorrhage. Packing or placing surgicel on the presacral foramina or placing thumbtack on the foramina (Nivatvongs and Fang, 1986) or bone wax are the only options. If nothing helps then pack/mop kept in place firmly controls the bleeding almost always. Presacral bleeding can be avoided by doing sharp dissection rather than blunt dissection. Laparoscopic dissection is very helpful for presacral dissection. Dissection should be in front of the endopelvic fascia, which covers the presacral veins. If presacral dissection is bloodless then it means it is in proper plane.

Most of the bleeding in rectal surgeries are venous and careful bipolar cautery fulguration controls the bleeding often also with suture ligation.

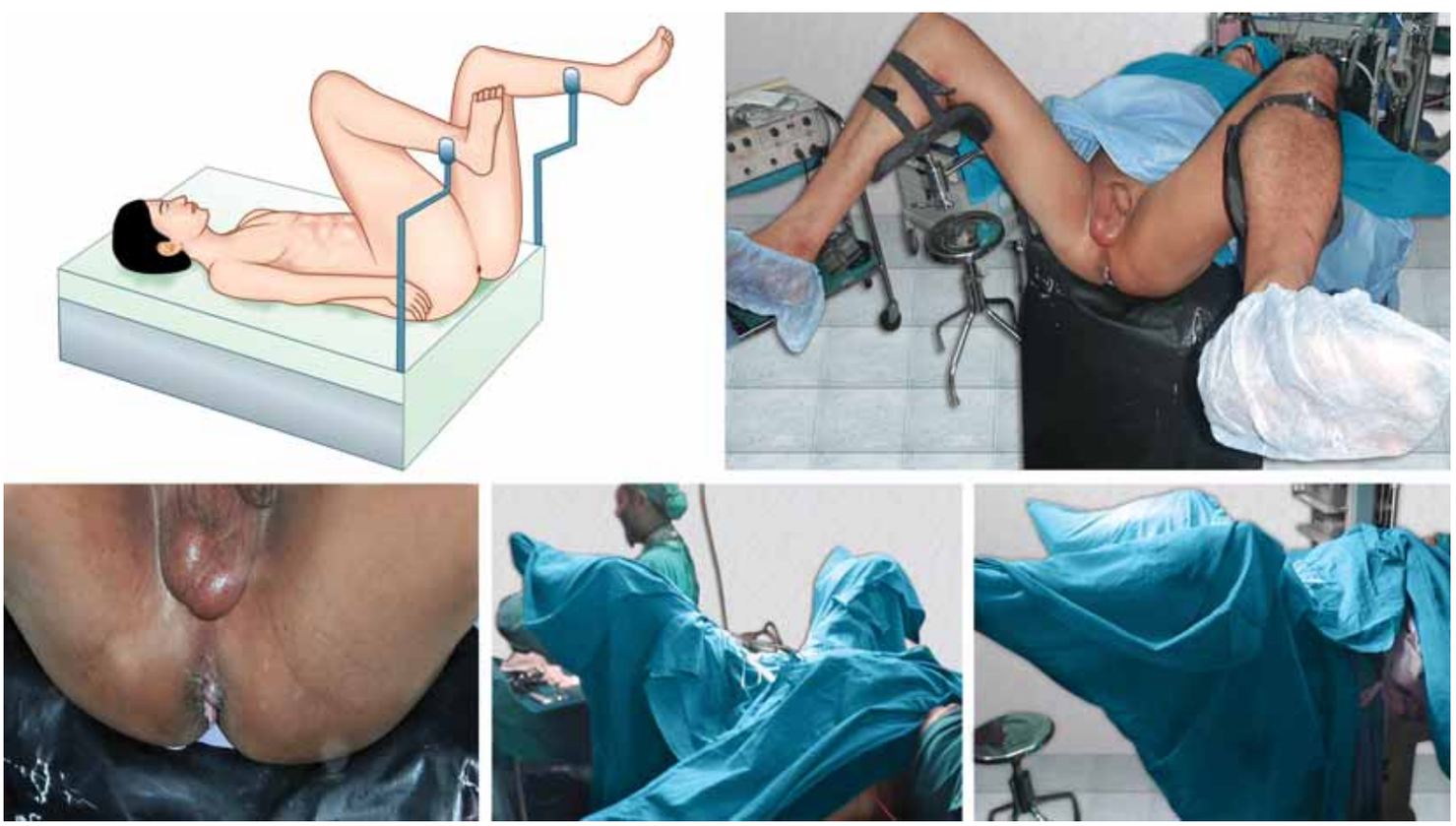


Fig. 25-12: Lithotomy position is commonly used for anorectal surgeries. Prone jackknife position is also used often.

Waldeyer fascia in the lower part behind the rectum is strong and tough and it should be dissected with sharp scissor or harmonic scalpel or using cautery. Care should be taken not to injure the rectal wall during this dissection.

Peritoneum in the pelvic floor after colorectal anastomosis should not be sutured as it will create a dead space around the anastomotic site. But it may be sutured after APR. It is to be sutured or not is a debate in patients who receive RT to avoid small bowel getting radiation enteritis and so adherent to pelvis.

Adequate blood supply is an absolute need in colorectal anastomosis. Inadequate blood supply means inadequate healing of the anastomotic site. It is better to ligate vessel after the branching of the left colic artery instead of ligating the inferior mesenteric artery at its origin.

Both ureters should be identified and safeguarded in rectal surgeries. It is important to have a fair knowledge of the surgical anatomy of the ureter, rectum and pelvis while doing rectal surgeries. Blind surgeries, surgeries without anatomical knowledge in the anorectum will lead into the complications. There cannot be presumption in surgical dissection and technique. Proper anatomical knowledge and safe dissection is the absolute need in rectal surgeries. Ureter crosses the common iliac artery at its bifurcation; it is identified on table by its colour, vascular network on its surface, by eliciting the peristalsis by gentle pinching or touching. Ureter should be traced beyond the lateral ligaments of the rectum.

For most of the rectal cancers, sigmoid is removed with the rectal specimen and continuity is achieved by anastomosing the descending colon to the rectal stump after complete mobilisation of the splenic flexure.

Stapled (circular) anastomosis is better in low resections. In resection suturing anastomosis can be done 10 cm above the anal verge. Below that level suturing is difficult. Angulated stapler is used to divide and close the rectal stump from above; then circular stapler is passed from below to complete the stapled anastomosis. This avoids the difficult purse string suturing of the rectal stump.

Difficult low anastomosis should be complemented with proximal diversion colostomy of transverse colon at right hypochondrium.

Anastomotic site is often passed with a tube 28–30 French Foley's catheter across and can be kept in place for 4–5 days. Through this, air can be injected on table to observe the possible air bubble in a saline filled anastomotic site to identify the leak (leak test). Leak test is commonly done in anterior resection even though many surgeons do not keep catheter in place for long time (4–5 days). In olden days, it is practice to do sphincter dilatation in presumption of preventing distal obstruction and fair anastomotic take up. It is not proved as such and so is not mandatory.

In anorectal surgeries like for fissure in ano, haemorrhoids, Sitz bath is given. Patient sits in a warm water bowl dipping the anal canal region for 25–30 minutes two to three times a day; it reduces the oedema, promotes the healing and relieves the pain significantly. Local heat increases blood flow to the area, promoting healing. A plastic tub that can be fit over the toilet commode to which few centimetres depth warm water is added. Small quantities of Eusol, povidone iodine or salt can be added to that. Delayed wound healing is common after excision of anal papilloma or similar lesions. Stricture is also common due to wound contraction and fibrosis **(Fig. 25-13)**.

Sphincter injury, stricture in anorectal surgery is common which should be avoided by careful dissection at anatomical plane.

All patients with colorectal surgery needs DVT prophylaxis using low molecular weight heparin. Stoma therapist should give advice in relation to stoma care prior to surgery if patient needs colostomy or ileostomy.

Fig. 25-13: Anal papilloma.

TREATMENT PLAN FOR CARCINOMA RECTUM

Surgical Principles

Surgery is the main method of treatment. Preoperative chemoradiotherapy is often used if growth is invading into adjacent tissues (T4). Adjuvant chemotherapy and radiotherapy is a must. Genetic, morphologic, biologic features of rectal cancers are similar to colonic cancers. But *anatomical factors* make it more complex than colonic cancers, like its location deep in the pelvis, relation to important structures like ureters, bladder, genital, autonomic nerves and anal sphincters. So surgical approach is very difficult. *Avascular endoplelvic fascial plane (holy plane of Heald)* is important during dissection to avoid injury laterally to autonomic nerves (will cause impotence in men and bladder dysfunction in both sexes); more medial dissection leads into incomplete clearance and high local recurrence. *Abdomino perineal resection (APR)* is the gold standard. But if tumour is well-differentiated and if there is adequate margin above the anal canal, a sphincter saving *anterior resection (AR)* can be done. *Low anterior resection (LAR)* is possible if EEA stapler is used for anastomosis. But anterior resection should not be done by compromising the adequacy of tumour clearance. Tumour clearance is still the priority in rectal cancer as it decides the eventual outcome. *Total mesorectal excision (TME) should be the goal* in all procedures as mesorectum contains nodes and lymphatics, clearance of which gives better result. It is a *sharp dissection* (not blunt) in avascular areolar plane between fascia of rectum which encroach the mesorectum and parietal pelvic wall fascia. Mesorectum should not be breached. Absolute haemostasis, *preservation of autonomic nerves* and dissection under vision are the essential principles. Both layers of membranous anterior Denonvillier's fascia should be dissected off the prostate and seminal vesicles in male to have proper clearance. In TME for middle and lower rectum, entire mesorectum should be removed. For upper rectal tumours, TME is done 5–6 cm below the lower margin of the tumour. *TME improves the quality of life in relation to impotence, retrograde ejaculation and urinary incontinence. These complications are around 50% or more in APR whereas in TME it is less than 20%.* Recommended *distal rectal margin clearance is 5 cm*, however, 1–2 cm distal margin

is an *acceptable* clearance. *Circumferential resected margin—CRM* (*radial margin,> 2 mm*) is more important than proximal and distal margin. A 5-cm clearance of mesorectum from the primary tumour is essential as tumour implants can occur only for up to 4 cm from primary tumour margin.

Principles to be followed—adequate lymphatic and vascular clearance; en bloc resection of primary tumour; no/less touch technique; avoiding spillage; adequate radical surgery. *Ultra low anterior resection or intersphincteric* resection can be considered in low rectal tumours. After resection (on table*) irrigation of rectal bed* with cetrimide or hypertonic solution like distilled water is often practiced as they are tumouricidal. Selection of the procedure, AR or APR is decided by proper staging using TRUS and MRI. Neoadjuvant chemotherapy or neoadjuvant chemoradiotherapy is often used in T3 lesions, which also may avoid APR; and AR may be sufficient. Local wide excision approaches are often used when tumour is < 4 cm; < 40% circumference involved.

T1 N0/T2 N0 tumour: *transanal approach* is used in small tumours that is 3–5 cm above the dentate line but within 10 cm from the anal verge: *transcoccygeal Kraske's approach* for posterior wall rectal tumours (dangerous posterior faecal fistula can occur); *Transanal endoscopic microsurgery* (Buess) using operating microscope and videoscope can also be done. This *endosurgical device* is 4 cm in diameter, specialised sealed proctoscope with ports for CO_2 insufflation, water irrigation, and suction and for monitoring intrarectal pressure. CO_2 insufflation distends the rectum and local excision is done with proper positioning of the device.

In females, partial vaginectomy with or without hysterectomy and bilateral oophorectomy may be needed in T4 lesions to achieve surgical resection. Removal of uterus and ovaries prevents patient from developing possible associated cancers of these organs. Carcinoma rectum also spreads to ovaries commonly, which can be prevented by oophorectomy. Often resection of liver secondaries can be undertaken in selected patients when one lobe is involved or solitary secondaries are present.

Laparoscopic APR/AR is becoming popular. *Features are*: Dissection will be more meticulous. Less blood loss, less post-operative pain; early bowel function; clearance is same as open method in relation to primary tumour and nodes.

Short hospital stay, mortality and morbidity are similar to open method. Port site recurrence chances are 0.5-2% (Earlier it was higher; now it has reduced due to proper technique, careful handling of the specimen, specimen isolation prior to extraction, trocar site irrigation with cytotoxic agents and povidone iodine).

For carcinoma rectum presenting with obstruction, an initial proximal colostomy is done. Neoadjuvant chemoradiation is given. Patient is reassessed for operability. Then APR is done with permanent colostomy.

Incidence *of local recurrent rectal cancer* is 30%. About 80% of local recurrence occur within 2 years of surgery. Common site of recurrence is in the pelvic wall. It also can occur at distal anastomotic margin. Intractable pelvic pain, urinary symptoms, sepsis, bleeding, perineal sinus, swelling and induration, bowel disturbances are the features. It is evaluated by CEA, biopsy, CT abdomen, MRI of pelvis and PET scan. It is often difficult to manage **(Figs 25-14 and 25-15)**.

Incidence of recurrence will come down to 5% in proper TME. Palliative chemoradiation, end colostomy, ureteral stenting are the palliation. RT controls pain and bleeding. Extensive radical surgery like removal of tumour with pelvic structures can be undertaken with diversions but with a high mortality rate and failure rate.

Proper *preoperative bowel preparation* is a must in all rectal cancers, which reduces the post-operative problems like sepsis, leak and increases the early chance of recovery. Bowel preparation by polyethylene glycol; electrolytes *orally*; bowel wash *per anally*; bowel antiseptics like neomycin 1 gm tid previous day/erythromycin 1 gm tid/metronidazole tid *orally.* Systemic antibiotics like cefazolin, metronidazole, gentamicin; prophylactic heparin or low molecular weight heparin; Foley's catheterisation and nasogastric tube—are other preparations. Preoperative adequate hydration using IV fluids; blood grouping and crossmatching and required bottles of blood should be reserved if needed to transfuse during the procedure.

Different Surgeries for Carcinoma Rectum

1. **Abdominoperineal resection** (A-P resection) (APR) wherein sigmoid, descending colon and upper rectum is mobilised per abdominally. Anal canal with perianal and perirectal tissues are dissected per anally. Retained colon is brought out as *end colostomy* in *left iliac fossa*.

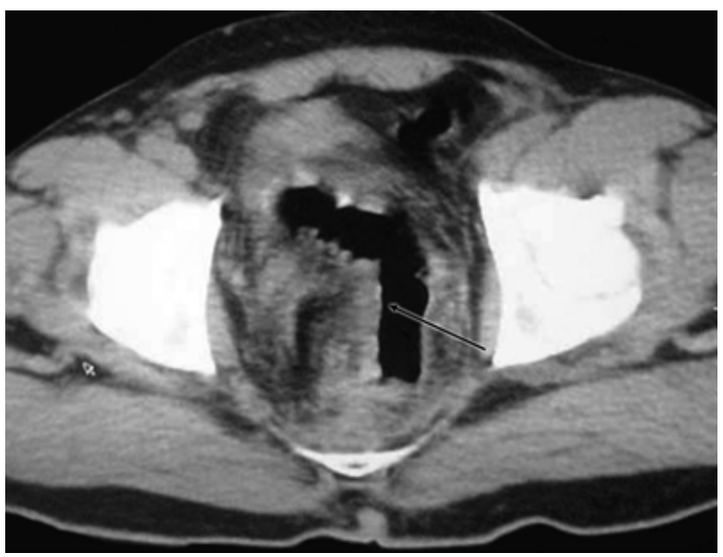


Fig. 25-14: CT scan showing extent of carcinoma rectum. CT is useful to assess nodal status.

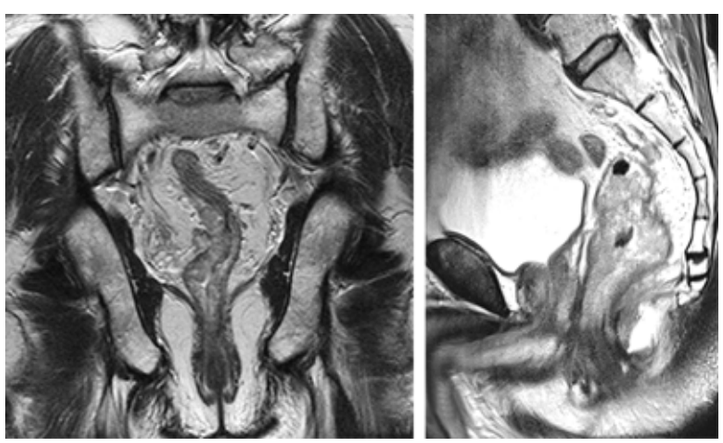


Fig. 25-15: MRI of rectum is useful to assess local infiltration.

APR—types
Miles—abdomen first, perineum later
Gabriel—perineum first, abdomen later
Lloyd-Davies—synchronised (together), (combined)

APR is done through lower midline incision in lithotomy position. Left-sided colon and entire rectum is mobilised from above. Rectum is mobilised posteriorly in avascular plane in front of nerve plane (hypogastric nerve) between mesorectum and sacrum. Inferior mesenteric artery is ligated high proximal (as lymphovascular ligation) at its origin or just beyond its first branch. Colon is transected and proximal cut end is fashioned for end colostomy in *left iliac fossa*. Through perineum, a purse string suture is placed around anal margin. Circumferential incision is placed around the anus. Dissection is deepened using scissor and cautery into the perineal body, coccyx, ischial tuberosity, ischiorectal fossa. First posterior and lateral dissections are undertaken until it reaches above. Lastly, anterior dissection is done to reach above and specimen is removed through perineal wound. Perineal wound is closed in layers often with a drain. Abdomen drain is placed. Colostomy is created by suturing skin to mucosa using silk. Colostomy done in left iliac fossa after APR. Colostomy care is important.

Complications of APR: Bleeding; infection of perineal wound; complications of colostomy like prolapse, stenosis, and infection; injury to urinary system, ureter, impotence, urinary incontinence. Operative mortality is less than 2%. *APR is the treatment of choice when mesorectum is involved or when it is poorly differentiated tumour or when nodes are involved*. It gives adequate clearance.

Sphincter saving APR with coloanal anastomosis: It is done in operable distal rectal tumour in young individual wherein within oncological principle anal sphincter need not be sacrificed but adequate oncological tumour clearance can be achieved. Here a permanent colostomy stoma is avoided. Approach is both abdominal and perineal. Initial dissection of rectal mobilisation is done from above; dissection of rectal mucosa from the anal sphincter at the level of dentate line and complete dissection of distal rectum is done through anal canal. Entire rectosigmoid is removed retaining only the anal sphincter. Colonic J pouch or coloplasty reservoir is created in the mobilised descending colon; coloanal anastomosis is done per anally using hand sutures under direct visualisation.

APR with neosphincter reconstruction is also occasionally sought; but technically difficult with complications.

Perineal colostomy is done with gracilis muscle wrap which is made to produce sphincter like muscle twitch using an implanted pacemaker.

2. **Anterior resection** (Abdominal radical restorative operation) is done in growths located in the mid and upper part of the rectum, which is well-differentiated, small-sized and with a clear adequate length for anastomosis after resection. *Anterior resection* is also called as *anterior proctosigmoidectomy* through *abdominal* approach wherein rectum *above* the peritoneal *reflection* is resected with colorectal anastomosis. *Low anterior resection (LAR)* is resection of rectum *below the peritoneal reflection* along with the sigmoid colon (as sigmoid should be removed due its precarious blood supply after dissection), with total mesorectal excision (TME) *through abdominal approach* (laparotomy) followed by *colorectal anastomosis* using *circular* stapler device (EEA stapler). Stoma should be inspected using proctoscope for integrity and when in doubt a covering temporary proximal colostomy should be done. LAR often leads to frequent small bowel movements causing more frequent stools called as *low anterior resection syndrome (LAR syndrome)/clustering*. It can be avoided by creating reservoir either by doing *colonic J pouch* or by doing *coloplasty* 6 cm from proximal divided end of colon (longitudinal colotomy between taeniae of 10 cm which is sutured horizontally).

Criteria for anterior resection—(Low anterior resection, LAR) are - Upper and middle third rectal growth; growth above the peritoneal reflection; well-differentiated tumour; < 4 cm size tumour; in females, growth 7 cm above the anal verge; T1 N0/T2 N0 tumour; Tumour without lymphatic or venous spread.

Advantages: It avoids permanent colostomy; sphincter is retained and so patient's acceptance is high **(Fig. 25-16)**.

Disadvantages: Uncertainty of clearance which is very important in cancer surgeries and so chances of local recurrence is high; anastomotic leak, infection; stenosis.

3. Hartmann's operation (Henri Hartmann, 1923) is an excellent palliative procedure—

It is done in elderly people who are not fit for major surgery like AP resection and also in locally advanced tumours. It is also done often in sigmoid diverticula with complications like abscess formation and sepsis. Here rectal growth is resected along with sigmoid colon and cut end of the rectum (rectal stump) is closed completely. Proximal colon is brought out as *end colostomy*. It is done as an emergency procedure wherein it is unsafe to perform a primary anastomosis and also due to insufficient length of the distal retained rectum it is also difficult to do mucus fistula. Midline laparotomy is done; sigmoid is mobilised similarly; ureter is safeguarded; vessels are ligated below the level of the left colic artery branch. Mesentery of sigmoid is divided. Distal dissection of the rectum is done just below the level of the peritoneal reflection. Rectum is resected using TA 55 linear stapler. Sigmoid is resected at its junction with descending colon; specimen is removed. Descending colon is mobilised to get adequate length for colostomy; extraperitoneal tunneling of the descending colon is not necessary as it is only temporary end colostomy. Drain is kept in the pelvis after thorough warm saline wash. Abdomen is closed. Complications are—burst abdomen; sepsis (pelvic abscess); rectal stump leakage; complications related to colostomy; haemorrhage; severe colitis; intestinal obstruction. As it is an emergency procedure

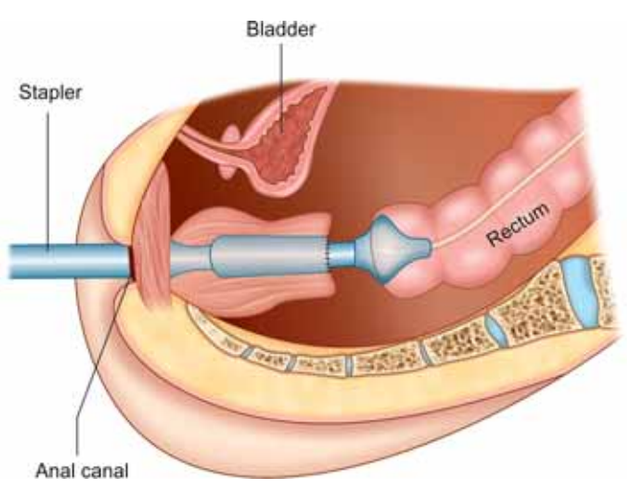


Fig. 25-16: Anterior resection for carcinoma upper rectum using stapler device.

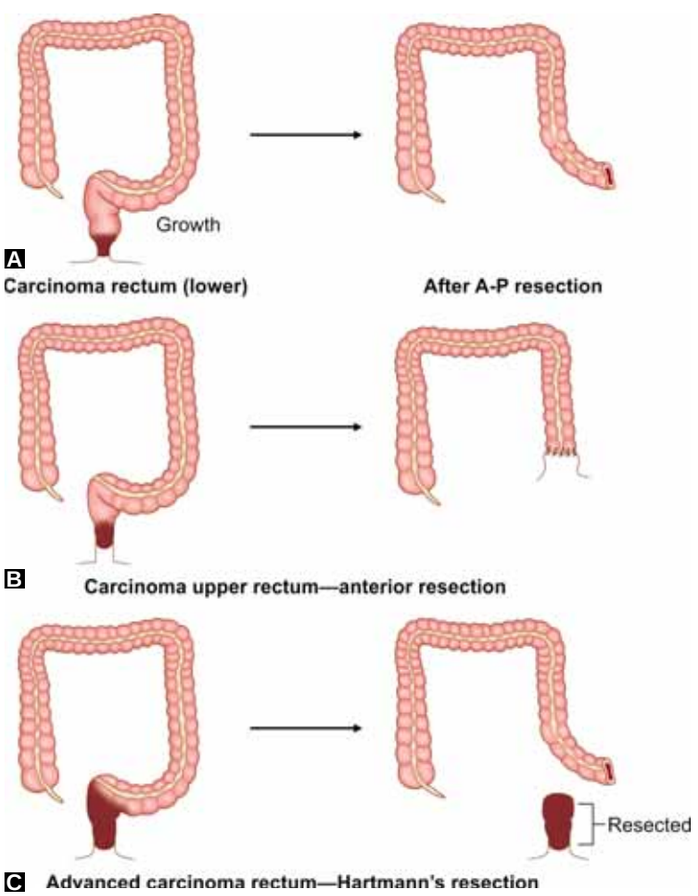
got high mortality of 10-20%. Restoration of the continuity is done only after 3-6 months for benign conditions **(Figs 25-17A to C)**.

4. **Pelvic evisceration (Brunschwig's operation):** It is removal of rectum with the tumour, all the lymph nodes, urinary bladder, fat, fascia, uterus, vagina, with colostomy and urinary diversion. It is neither favourable nor popular.
5. **Palliative colostomy** is done in advanced unresectable growth which presents with intestinal obstruction.

ANTERIOR RESECTION/ABDOMINAL RADICAL RESTORATIVE OPERATION/ ANTERIOR PROCTOSIGMOIDECTOMY (OPEN METHOD)

It is called as anterior resection as dissection is done from above in front through laparotomy. It is done in rectal carcinoma wherein tumour is above, 6–14 cm from the anal verge; i.e. middle and upper thirds of the rectum. Anterior resection is done as sphincter saving procedure otherwise patient might have undergone abdominoperineal resection with a permanent end colostomy.

Presently anterior resection of the rectum has widened definition than the earlier one due to availability of the modern laparoscopic set up. Anterior resection may be ***high*** (anastomosis above the peritoneal reflection); ***low*** (anastomosis below the peritoneal reflection; ***ultra low*** (anastomosis within 2 cm of the dentate line with sphincter preservation). *Coloanal anastomosis as sphincter saving procedure* is done by anastomosing the colon to the dentate line or below it. Ultralow and coloanal types need laparoscopy for dissection and stapler for anastomosis. ***Low anterior resection (LAR)*** is commonly advocated either by open or through laparoscopy.



Figs 25-17A to C: Surgeries for carcinoma rectum (A) A-P resection, (B) Anterior resection, (C) Hartmann's resection.

Preoperative evaluation and preparations are same—colonoscopy and biopsy; CEA; CT abdomen and pelvis to check nodal status and secondaries in liver; MRI pelvis to identify local infiltration; EUS is also very useful. Bowel preparation is done as similar for colonic diseases (please read in previous Chapter 24).

Technique

Position

Patient is kept in modified lithotomy position with steep head down at 40°. Surgeon stands on left side. One assistant stands on right side; another in between legs of the patient.

Incision

Lengthy midline incision is placed; abdominal cavity is explored for secondaries; self retaining retractor is placed.

Sigmoid Dissection

Small bowel is pushed upwards and kept away from the pelvis. Distal sigmoid may be occluded using a tape. Sigmoid colon is retracted medially. Peritoneum on the left lateral paracolic gutter is exposed; held between two haemostats and incised using scissor. Adhesions in this lower pat are common which are released carefully. Peritoneal incision on the lateral paracolic gutter is extended towards the splenic flexure. Left ureter, left gonadals are identified. Left ureter is dissected carefully and plastic loop is passed around it. Ureter is dissected carefully downwards using scissor and bipolar cautery down into the pelvis. Left hypogastric nerve in front of the internal iliac artery is identified and safeguarded. Sigmoid colon is retracted medially; incision is made on the right side of the sigmoid mesocolon. Dissection is done from bifurcation of the aorta downwards into the pelvis. Right ureter is also identified as it crosses the bifurcation of the common iliac artery in front of it. Right hypogastric nerve is identified now. Incision is made on the rectovesical or rectouterine pouch to mobilise the rectum from front. This also can be done at later period during rectal mobilisation.

Vascular Ligation

Colon is mobilised and held upwards and left with traction. Gonadal vein is separated. Inferior mesenteric artery originating from the front of the aorta is identified; fat and lymphatics (lymphovascular bundle) are swept towards the specimen colorectum; inferior mesenteric artery is divided 1.5 cm from its origin; it is also ligated and divided after it gives off left colic branch to maintain the adequate blood supply in the eventual anastomotic site which is essential. Preaortic sympathetic nerve should be retained.

Presacral Dissection

Sigmoid is retracted upwards and towards left to identify a tissue band between posterior aspect of the rectum. It should be divided using cautery as it contains branches of the middle sacral artery. Loose

avascular areolar tissues on both sides of this band are identified. Dissection is continued in this avascular holy plane (*avascular plane of Heald)* using scissor; blunt dissection as it is tempted for will open the posterior endopelvic fascia to expose presacral veins which if get injured cause torrential haemorrhage. Slow gentle meticulous sharp dissection is better. Posterior presacral dissection is done down into the pelvis up to the coccyx. Ureter and hypogastric nerves are visualised again for safety. Laterally lateral ligaments are identified by stretching the rectum towards opposite side. Lateral ligament is dissected and divided using cautery with right angle forceps underneath. Once both lateral ligaments are divided, tough Waldeyer's fascia is seen extending from the coccyx to the posterior rectal wall which is divided with sharp dissection. If difficulty in ureter dissection is anticipated by imaging study then prior stenting of the ureter is better. If on table ureter is injured then it can be closed primarily with 4 zero vicryl interrupted sutures with a J stent inside or by ureteric reimplantation into the bladder or ureteroureterostomy to opposite ureter. If hypogastric nerve is infiltrated by tumour one nerve can be sacrificed.

Anterior Dissection of the Rectum

Anteriorly peritoneum in rectovesical/rectouterine fold is incised. Dissection is carried out downwards behind the prostate and seminal vesicles along the Denonvillier's fascia. Initially sharp dissection, then blunt and sharp dissection helps to separate this fascia and rectum from prostate and seminal vesicle. Rectal wall and tumour should not be breached to avoid tumour spillage and contamination of the field. Dissection in woman is between the uterus and rectum and posterior wall of the vagina and rectum. Bilateral salpingo-oophorectomy is often done by few surgeons in anticipation of spread of tumour from rectum to ovaries. It is not mandatory.

In low and ultralow anterior resection, Waldeyer fascia should be divided completely; Denonvillier's fascia in front should be dissected adequately beyond the apex of the prostate up to the urethra; laterally beyond the lateral ligaments down to the puborectalis, pubococcygeus proper and iliococcygeus (parts of levator ani). Dissection should not go beyond the puborectalis. All fat and lymphatics should be cleared up to this point. Distal tumour clearance in such patients will be only 1 cm which is oncologically sufficient.

In females, anterior dissection is done between vagina and rectal wall and Denonovilier's fascia is less developed in females; posterior to cervix and posterior fornix this fascia is vascular due to venous plexus. Cuff of the vagina may require to be excised to include with the specimen. Often, if tumour is infiltrating the cervix hysterectomy is done along with the procedure like in APR. Nervi erigentes curves anteriorly from sacral foramina to converge and join the presacral nerves and form *neurovascular bundle of Walsh* at 2 and 10 o'clock positions in the Denonvillier's fascia just behind the lateral edges of the seminal vesicles. This bundle controls both potency and bladder function.

If seminal vesicles are involved by tumour infiltration in rare occasion only they are also excised along with the specimen; in such situation, it is difficult to preserve nerves in Denonsvillier's fascia.

Extended anterior resection may be advocated. It means removal of the involved internal iliac nodes and lateral pelvic wall. Plane of dissection here is lateral to the anterior division of internal iliac vessels; so these vessels are ligated at their origin/joining.

Haemostasis

Presacral haemostasis is a must. It is usually venous bleeding which stops by pressure. Presacral venous tear may be torrential; it is controlled by gel foam, surgicel, bone wax, pressure, titanium thumbtack—titanium preloaded haemorrhage occlude pin with applicator, muscle fragment welding (rectus abdominis muscle piece is harvested and placed on the bleeding vein in the foramina and held with forceps and high coagulation current is passed to the muscle through the forceps), silastic tissue expander tamponade. Occasionally, need may arise to pack the presacral area with mops which are removed in 48 hours once control of haemorrhage is obtained.

Splenic Flexure Mobilisation

Adequate mobilisation of the splenic flexure is done to avoid tension at anastomotic site. Renocolic, splenocolic, pancreaticocolic and gastrocolic ligaments are divided to mobilise the splenic flexure; mobilisation should be done under vision and so adequate exposure through lengthy incision is ideal always. Colon is divided above the sigmoid level using an occlusion clamp; bleeding from the cut edges should be ensured; fat and appendices epliploicae are cleared off for 1 cm from the cut edge. Colonic wash with warm distilled water is also often used; it will be beneficial.

Division of the Rectum

After complete mobilisation of the rectum, mesorectal pedicle which runs on the posterior aspect of the rectal wall containing few blood vessels is ligated securely distal to the line of the division. Distal rectal stump is dissected to remove all fat and perirectal tissues so as to expose the longitudinal muscles. Rectum is divided 3 cm distal to the rectal tumour after applying curved crushing clamp proximal to line of division. Distally soft curved occlusion clamp may or may not be needed; often even if clamp is applied it tends to slip. Distal rectal stump is irrigated with warm ½ to 1 litre of sterile warm water or warm dilute povidone iodine solution. There should be adequate bleeding from the cut edge of the rectum. Specimen is retrieved. Specimen and lymph nodes should be marked. Line of resection distally taken as 3 cm is sufficient; even 1-3 cm is adequate enough as it is proved that microscopic mural spread beyond the palpable lower edge of the tumour is very rare.

*In low and ultralow anterior resection (*open method), resection at lower end of the tumour on the rectal stump is difficult. Strong right angle clamp is placed 1-2 cm dial to the tumour after thorough irrigation of the rectum per anally using warm distilled water. Small incision is made distal to the clamp on the anterior surface of the rectum; polypropylene 1 zero continuous suture bites are taken from the distal cut edge with 5 mm gap with 5 mm thickness; sequentially rectum is cut part by part and suturing is continued as *whip stitch* until entire rectum is transected beyond the clamp to retrieve the specimen. Frozen section biopsy from distal end should be done ideally. One should remember that it is not possible to take circumferential stitches around the stump after transection of the rectum in open method. Stapler should be used for anastomosis. J pouch may be done if surgeon is well versed with technique in ultralow resections.

Anastomosis

It is achieved usually as end to end two layer or one layer anastomosis. 3 zero or 2 zero silk or vicryl is used. In single layer anastomosis

interrupted silk sutures are used. In two layer, outer silk and inner vicryl or silk interrupted sutures are used. Full thickness horizontal mattress sutures also can be placed. If there is discrepancy between colonic end and rectal stump (rectal ampulla is wider often 6 cm or more) then side to end anastomosis can be done to correct the discrepancy (Baker). Circular stapling anastomosis can also be done. Rectal stump can be transected using linear stapler and also the proximal colonic resection site. Anvil is passed to the proximal colonic end and fixed using polypropylene purse string sutures; circular stapler is passed per anally across the distal rectal stump; if linear stapler is not used then circular stapling end is fixed to rectal stump using similar purse string sutures. Anvil is connected to the circular stapler and is fired. Stapler with anvil is removed with completion of the colorectal anastomosis. Doughnut should be observed for adequacy. Fat should be cleared for 1.5 cm in both ends prior to stapler anastomosis as fat interposition can cause disruption and leak. Blood vessels adjacent to bowel wall near cut edge should be ligated or fulgurated properly otherwise after stapling troublesome bleeding can occur.

Closure

Pelvic peritoneum should not be closed. Large Foley's catheter is passed per anally towards the anastomotic site; pelvis is filled with warm distilled water; air is infused through the Foley's catheter to check the leak from the anastomotic site by seeing the air bubbles; if present additional silk sutures may be needed. Suction tube drain is placed into the pelvis and abdomen is closed in layers. Usually covering proximal colostomy is not needed as bowel is already been prepared as an elective surgery. If there is lot of contamination in the field or if it is very low anterior resection, then diversion colostomy should be done.

Post-operative Care

Nasogastric tube is removed in 5 days; drain is removed in 5-7 days. Foley's catheter from the urinary bladder is removed in 7 days. Oral fluid is started in 5 days. Observation for leak, sepsis, should be done.

Complications

Injury to ureter: If it occurs it should be sutured on table using 4 zero vicryl interrupted sutures with a J stent within. Ureteric reimplantation to the urinary bladder or ureteroureterostomy are other options.

Haemorrhage from pelvic presacral veins can be dangerous; surgicel, bone wax, packing are the options. Blood transfusions are required.

Pelvis abscess formation or pelvic infection or pelvic irritation is common. Fever with chills, lower abdomen pain, tenesmus, tenderness on gentle rectal examination, raised total count are the features. US may show abscess. CT is confirmative. CT guided percutaneous drainage, posterior colpotomy and drainage may be needed. If still persists then open drainage with diversion colostomy is needed. As already there is a anastomotic site per rectal drainage is impossible.

Sexual dysfunction in males if nerves in the pelvis are injured. Use of excessive monopolar cautery in posterior dissection may cause nerve injury; so judicious use of monopolar cautery or use of bipolar cautery or harmonic scalpel (open, focus) is better.

Bladder dysfunction is common in males which is usually mild and subsides gradually.

Anastomotic leak due to disruption can occur. It needs diversion proximal colostomy.

Stenosis at anastomotic site is not uncommon. Sigmoidoscopy confirms it. It should be differentiated from recurrence and so needs biopsy in suspected cases. Dilatation is sufficient usually; occasionally resurgery is required.

Abdominal wound infection, wound dehiscence and incisional hernia also can occur.

ABDOMINOPERINEAL RESECTION (APR)

Abdominoperineal resection (APR) is based on the concept that lymphatics spread from the rectum occure upwards, laterally and downwards and so entire field is removed. In 1908, *West Ernest Miles* did first APR. Presently APR is done if LAR (Low Anterior Resection) is not possible or in invasive rectal cancers **(Fig. 25-18)**.

Abdominal Part

Initial evaluation, abdominal phase of surgery are same as in anterior resection described above. Urinary catheter, nasogastric tube, steep head down low wide lithotomy position under epidural/general anaesthesia - are the preliminary steps. Incision is midline with umbilical curve towards left/colostomy site is in left iliac fossa **(Fig. 25-19)**.

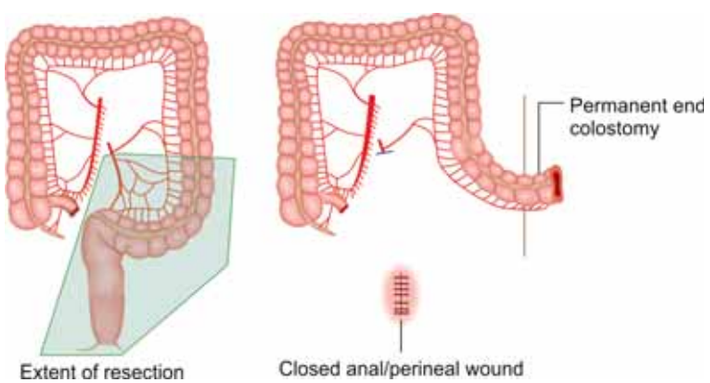


Fig. 25-18: Extent of resection and citation of colostomy in APR.

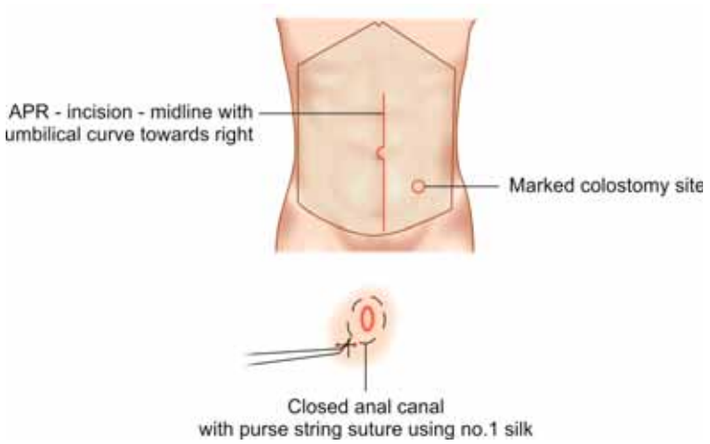

APR - incision - midline with umbilical curve towards right
Marked colostomy site
Closed anal canal with purse string suture using no.1 silk

Fig. 25-19: Midline incision with umbilical curve towards right side; colostomy site should be marked. Anal canal should be closed using no 1 silk with purse string suture.

Extent of resection is above the sigmoid below the left colic artery level. Peritoneum in the left paracolic gutter is incised and extended proximally across the sigmoid mesentery; below it is extended into the pelvis; left ureter is identified. Peritoneum on the right side is incised and sigmoid is retracted towards left; upward it is dissected up to the sacral promontory and aortic bifurcation. Right ureter is identified and preserved. Inferior mesenteric vessels are ligated and divided. IMA is ligated after the origin of the left colic artery. Sigmoid mesentery is dissected up to the colon margin. Presacral dissection is done in similar fashion like low anterior resection. Lateral ligaments are divided. Anterior dissection is done by incising the rectovesical peritoneal fold. It is extended downwards behind the prostate and seminal vesicle up to the membranous urethra in males and up to posterior fornix in females. In females, vaginal cuff may be removed; or hysterectomy can be done if needed. Further, dissection to complete the division of the entire lateral ligaments downwards facilitates to achieve the mobility of entire rectal tube. Levator ani muscle on both sides should be visualised to complete the abdominal part. Colon is resected after deciding the line of resection. Distal part is tied with an umbilical tape or roller gauze if stapler transection is not done. Proximal part is left for colostomy with an occlusion clamp.

Perineal Part of the Surgery

Purse string suture is placed using no 1 silk suture using cutting needle around the anus so as to close the aperture. Elliptical incision is made beginning 3 cm in front of the anus extending posteriorly towards the coccyx. Incised skin is held with Allis' forceps with purse string silk suture; dissection is carried out in the posterior plane in front of the coccyx. Coccyx can be excised if needed. Inferior haemorrhoidal arteries are identified, ligated and divided. Anococcygeal ligament is visualised and divided using cautery or scissor. Waldeyer's dense condensed fascia extending between the lower rectum and the lower presacral and precoccygeal region is divided using cautery. Often this fascia is divided from above through abdominal approach. Levator ani muscle is divided on either side to reach the abdominal pelvic area after incising the peritoneum there. Lateral dissection is done upwards by giving traction on the specimen towards the opposite side.

Lastly, anterior perineal dissection is done; lower edge of the transverse peronei muscle is identified; plane below it is dissected which is a natural plane separating rectum and urinary system. Incision on the anterior aspect is deepened to reach the apex of the prostate. Plane behind the prostate is dissected; rectourethralis muscle is transected to reach the peritoneal cavity behind the urinary bladder. As dissection is completed, all around specimen is removed. In females, dissection between vagina and rectum is done; if tumour is closer then cuff of the vagina adjacent to tumour is also removed. If vaginal cuff is not removed then during dissection blood supply to vagina should be retained otherwise it will cause perineo vaginal fistula which may persist for long time.

Closure of the perineal wound—all bleeders are cauterized. Wound is washed with warm distilled water and warm saline. Two suction drains one on each side is placed; deeper vicryl sutures are placed. In case wound is contaminated with faecal matter thorough wash is given; deeper vicryl sutures are placed and external wound is kept open. This wound is dressed regularly and allowed to granulate and heal on its own.

Many surgeons use prone jackknife position for perineal surgery, which is said to be better, but not popular. Here once abdominal part is entirely completed with closure and creation of colostomy, patient's position is changed to prone position for perineal part of the dissection **(Fig. 25-20)**.

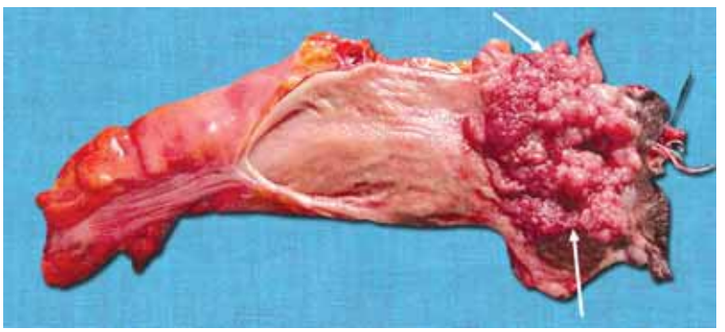


Fig. 25-20: Specimen of carcinoma rectum after APR.

Creation of Colostomy

Colostomy is created as end one in the left iliac fossa on the rectus muscle. A circular piece of skin is excised. Anterior rectus sheath is excised; muscle is split; peritoneum is opened to bring the end of the colon outwards. It can be brought out extraperitoneally to prevent herniation. Seromuscular suture bites are taken from the colon 5 cm proximal to cut margin which is also passed through the peritoneum and rectus sheath; interrupted vicryl sutures are placed. After closure of the abdominal wound, maturation of the colostomy is done by trimming the end if there is stapler line and suturing the full thickness edge of the colon to the skin using interrupted silk sutures.

Closure

Pelvic peritoneum is irrigated. Pelvic peritoneum can be closed in APR if it is amenable for closure. Usually, there is no need to place the drain into the peritoneal cavity. If pelvic cavity is not sutured and kept open (can be kept open without suturing also) then abdominal drain may be needed. Omentum is brought out lateral to the colostomy part of the colon towards the pelvis to fill the free space. It also absorbs fluid, prevents sepsis and supports urinary bladder. Alternatively if omentum is not adequate then absorbable mesh of large size can be sutured to posterior and lateral abdominal wall without injuring the ureters. In females uterus if not removed will fall retroverted and fill the pelvic cavity. Few surgeons do the caecal mobilisation so as to allow it to drop into the pelvic cavity to fill the space. Abdomen is closed in layers. Pelvis is already drained from below.

Colostomy care: Immediate care is given by doing irrigation daily with one litre warm saline to the proximal colon through colostomy. It is to distend the proximal colon so as to produce reflex peristalsis to empty the entire colon; so patient should feel colicky pain after saline infusion. Infusion is done through a tube, which should be gentle otherwise perforation may occur.

Postoperative Care

Nasogastric tube can be removed in 24 hours. Usually, colostomy starts functioning early. Oral feeding can be started in 48 hours. Perineal drain is removed in 7 days. Urinary catheter is removed in 7-10 days.

Colostomy bag is placed and colostomy care should be given. Colostomy site should be observed for mucosal necrosis; hence, initially transparent bags are used to visualise the mucosa easily. Perineal suture is removed in 14 days. *Sitz bath* to the perineal wound helps in faster healing of the wound.

Complications

Bleeding during abdominal dissection due to presacral vein or dissection; bleeding from perineal wound can occur from inferior haemorrhoidal vessels and branches of the internal iliac vessels.

Injury to ureter during abdominal and presacral dissection can occur. Urethral injury can occur while dissecting the rectum in front either from above or from below.

Small bowel adhesions can occur onto the pelvic suture line; or herniation of the small bowel across the pelvis leading into *intestinal obstruction* can occur. Colostomy in such situation will not function. Contrast CT is useful to confirm the obstruction. Initially it is treated conservatively; if patient is not responding then laparotomy may be needed.

Infection—wound infection, pelvic infection, septicaemia and urinary infection can develop after abdominoperineal resection **(Fig. 25-21)**.

Fig. 25-21: Wound infection after APR.

Bladder dysfunction is very common due to lack of pelvic support to urinary bladder. *Sexual impotence* is common after APR due to nerve damage (>50%).

Colostomy complications can develop—necrosis, retraction, prolapsed, parastomal hernia.

Problem in healing of the perineal wound—wound may partially heal by forming a chronic sinus. Wound healing may be delayed often. Persistent discharging sinus can occur; it will last for years often; it needs exploration of the sinus, excision of the sinus with coccyx; once it granulates well split skin graft is placed on the raw area.

LAPAROSCOPIC ABDOMINOPERINEAL RESECTION

First laparoscopic APR was done by Sackier in 1991. Laparoscopic abdominoperineal resection with formation of the colostomy is commonly done. Here abdominal part dissection is easier under direct vision; perineal dissection is same as in open. It is technically easier compared to laparoscopic anterior resection as anastomosis is not done **(Fig. 25-22)**.

Fig. 25-22: Laparoscopic APR. Colostomy is in left iliac fossa.

Present indication for laparoscopic APR—tumours within one cm of the anal verge; invasive rectal cancers.

Contraindications—perforated or obstructed tumours; severe obesity; previous pelvic surgeries. Tumours invading the bladder, pelvic wall, uterus needs open approach.

Patient position, trocar placements are same as described in laparoscopic low anterior resection. But here dissection is done much more distally beyond the levator ani posteriorly and up to proximal urethra beyond the apex of prostate anteriorly.

Laparoscopic USG is better to confirm the operability and to rule out any possible metastases in liver, nodes and retroperitoneum.

Abdominal part of the technique is same as laparoscopic anterior resection. Perineal part is same as perineal part of the open APR.

Steps in Laparoscopic APR

Proper positioning—lithotomy with steep head down; proper port placement

↓

Release of adhesions; in women elevation of uterus towards abdominal wall using silk sutures

↓

Holding the sigmoid up and left

↓

Opening the mesocolon adjacent to sacral promontory and dissecting upwards

↓

Identification of left ureter and gonadals; dissection should not be too anterior and too posterior

↓

Ligation of inferior mesenteric artery after dissection beyond the origin of the left colic artery.

↓

Division of IMA is done using ligatures, endovascular stapler, clipping, ligasure.

↓

Division of the inferior mesenteric vein at the lower border of the pancreas.

↓

Splenic flexure mobilisation is not necessary but paracolic gutter along the line of Toldt needs to be incised.

↓

Medial to lateral dissection of the sigmoid mesocolon up to the colon margin.

↓

Ureter, gonadals on both sides are preserved.

↓

Posterior presacral dissection along the avascular holy plane of the Heald which is identified by loose areolar tissue; in front endopelvic fascia is present enveloping the mesorectum; behind presacral pelvic (parietal) fascia will be present which should not be breached to avoid injury to presacral veins and hypogastric nerves (one on each side).

↓

Sharp dissection is done with division of Waldeyer fascia to identify the levator ani.

↓

Lateral ligaments are divided between mesorectum and the autonomic nerves using harmonic scalpel; mesorectum should not be breached and autonomic nerves should not be injured.

↓

Mobilisation in front between the anterior rectal wall mesorectum and prostate and seminal vesicles along and in front of the Denonvillier's fascia beyond the prostate apex to urethra up to the pelvic floor; in females anterior dissection is done between vagina and rectal wall and Denonvilier's fascia is less developed in females; posterior to cervix and posterior fornix this fascia is vascular due to venous plexus. Cuff of the vagina may require to be excised to include with the specimen. Often, if tumour is infiltrating the cervix hysterectomy is done along with APR (like in open). Nervi erigentes curves anteriorly from sacral foramina to converge and join the presacral nerves and form *neurovascular bundle of Walsh* at 2 and 10 o'clock positions in the Denonvillier's fascia just behind the lateral edges of the seminal vesicles. This bundle controls both potency and bladder function.

↓

Sigmoid is divided along the proposed line of resection using linear stapler.

↓

Perineal procedure—elliptical skin incision; dissection in front of coccyx; division of anococcygeal ligament; division of levator ani on both sides; division of superficial transverse muscles in front; then puborectalis and rectourethralis muscles.

↓

Retrieval of specimen through perineal wound.

↓

Suction tube drains are placed on both sides of the perineal wound; levator on both sides are approximated using vicryl in front of the coccyx; skin is closed using interrupted sutures.

↓

Pneumoperitoneum is recreated; proximal cut end of the colon is observed to rule out any twist and kept ready for colostomy; pelvic floor is visualised for any bleeding; omentum is brought into the pelvic cavity which minimises the fluid collection and so sepsis; it supports the urinary bladder in front in males so as to reduce residual urine; it prevents the small bowel adhesions also.

↓

Creation of the terminal permanent colostomy.

LAPAROSCOPIC LOW ANTERIOR RESECTION (LAR)

***Indication*:** Rectosigmoid and rectal growth 4 cm proximal to the dentate line. In LAR resection is done 2 cm above the dentate line. Presently high, low, ultralow anterior resections can be done through laparoscopy with expertise.

Advantages: Magnification, better visualisation, better dissection, preservation of the nerves, easier dissection through the avascular holy plane of Heald; better haemostasis, faster recovery.

Problems: Learning curve, need for modern equipments and cost, time consuming, inability to feel the tumour.

Preparation: Colonoscopic confirmation with biopsy is done. CT abdomen and pelvis is done to see nodal status, liver secondaries and local invasion. Carcino embryonic antigen (CEA) is done as a base line level for later follow up. Patient is prepared using polyethylene glycol or sodium phytate solutions 12 hours prior to surgery. Oral aminoglycoside and metronidazole may be given as bowel antiseptic.

Anaesthesia: General anaesthesia is used. Perineal scrub cleaning is done properly.

Position: Low lithotomy position with steep head down like for laparoscopic hysterectomy to make small bowel to settle in proximal abdomen. Cleaning and draping is done. Left side of the patient is raised to allow small bowel to fall out of the pelvis.

Surgeon stands on right side. Camera surgeon stands on left side of the surgeon; scrub nurse in between legs; first assistant on the left side of the patient near left shoulder to hold the colon using bowel grasper. Monitor is placed on the left side near foot end.

A 10-mm umbilical port is used for 30° telescope. *5 mm port is placed in midclavicular line on right side*. 10 mm port is placed at right iliac fossa 2.5 cm medial and above the anterior superior iliac spine. This port later requires to be converted to 12 mm port to pass *articulating endo stapler* to staple the low rectum. Additional 5 mm port is later required in midline just above the symphysis while mobilising the splenic flexure.

After pneumoperitoneum, with assistant holding and pulling sigmoid upwards and towards left (through left upper 5 mm port); surgeon does dissection through two working ports—right 5 mm upper port and right 10 mm lower port; medial side of the mesocolon is incised from below upwards from left rectovesical/rectovaginal peritoneal reflection extending proximally across the sacral promontory upwards towards inferior mesenteric artery (IMA) origin. Left ureter and left gonadal vessels are identified and dissected off the posterior peritoneum. Sympathetic nerve at the level of the sacral promontory is preserved. IMA near its origin (usually after it gives left colic branch in case of carcinoma rectum) is clipped/ligated and divided using ligaseal or harmonic scalpel. Dissection further towards left visualises Gerota's fascia covering the left kidney.

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Colour of Gerota's fascia is more deep yellow than the surrounding fat. Incision is further extended upwards towards the duodenojejunal flexure. Inferior mesenteric vein is identified close to the ascending branch of left colic artery at the lower border of the pancreas which is double clipped and divided. Accessory left colic artery when present should be preserved carefully.

Now it is better if surgeon shifts his position in between legs of the patient to do mobilisation of the splenic flexure of the colon. Right lower and suprapubic ports are used for splenic flexure mobilisation. Dissection begins at the left paracolic gutter extending upwards towards splenic flexure; renocolic, splenocolic, gastrocolic and pancreaticocolic ligaments are incised. Splenic flexure is mobilised from left kidney, spleen and pancreas. It can be done from left side towards right or from middle level of transverse colon by dividing gastrocolic omentum towards left using harmonic scalpel.

Once splenic flexure is mobilised, surgeon again shifts his position towards right with working ports on right upper and lower area.

A 30° camera is placed on the right 10 mm port to visualise the pelvis for pelvic dissection. Plane of dissection is in a potential space between parietal and viscera pelvic fascia, which is avascular. Incised peritoneum on the sacral promontory is extended downwards on the right side of the rectum towards pelvis. Superior hypogastric plexus and two hypogastric nerves are identified and preserved. Peritoneum is incised on the left side and in front like U on the rectovesical or rectouterine fold. Dissection is continued in this *avascular holy plane of Heald* down towards the levator in front of the parietal pelvic fascia to clear the mesorectum. Levators are clearly seen now; midline raphe and Waldeyer fascia, which is strong and condensed is divided using harmonic scalpel. Mesorectum should be removed up to the levator ani.

Lateral mobilisation is done by dividing the lateral ligaments on both sides close to the rectum. It contains middle rectal vessels. Medial part of the autonomic plexus and branches passes through the lateral ligament. These nerves should be preserved.

Anterior mobilisation is done along the Denonvillier's fascia behind the prostatic capsule up to the apex of the prostate. Mesorectum also should be cleared.

At the end circumferential dissection is done to achieve fully mobilised rectal tube. Fat and fascia of the rectal tube is removed to achieve complete denudation and muscularisation. This is essential step prior to stapler application. Cautery should not be used as it may injure the rectal wall; sharp dissection should be done; mucosa should not be breached. Rectal examination and proctoscopy can be done to assess the completion of the mobilisation.

Using *roticulating stapler* rectum is transected. Per anally warm distilled water wash is given to the rectum. This needs conversion of 10 mm port into 12 mm port (of suprapubic port). If this is not available then small Pfannenstiel incision (5 cm) made through which conventional linear stapler is used to divide the rectum. Tumour distal margin is felt for clearance. Bowel is brought out of the wound and specimen is removed after placing a sterile plastic sheath in the abdominal wound to prevent contamination and tumour spillage on the abdominal wound **(Fig. 25-23)**.

Transected proximal colon is prepared for anvil of the circular cartridge placement. After positioning the anvil, using 2 zero polypropylene purse string suture is placed around it through the cut edge of the colon. Colon with anvil is dropped into the peritoneum carefully without allowing the rotation. Circular stapler cartridge is passed through the anus carefully gently towards rectal stump and

Fig. 25-23: Roticulating stapler is used to transect the rectum.

is perforated just adjacent to the stapler line in the middle; cartridge is locked to the anvil using two instruments. While locking the instrument care should be taken not to interpose other structures. It is done by counter clockwise movement of the shaft of the stapler. Stapler is fired through circular anastomosis. One minute after firing stapler is released by clockwise movement with careful rotation.

Pelvis is filled with warm distilled water and Foley's catheter is passed per anally; air is infused to check the air bubble leak in the pelvis. After completion, tension in the anastomotic site is assessed. Tube drain is placed through one of the 10 mm ports. Diversion colostomy is done if needed.

TOTAL PROCTOCOLECTOMY WITH ILEOANAL POUCH

It is removal of entire colon and rectum with creation of ileal distal pouch and doing ileoanal anastomosis.

Indications

Ulcerative colitis; indeterminate colitis; familial adenomatous polyposis, multiple sessile polyps, synchronous multicentric carcinomas.

Contraindications

Crohn's disease is a contraindication as terminal ileum is involved now or later ileum may get involved after anastomosis leading into failure of the treatment.

Preoperative Preparation

Preoperative planning is essential. Colonoscopy, biopsy, marking of stoma, mechanical bowel preparation, nasogastric tube and urethral catheter placement and rectal washes with normal saline is done.

Total Colectomy

Lithotomy with head down with lengthy midline incision is used under general anaesthesia. Mobilisation is same as combinations of right and left colectomies with proctectomy. Right paracolic gutter is incised and right colon is mobilised from lateral to medial approach unless malignancy is confirmed or suspected wherein dissection is done from medial to lateral. Right ureter, gonadals, duodenum, SMA, SMV are carefully preserved after dissection. *Vessels are ligated either close to colon wall.* Once ileocolic artery is ligated terminal

ileum is supplied by jejunal branches of SMA; arcade should be kept intact. Left side is mobilised from sigmoid towards the splenic flexure. Splenic flexure including transverse colon is mobilised fully. Sigmoid is mobilised; vessels are ligated securely using ligatures; clips can be used.

Proctectomy

Proctectomy (Excision of the entire rectum) is done in same way as abdominal part of APR. Both ureters and hypogastric nerves with autonomic plexus are retained carefully. Presacral dissection is done in avascular holy plane of Heald which is identified by loose areolar tissue. One should not open posterior presacral fascia to avoid injury to presacral veins and nervi erigentes. Waldeyer fascia is divided. Lateral dissection is done by dividing the lateral ligaments; autonomic nerve plexus are close to it; one should avoid injuring it. Anterior dissection is done behind the Denonvillier's fascial plane; behind prostate and seminal vesicles. Neurovascular bundle of Walsh at 2 and 10 O'clock positions. Posterior dissection is done up to levator ani muscles. Entire rectal tube is mobilised. Distal small length of the mucosa if retained needs anorectal mucosectomy prior to doing hand sewn ileoanal anastomosis. Distal rectum is transected. Entire colorectum is removed after transecting the ileum very close to the caecum between soft occlusion clamps retaining its blood supply.

Mobilisation of the Small Bowel for Adequate Length

Small bowel mesentery is mobilised up to the 3rd part of the duodenum and inferior border of the pancreas. If still mobilisation is needed, then all peritoneal tissues are cleared from right of the superior mesenteric vessels. Using transillumination, superior mesenteric vessels and arcade should be identified for preservation. Small tiny 1 cm transverse incisions are made carefully on the peritoneum overlying the superior mesenteric vessels and also Kocherisation of the duodenum will also be helpful.

Construction of Ileal Pouch

Different pouches are used. J, S, W, H are different types. S pouch is easier to reach to the anal canal (more than 3-4 cm better than J pouch). J pouch is easier to construct. Possibility to tension free pouch should be confirmed prior to construction of the pouch. Pouch plan is done; proposed apex is held with Babcock's forceps which is pushed down towards the anal canal; finger is placed in the anal canal to feel the Babcock's tip easily without tension confirming that pouch is tension free. A point in the ileum 20 cm from the cut end if brought down 6 cm beyond the pubic symphysis, it is said that tension free pouch is possible. Pouch is created either by hand sewn or by stapler. Interrupted or continuous inner full thickness vicryl sutures and outer seromuscular interrupted silk sutures are used to create the pouch after doing enterotomy on the antimesenteric border. Stapler can be used to create pouch. 15 cm each limb (total of 30 cm of terminal ileum) J pouch is created. Pouch should be checked for leak proof by infusing saline into the pouch. Apex of the pouch is opened; saline filled syringe is passed through this enterotomy and pushed to check for leak. Syringe is removed. Anvil of the circular stapler is passed into the pouch through the enterotomy and purse string suture is placed using 2 zero polypropylene sutures **(Fig. 25-24)**.

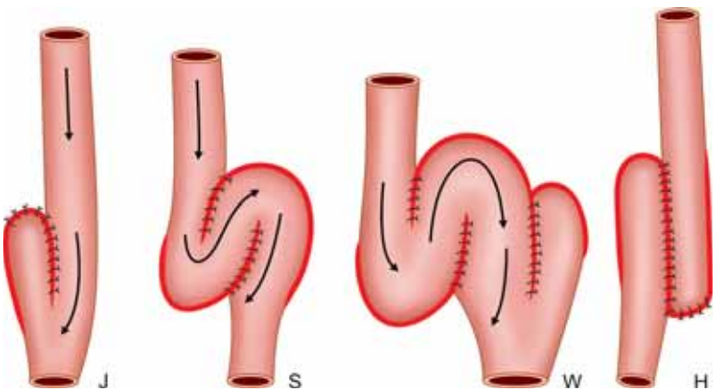


Fig. 25-24: Different pouches are used – J, S, W,H.

Ileal Pouch Anal Anastomosis

When stapler is used, anastomosis is achieved at anorectal ring at the top of the anal column; here anal sensory epithelium is retained and anastomosis is tension free as it is higher level than hand sewn. Stapled anastomosis at further lower level is not possible as it will damage the internal sphincter. Stapled type is easy to do; less infective complications, functionally better. But there is potential malignant transformation in transitional zone (4-5%). So, whenever biopsy report shows dysplasia then mucosectomy with hand sewn anastomosis should be done. Cartridge is passed into the anal canal; rectal stump is already stapled during transection; cartridge is punctured through rectal stump and is locked with anvil of the pouch; stapler is fired to achieve the anastomosis. Stapler is removed; doughnut is checked. Sphincter should not be included in the stapler; posterior vaginal wall should not be included to avoid formation of pouch-vaginal fistula. Apex of the J pouch or end of the S pouch is used.

When *mucosectomy* is needed in patients with dysplasia, rectum is transected just above the levator ani; mucosa is stripped off the muscular layer of the rectum from dentate line up to the anorectal ring/levator ani. Ferguson anal retractor is needed for this purpose. 10-20 mL of 1 in 2,00,000 units of adrenaline solution is used to raise the mucosa from the muscle layer. Every parts of the mucosa should be removed carefully and gently. Frozen section biopsy of the excised mucosa is a must to rule out carcinoma and Crohn's disease. Cautery is used to control bleeding. CUSA can be used to do mucosectomy. Mucosectomy is better achieved in prone Jackknife position. Sullivan and Garnjobst in 1982 started to do mucosectomy prior to abdominal procedure in prone position. Mucosectomy is done from dentate line upwards for 4-6 cm in a tubular fashion **(Fig. 25-25)**.

Pouch is brought down towards anal canal and is anastomosed to anal canal. Hand sewn anastomosis is technically difficult and demanding. Ileal pouch end is brought down into the anus after mucosectomy. Bivalved Park's retractor is of great help for this. Two Gelpi retractors one at right angles to each other are also very useful. 4 zero vicryl interrupted sutures are taken. Bites should take few fibres of underlying internal sphincter muscle

Covering Diversion Loop Ileostomy

Covering diversion loop ileostomy is done 20 cm proximal to the pouch which should not have any tension. Routinely diversion should be done as usually patients are on high dose of steroid, malnourished, toxic, anaemic. In selected patients restorative proctocolectomy with

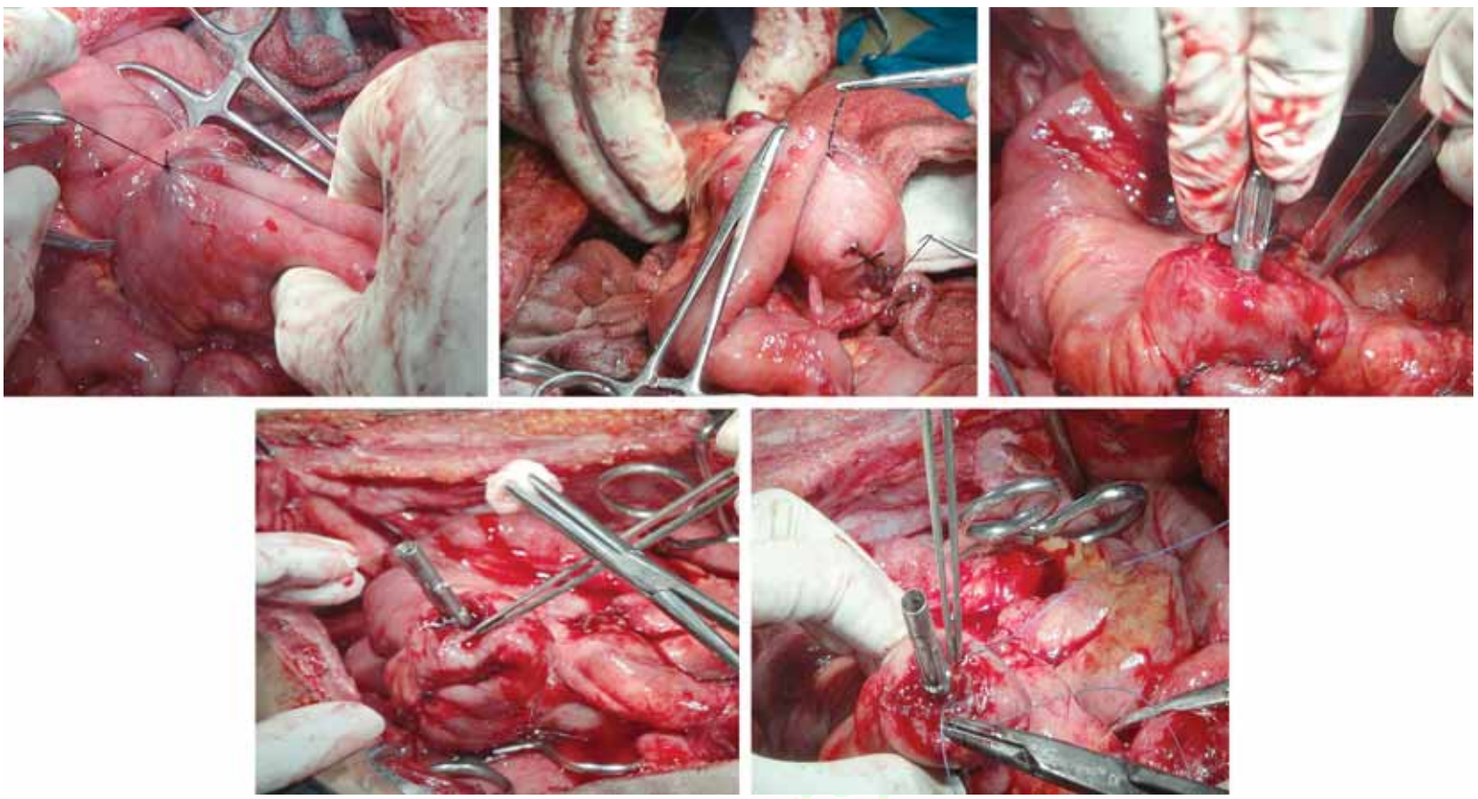


Fig. 25-25: Construction of ileal pouch and placing anvil in the pouch.

ileal pouch anal anastomosis is done without any diversion ileostomy. Transanal pouch (32 French) catheter is placed often for 5 days.

Posto-perative Care

Ileostomy created is usually of high output that drains about 1 to 2 litres of liquid causing severe dehydration and electrolyte imbalance. One should avoid hot weather, exercise, high fibre diet; plenty of oral fluids should be taken. Loperamide orally is useful to reduce the pouch output. Steroid if patient is on; it should be tapered gradually under observation. Antibiotics, correction of nutrition and anaemia are needed depending on the individual patients.

Complications

Usual complications are anastomotic leak, stricture, recurrent pain, diarrhoea, perianal ulceration, perianal infection, pelvic abscess formation, irritable pouch syndrome.

Pouchitis is a specified complication in ileal pouch surgeries. In pouchitis patient presents with acute diarrhoea, urgency, rectal bleed, suprapubic pain. Pouchitis disease activity index is often used to assess the severity of the pouchitis—by features, endoscopy and biopsy. Local steroid, mesalamine are useful. If persists then pouch excision and permanent ileostomy should be done.

Cuffitis, cuff abscess if inadequate mucosectomy is done.

Technical complications like injury to ureter, bleeding, impotence, sepsis, intestinal obstruction can occur.

Faecal incontinence is another distressing problem.

TREATMENT FOR RECTAL PROLAPSE

Treatment for Partial Prolapse

The nutrition of the child is improved and digital repositioning is tried. *Correction of constipation* is important **(Fig. 25-26)**.

Submucosal injections of 10 mL of 5% phenol in almond oil or ethanolamine oleate is given into the apex of the prolapse under general anaesthesia so as to create an aseptic inflammation leading to tethering of mucosa to the underlying muscular coat. Injection can also be given at the base or both at the apex and base. Alternatively, 30 mL of tetracycline or oxytetracycline or hypertonic saline injection can also be used. Initial injection is supported by

Fig. 25-26: Partial rectal prolapse.

http://vip.pers

Thiersch wiring using (temporary) chromic catgut until adhesion occurs between the mucosa and muscular layer (in 3 weeks). In adults, injection therapy is tried for partial prolapse, results are not as good as in children.

Thiersch wiring alone is tried with good success rate in children.

Goodsall's operation is excision of the prolapsed mucosa at its base, usually in three positions. Stapled transanal rectal resection surgery *(STARR)* is also often used **(Fig. 25-27)**.

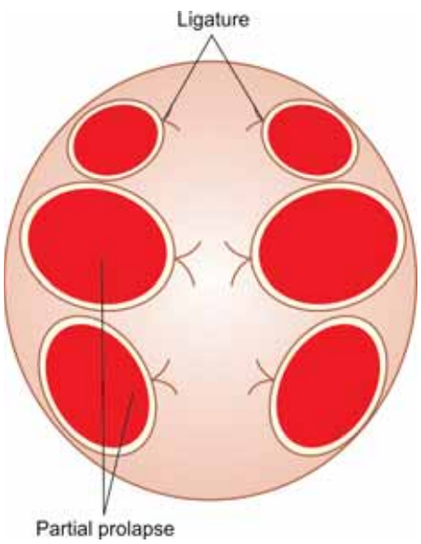


Fig. 25-27: Goodsall's ligature for partial prolapse. Prolapsed mucosa is ligated at different positions using nonabsorbable suture material often with double needled. Usually, it is done for one side in three portions.

Treatment for Complete Prolapse

Principles

Surgery is done to *control* the prolapse; to *restore* continence; to *prevent* constipation **(Fig. 25-28)**.

Fig. 25-28: Complete rectal prolapse.

In young males, abdominal repair should be avoided as it injures pelvic nerves leading to sexual impotency. So perineal approach is better.

Rectopexy is fixing the rectum to sacrum by sutures or mesh after complete mobilisation of the rectum. Laparoscopic rectopexy using polypropylene mesh and sutures gives good result and has become very popular.

Delorme's operation is better option in young individual with complete prolapse. In elderly perineal proctectomy with anterior and posterior reefing of the sphincter muscle is the accepted method now. It is similar to Altemeier technique (It is perineal rectosigmoidectomy). Here entire prolapsed rectum and redundant sigmoid is resected through perineum prior to reefing of the sphincter. Anal encircling surgeries using synthetic wires/mesh/suture materials are limited to extremely ill patients and elderly who will not withstand perineal proctectomy. *Choice of procedure* depends on age, sex, operative risk, pelvic floor defect, degree of incontinence, history of constipation.

Colonoscopy, defaecating proctography, bowel preparation, nasogastric tube, urinary catheterisation and perioperative antibiotics are needed in preoperative preparation.

Procedures for repair of rectal prolapse

Perineal Operations	*Abdominal Operations: Open/ Laparoscopic*
• Mucosal sleeve resection (Delorme) • Perineal rectosigmoidectomy (Altemeier) • Posterior fixation of the rectum of Lockhart-Mummery • Wyatt operation • Mickulicz Miles perineal transanal rectosigmoidectomy/amputation of prolapse • Anal encircling (Thiersch)	• Suture rectopexy – Goligher, Lahaut, Devadhar, Rosoe Graham • Prosthetic or mesh rectopexy – Anterior/posterior – Ripstein, Well's • Resection rectopexy – Muir's • Anterior resection • Lahaut's operation

Surgery—Types

Abdominal Procedures

Laparoscopic Rectopexy

It is ideal and good approach to fix the rectum to sacrum. *Laparoscopic posterior mesh rectopexy (**LPMR**)* is the procedure done. Prior colonoscopy and bowel preparation is needed using exelyte or Peglec. Head down, low lithotomy position is needed. Ports placement is same as for anterior resection or APR. 10 mm umbilical camera port; 10 right lower pararectus right hand working port; 5 mm left lower pararectus left hand working port; 5 mm left lumbar port for traction to the sigmoid colon; another extra 5 mm suprapubic port in female patients to fix the uterus **(Fig. 25-29)**.

Sigmoid colon is held with left sided port. Surgeon does dissection from right side. Peritoneum on the right of the rectum is opened from sacral promontory downwards to reach avascular holy plane of Heald which is identified by typical presence of loose areolar tissue. Care should be taken to avoid injury to autonomic nerves, ureters. Dissection is extended down as posterior mobilisation into the pelvis with adequate mobilisation of the rectum. Lateral peritoneal reflection on left side is incised and is dissected to connect on both sides of the mesorectum. Left ureter is preserved. Presacral mobilisation is done below up to levator ani muscle. Lateral ligaments are either divided

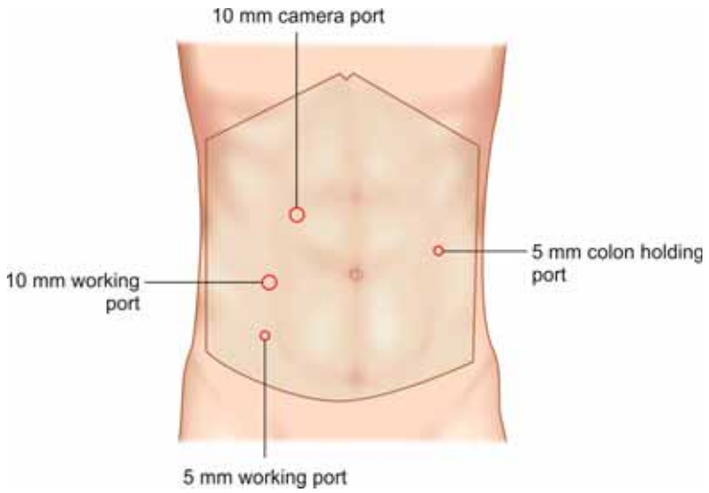


Fig. 25-29: Ports placement for laparoscopic rectal prolapse.

or left alone. It is divided usually in elderly; it is preserved in young individuals unless there is a need to correct undue redundancy of the rectum. *Anterior mobilisation* is also important. Anterior mobilisation along the Denonvillier's fascia is done 5 cm below the peritoneal reflection. 15 × 10 cm polypropylene mesh is placed in the presacral space deep to rectum, which is fixed to presacral fascia along the sacrum and sacral promontory. Mesh is also sutured to rectal wall on both sides using interrupted polypropylene sutures to create a mesh wrap around the mobilised rectum. Only partial wrapping of mesh is done. This partial wrap corrects the prolapse completely without incontinence and constipation. Partial wrap may be ½ or 2/3rd or 3/4th one. Peritoneum is closed using vicryl to extraperitonealise the mesh. Many advocate laparoscopic mobilisation and fixation of mobilised rectum to sacral promontory using polypropylene sutures without mesh.

Laparoscopic sigmoid resection and rectopexy (Laparoscopic resection rectopexy, LRR) is done when there is rectal prolapse with constipation, with excess redundant sigmoid colon with kinking. Here complete resection of the sigmoid colon is done with colorectal stapled anastomosis. Suture rectoplexy is done by suturing the rectal wall to the mesorectum and the presacral fascia below the level of the sacral promontory. Usually three interrupted sutures are placed. Often fixation between lateral ligaments and sacral promontory is also done. Sigmoidoscopy is done to check the anastomosis. In LRR mesh should not be used as field may be contaminated during resection.

Well's (Britain, 1959) Operation

Polyvinyl alcohol sponge is wrapped around the mobilised rectum posteriorly (from behind) and is fixed to sacrum. Infection, fistula formation is high. Polypropylene mesh is used as a modification now instead of polyvinyl sponge; wrapping is only partially done to reduce the incidence of constipation. But this Ivalon sponge is not approved in USA FDA. Teflon (poly carbon fluoride) and polypropylene mesh are commonly used now. Patient under general or epidural anaesthesia is placed supine head down position. After midline laparotomy, small bowel is pushed and packed upwards. Peritoneum on both sides of the rectosigmoid is incised 5 cm above the pelvic brim one after the other. Both ureters are identified and protected. At the sacral promontory posterior peritoneum is incised; avascular presacral holy plane of Heald is identified by the presence of loose areolar tissue. Dissection is done in this plane. Anteriorly mesorectum should not be disturbed and posteriorly presacral fascia should not be breached to avoid injuring the presacral veins and nerves. Dissection is done using cautery and scissor up to the coccyx. Tougher Waldeyer fascia behind the lower rectum and coccyx is also divided. Anterior dissection is done carefully up to distal part of the seminal vesicles. Care should be taken not to injure the neurovascular bundle of Walsh at 2 and 10 o'clock positions. Lateral ligament if needed should be divided to avoid the redundancy. Full mobilisation is essential to avoid redundancy and so recurrence. Proper haemostasis is achieved. Ivalon sponge used is 22 × 10 cm size × 3 mm thickness, which is fixed to presacral fascia using three interrupted 2 zero polypropylene sutures posteriorly. All three sutures are taken first then sutures are moved deep down into the pelvis to tie knots. 3/4th circumference of the rectum is encircled by the sponge and is fixed on both sides to the rectal wall using three interrupted 3 zero polypropylene sutures. Pelvic peritoneum is closed using continuous vicryl sutures to extraperitonealise the sponge. Now polypropylene mesh (6 × 4) is used **(Fig. 25-30)**.

Ripstein Operation (Charles Benjamin Ripstein, Canada, 1965)

After mobilisation of the rectum, 5 cm width Teflon mesh sling is passed around the rectum from front to fix it behind to fascia 5 cm below and in front of the sacral promontory. Sling is also fixed in front and laterally to rectum. As anterior fixation is dangerous, this procedure is not advocated now **(Fig. 25-31)**.

Suture Rectopexy

Rectum is mobilised fully; rectum is secured to sacral fascia or bone using interrupted nonabsorbable sutures. It is simple, easy to undertake with high success rate; but causes evacuation disturbances, constipation and obstruction **(Fig. 25-32)**.

Goligher's Operation

Rectum is entirely mobilised up to anorectal ring and its posterior muscular layer is fixed to presacral fascia using interrupted polypropylene sutures.

Devadhar Rectal Plication

Through abdominal approach, junction between thicker lower part and thinner upper part of the intussusception is identified. A purse

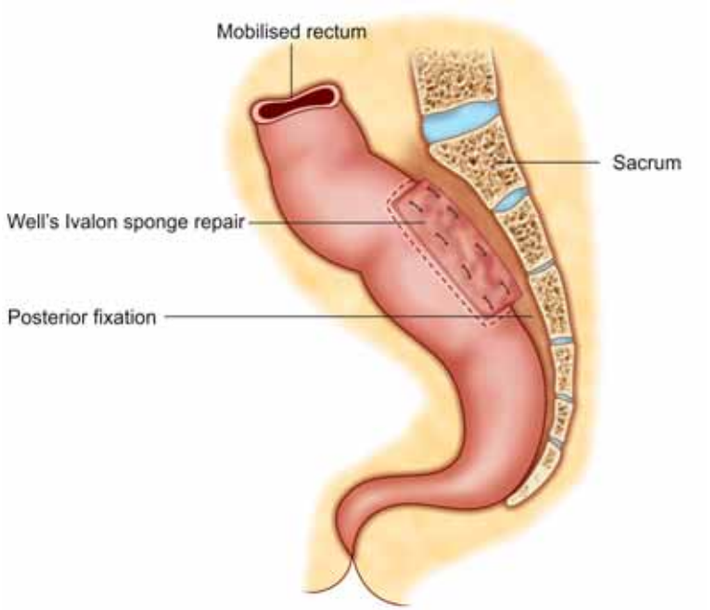


Fig. 25-30: Well's Ivalon sponge repair—posterior repair.

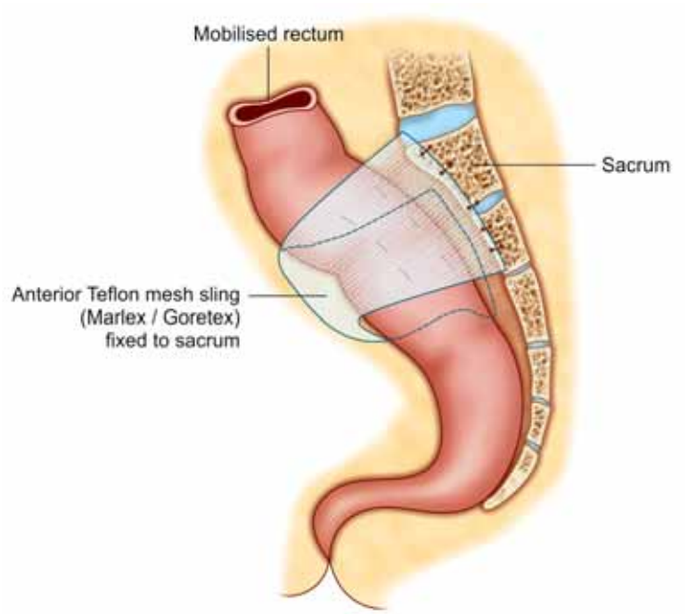


Fig. 25-31: Ripstein repair—anterior repair.

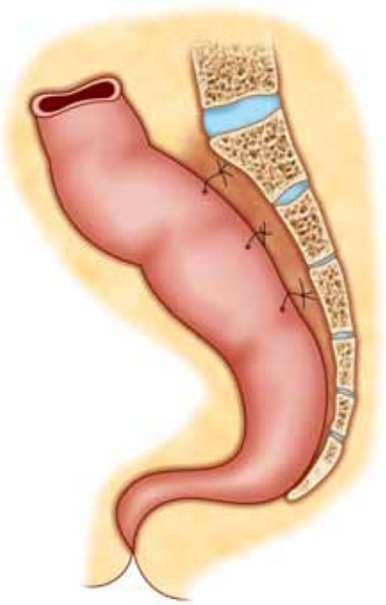


Fig. 25-32: Suture rectopexy.

string suture using silk is placed in front and laterally; further 3-4 interrupted submucosal Lembert sutures are placed to create reverse intussusception.

Lahaut's Operation

Rectosigmoid is mobilised fully; mobilised loop of rectosigmoid is passed in front through posterior rectus sheath behind the rectus muscle; extraperitonealisation is done to pull the rectus forward to prevent descent.

Rosoe Graham Operation

After mobilisation of the rectum, levator muscles are exposed and sutured in front of the rectum along with removal of pouch of Douglas.

Dumphy Operation

It is done through combined abdominoperineal approach with perineal rectosigmoidectomy. Both procedures control prolapse well but not incontinence.

Muir Low Anterior Resection

In a redundant rectosigmoid with prolapse, rectosigmoid resection is done; excision of redundant pouch of Douglas is done; rectum is fixed to sacrum behind.

Nigro Teflon Halter Operation

It is suspension of the rectum through intra-abdominal sling approach from pubis around the mobilised rectum using 4 × 20 cm mesh sling middle part of the mesh is sutured to rectal wall using interrupted sutures. Pubic rami are dissected in space of Retzius. Each end of the mesh is sutured to pubic ramus on each side to suspend the rectum.

Orr (1947) Fascia Lata Sling Suspension

Fascia lata sling is taken from lateral part of the thigh; it is sutured to wall of the rectums and sacrum with interrupted sutures on both sides after complete mobilisation of the rectum. Nylon is used by many instead of fascia lata for similar suspension.

Complications of Abdominal Procedures

Intraoperative—presacral bleeding, nerve plexus injury, injury to ureter.

Post-operative—Intestinal obstruction, adhesions, faecal impaction, fistula formation, mesh erosion, recurrence, stricture formation. Constipation rate is more if lateral ligaments are divided; if slings are placed anteriorly also along with posterior slings. Pelvic abscess is common especially in Well's operation which can be prevented by proper bowel preparation prior to surgery. Once abscess forms, Ivalon sponge or mesh has to be removed. Preoperative antibiotics are used to prevent this complication.

Perineal Procedures

Delorme's operation (Mucosal sleeve resection and rectal muscle plication, Edmond Delorme, French surgeon, 1900;)

After prior bowel preparation, under spinal anaesthesia, in lithotomy position, completely prolapsed rectum is held with Babcock's forceps. 1 in 2,00,000 adrenaline solution is injected into the submucosal plane of the rectum to cause haemostasis. Rectum is pulled down to create complete prolapse and held using Babcock's forceps at the apex. A circumferential incision is made 1-2 cm away from dentate line; often additional longitudinal incisions may be needed in oedematous friable mucosa. Dissection is done with sharp scissor and cautery; mucosa is stripped off from the deeper muscular layer from 1-2 cm below the anal margin (1-2 cm proximal to dentate line in nonprolapsed position) to the apex of the prolapsed rectum. This 1-2 cm gap is needed to preserve the anorectal sensation. Tubular mucosa is held down with traction; this stripped sleeve can be resected at apex now or later placing plication sutures on the muscular layer; it is better to keep if it is not friable as it helps in giving traction to the rectum while placing plication sutures. Muscular layer of rectum is plicated using absorbable vicryl 2 zero interrupted sutures all around; approximately 12-15 plication stitches are needed. These sutures are tied after finishing the passage of all sutures. Cut end of the mucosa of the apex is sutured to anal margin using interrupted vicryl sutures. It is technically easier **(Fig. 25-33)**.

Figs 25-33(1)

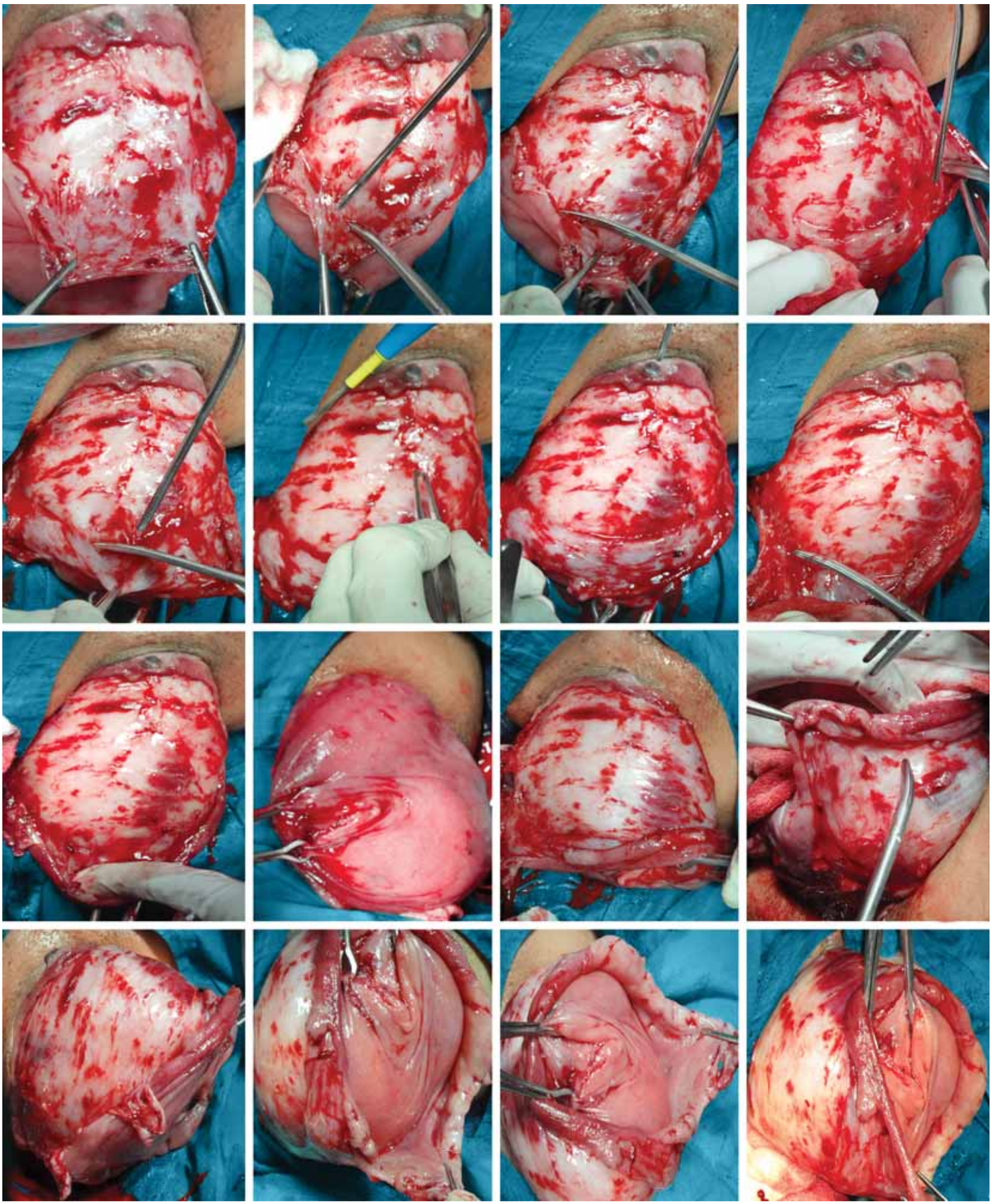


Fig. 25-33(2)

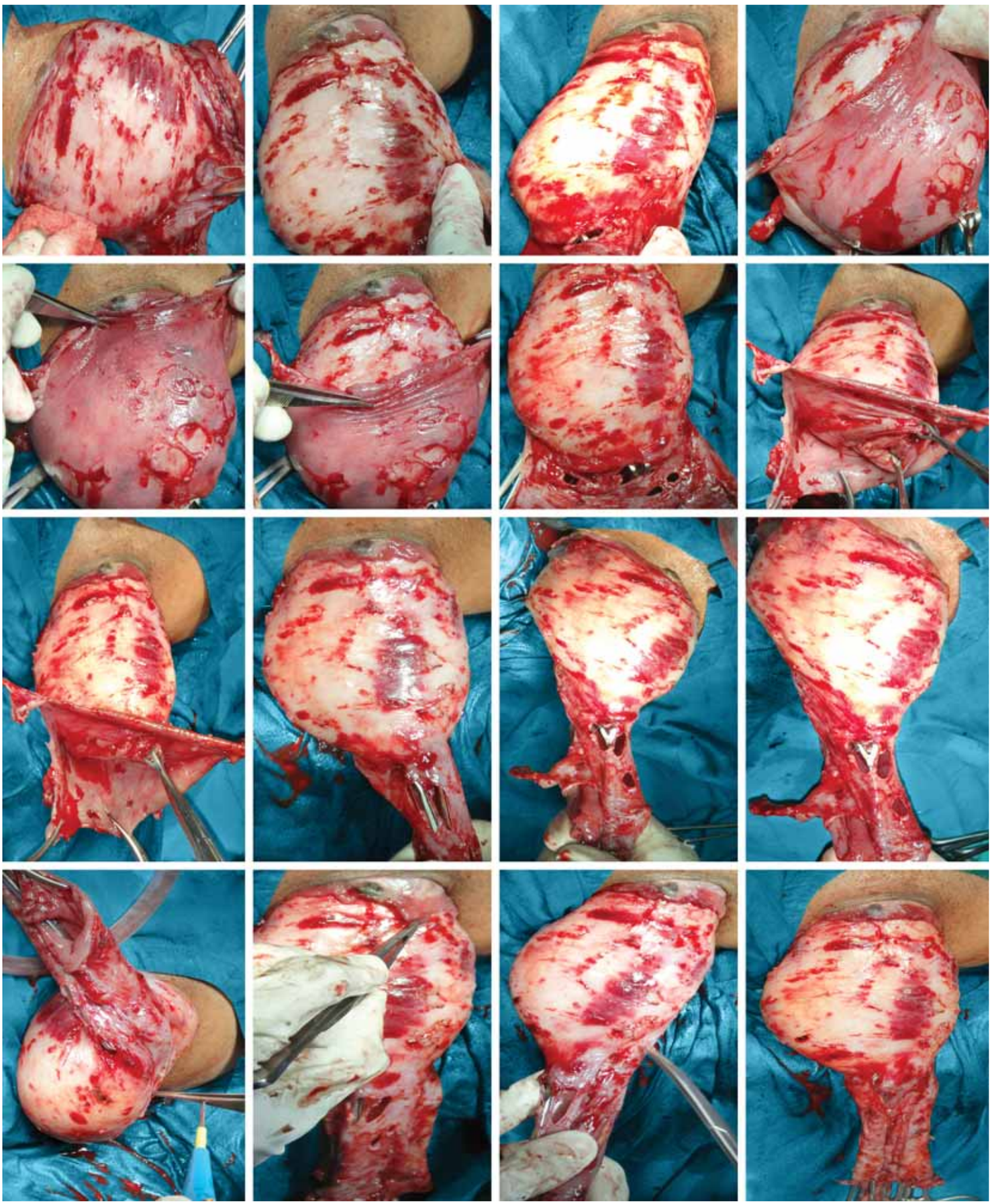


Fig. 25-33(3)

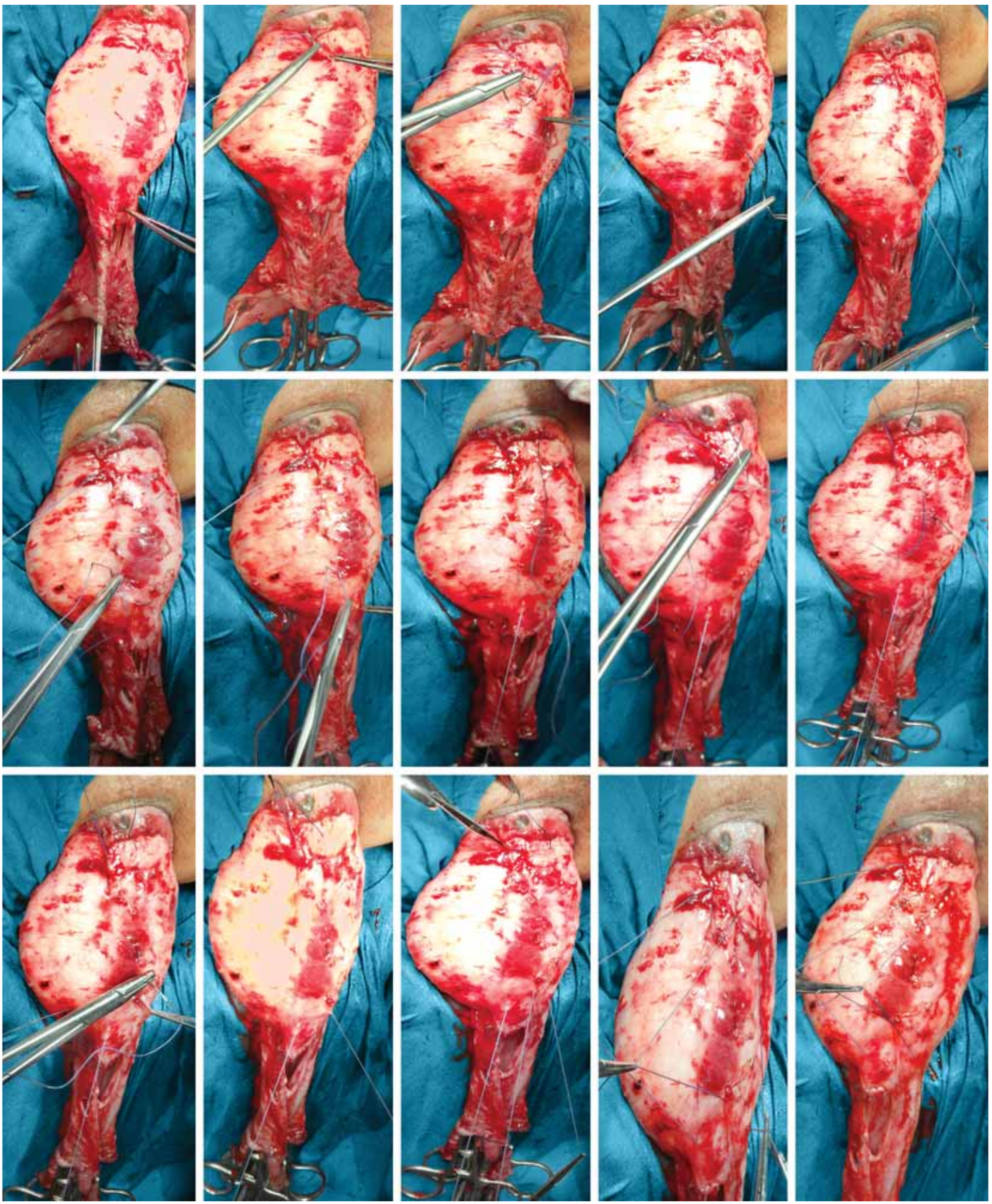


Fig. 25-33(4)

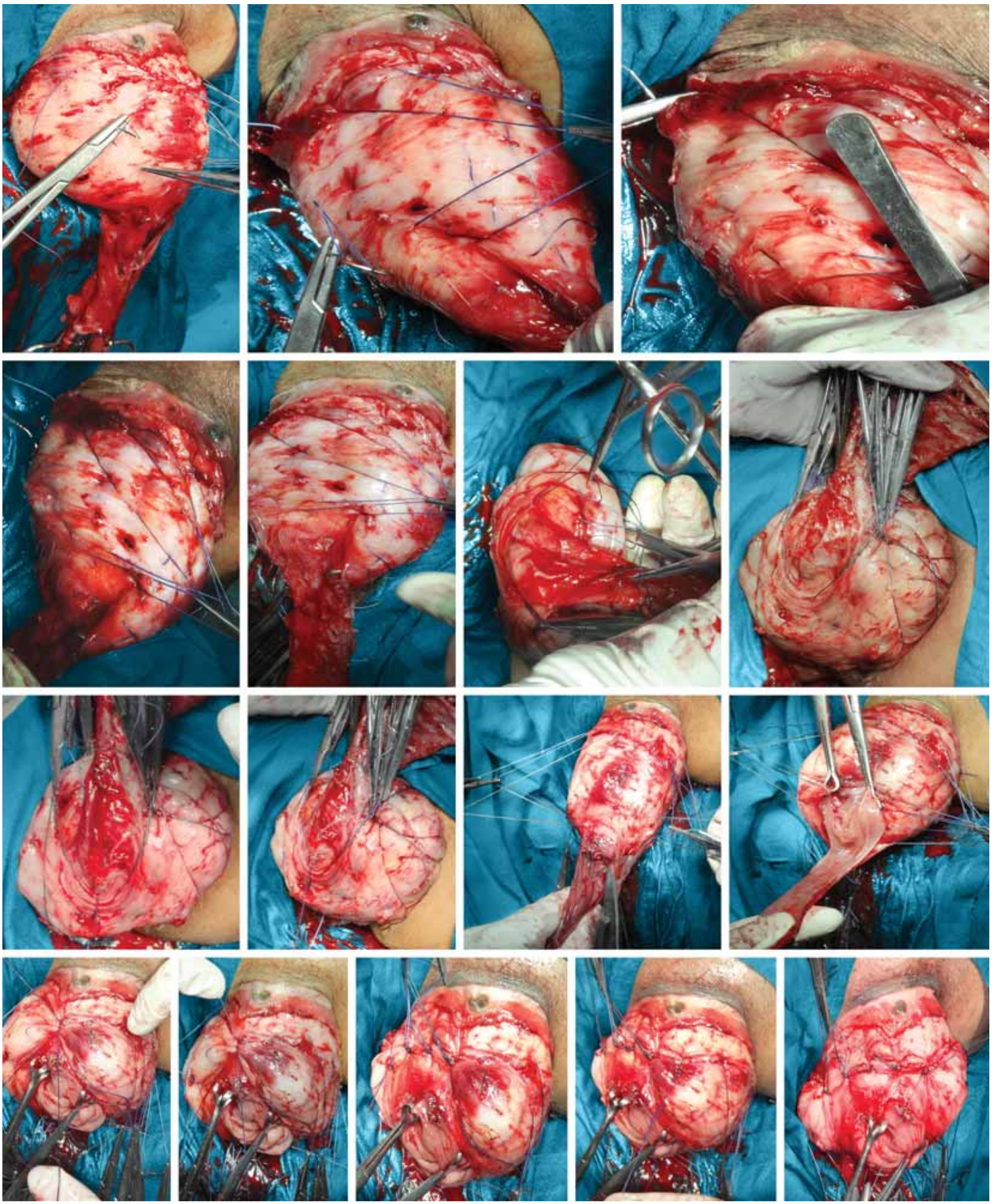


Fig. 25-33(5)

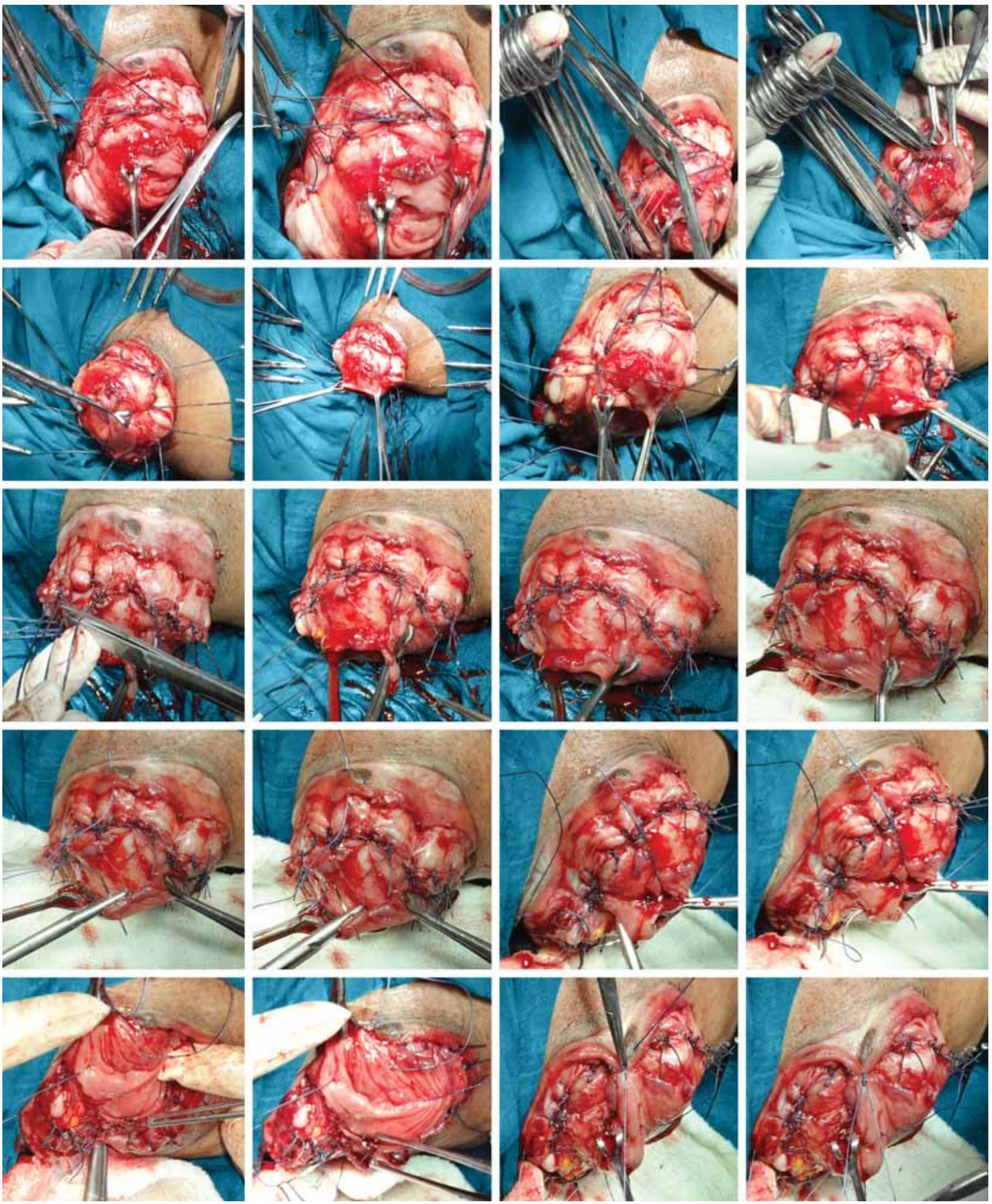
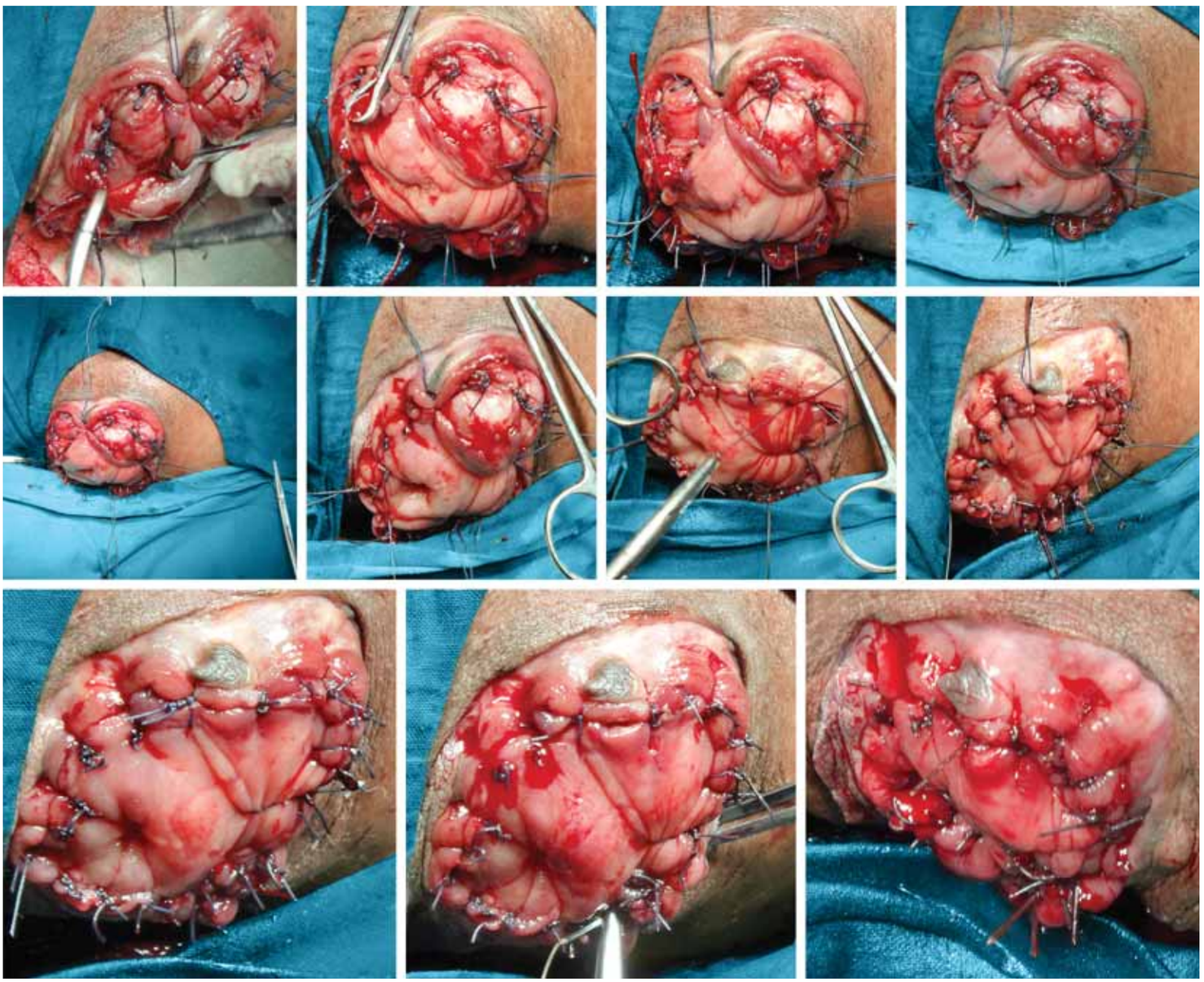


Fig. 25-33(6)



Figs 25-33(7)

Figs 25-33(1 to 7): Delorme's procedure for rectal prolapse.

Complications: It causes alteration in rectoanal inhibitory reflex, complete loss of rectal reservoir function, incontinence may persist and recurrence chance is high. Abscess in plicated segment can occur. Occasionally stricture can develop.

Perineal Posterior Fixation of the Rectum of Lockhart-Mummery

Retrorectal space is dissected through perineal approach and posterior rectal wall is sutured to sacrum and coccyx, additionally placing a retrorectal gauze pack to stimulate adhesions.

Wyatt Operation

Through perineal post-anal approach, dissected retrorectal space is placed with a Marlex/mersilene mesh which is sutured high to the sacral promontory and rectal wall laterally.

Mickulicz Miles Perineal Transanal Rectosigmoidectomy/ Amputation of Prolapse

Prolapsed rectum is excised and sigmoid is sutured to the anal margin.

Altemeier's Perineal Rectosigmoidectomy (1952)

After rectosigmoidectomy, colonic anastomosis and pelvic floor is supported by suturing puborectalis muscle in front of the rectum using nonabsorbable sutures.

Rectum is fully prolapsed and held with Babcock's forceps. 1:2,00,000 adrenaline is injected to the submucosal plane. Circumferential incision is made 1.5 cm away from the dentate line; first on the posterior surface then on the anterior surface. All the layers of the rectal wall is incised to its full thickness. Perirectal fat is identified

between two outer and inner rectal tubes. Inner rectal wall is not incised. Mesorectum between two tubes is identified. Mesorectum is carefully ligated using two ligatures proximally sequentially at proximal level. Peritoneal cul de sac of sliding hernia is identified and opened. Bowel contents inside peritoneal cavity is pushed upwards; further ligation, division and mobilisation of the mesorectum and mesosigmoid is done. Hernial sac is closed with absorbable vicryl sutures. Levator ani is sutured posteriorly using 2-3 interrupted 2 zero polypropylene sutures to achieve levatorplasty; often anterior levatorplasty is also done. Sigmoid on its anterior part is cut and is sutured to the anal canal above the level of pectinate line to preserve columns of Morgagni; preservation of columns of Morgagni retains the fine anal continence and reduces the chances of anal stricture formation after surgery. Once anterior part of sigmoid colon is cut and sutured (using 3 zero vicryl) only then posterior part of the sigmoid colon is cut and sutured to anal canal. This avoids retraction of the cut part of the sigmoid proximally. Anastomosis can also be done using circular stapler.

Complications are—bleeding, anastomotic dehiscence, sepsis, anal stenosis, which may require regular dilatation.

Gant-Miwa Operation (1920, Japan)

Placement of 30-40 absorbable interrupted sutures incorporate the mucosa and submucosa from the apex of the prolapse 1 cm above the dentate line with each at 5 mm apart; with anal encirclement. It has got 15% recurrence rate.

Anal Encircling

In 1891, Thiersch did anal encircling using silver wire to provoke inflammatory fibrosis as well as to give mechanical support to the anal orifice—*Thiersch wiring*. It is done under local anaesthesia. Two small incisions are made at lateral parts or anterior and posterior parts of the anal canal. Submucosal tunnel is created using a curved haemostat. Silver wire is passed around deeper to these incisions and tied after placing the *index finger* into the anal canal. Wire can be removed after 12 months. Polypropylene, nylon are the other materials that can be used. Ribbon shaped prosthetic mesh also can be used. Procedure leads into partial closure and narrowing of the anal canal. *Temporary wiring* along with Goodsall's ligature or injection sclerotherapy using thick catgut are often advocated. *Complications*: Pain due to wire erosion, infection, faecal impaction, incarceration, rectal prolapse, recurrence (80%).

Supralevator high encirclement of anal orifice (of Notaras) is done above the level of levator muscles by placing Teflon or nylon ribbons through anterior and posterior incisions. It gives better support and will not cut through. *Thoralsksen* modified this by placing plastic/mersilene tape around the bowel high up.

Complications of rectal prolapse surgery

Injury to hypogastric nerve causing impotence.
Bladder dysfunction.
Bleeding from presacral venous plexus.
Injury to rectum and colon causing faecal fistula.
Constipation after rectopexy is a known complication.
Recurrence of prolapse.
Incontinence persists in 50% of cases post-operatively.
Infection—proctitis/pelvic abscess.

TREATMENT OF PILONIDAL SINUS

Pilonidal sinus may consists of primary and secondary sinuses. It is common in hairy people. Tuft of hairs in the track is common presentation **(Figs 25-34 and 25-35)**.

In Acute Phase Initially

Drainage of the abscess is done and antibiotics are given; later definitive treatment is undertaken.

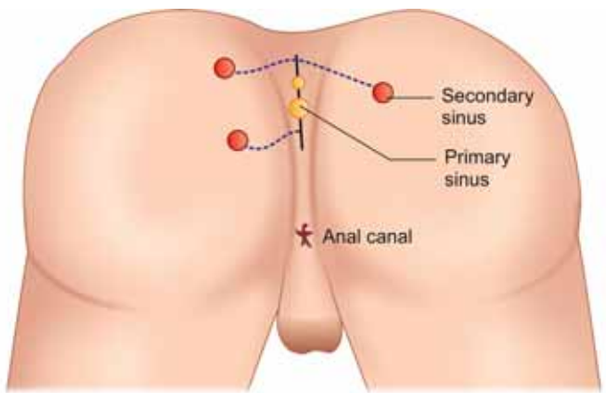


Fig. 25-34: Primary and secondary pilonidal sinus tracks.

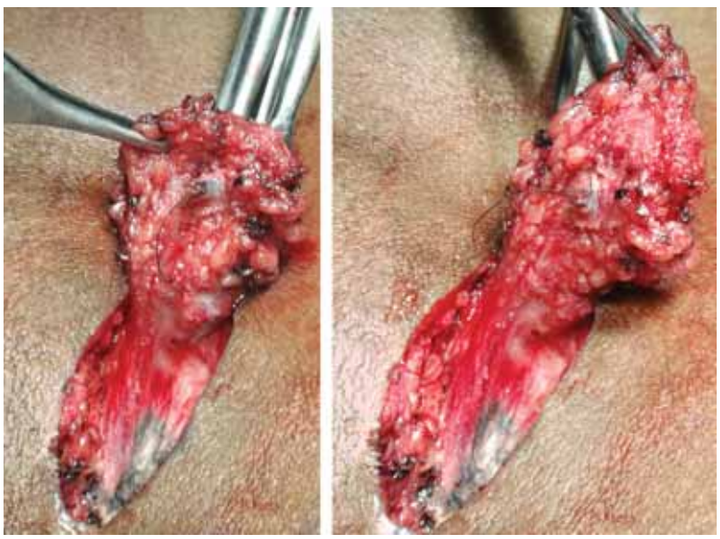


Fig. 25-35: Tuft of hairs in pilonidal sinus track.

Definitive Treatment

Excision

In prone position (*jackknife* position, i.e. prone with buttocks elevated) excision and primary closure is done under general anaesthesia or local anaesthesia. All sinus tracks, unhealthy granulation tissues with hairs are removed completely. Methylene blue is injected to demonstrate the multiple tracks properly. Excision and skin grafting—has got high recurrence rate **(Figs 25-36 and 25-37)**.

Excision with Z Plasty

It shows good result. Excision with multiple Z plasty is said to be better but technically difficult **(Figs 25-38 and 25-39)**.

Karydakis Excision

It is done through a semilateral incision and lateralised suturing of the wound away from the midline, gives good result. In prone position with buttocks strapped outwards, paramedian vertically elliptical incision of 5 cm length 2 cm from the midline is placed; edges of the ellipse should be symmetrical; elliptical skin, fat and deep fascia is excised. Medial part of the ellipse will cross the midline to include all midline primary sinuses. Medial flap of the incision is raised for 2 cm further towards midline and opposite side and all fat and deep fascia under the entire length of the medial flap is excised. Haemostasis is maintained. Suction drain is placed. Buttock straps should be released prior to wound closure. Pressure dressing is placed. Subcutaneous tissue and skin are closed. Sutured wound will lie away from newly formed midline **(Fig. 25-40)**.

Rhomboid Flap

Excision with closure using *Limberg (Rhomboid) buttock flap* (single or double rhomboid flaps)—good result. Under general or local anaesthesia, in prone position with buttocks strapped outwards to table using wide plaster after cleaning and draping, rectangular (rhomboid) tissue of full thickness skin and subcutaneous fat is excised including the midline with its long axis in the midline. Angles of rhomboid should be 60° and 120°. Angles are adjusted meticulously as shown in the pictures; flaps are elevated, rotated and

Sinus
Strp
Strapping in pilonidal sinus surgery is essential
Strapping is released after dissection prior to suturing
Methylene blue injection to the sinus track

Fig. 25-36: Pilonidal sinus—operative jackknife position; making incision for the same.

Fig. 25-37: Excision and primary suturing of the pilonidal sinus. It has got high recurrence rate as scar formed here is in the midline.

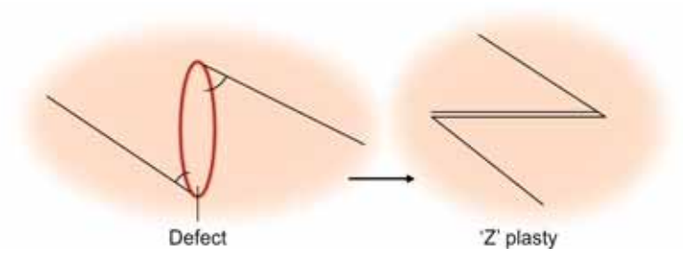


Fig. 25-38: Incision and mobilisation for Z plasty.

sutured using 3 zero polypropylene or polyethylene. While elevating the flap monopolar cautery should be avoided or used only with care; bipolar cautery is better. No. 15 blade or fine scissor is always better to retain the blood supply of the flap. Suction drain is placed underneath. Buttock straps should be released before suturing. Subcutaneous absorbable sutures are placed. First sutures should be placed over the angles other sutures. Pressure dressing is placed **(Figs 25-41 to 25-43)**.

Bascom Technique

It is the excision of the pilonidal sinus through lateral approach—is a good method. Through a lateral incision or multiple small lateral

Figs 25-39(1)

Pilonidal sinus track excision
Suction drain tube
Stay suture
Stay suture

Figs 25-39(2)

Figs 25-39(3)

Figs 25-39(1 to 3): Technique (Steps) in 'Z' plasty—done for pilonidal sinus. It gives good result. Multiple Z plasties are also used.

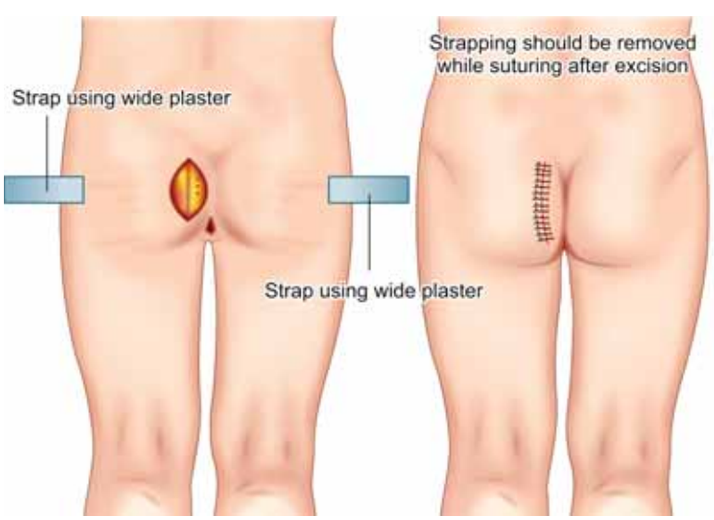


Fig. 25-40: Karydakis excision.

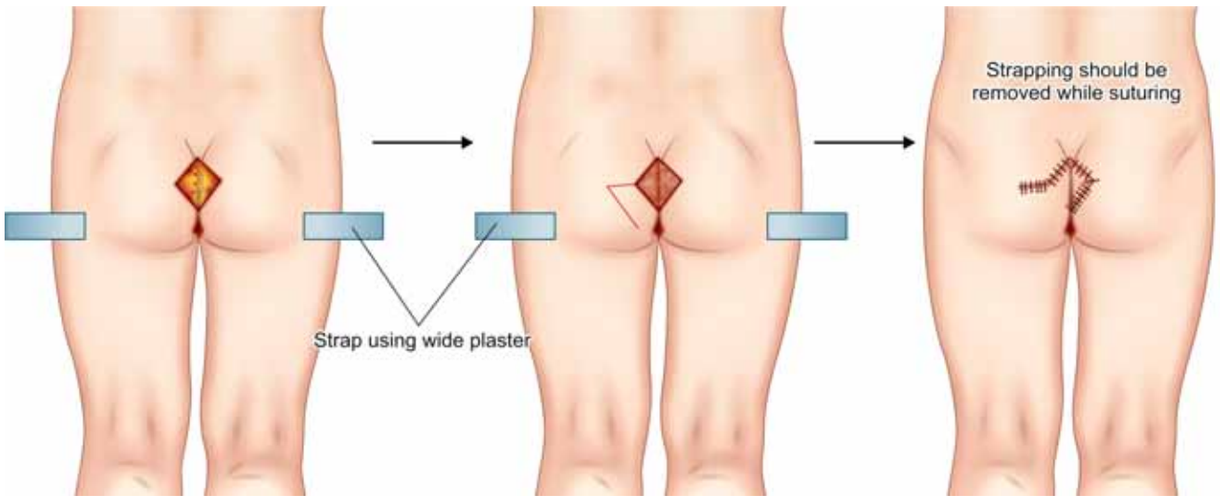
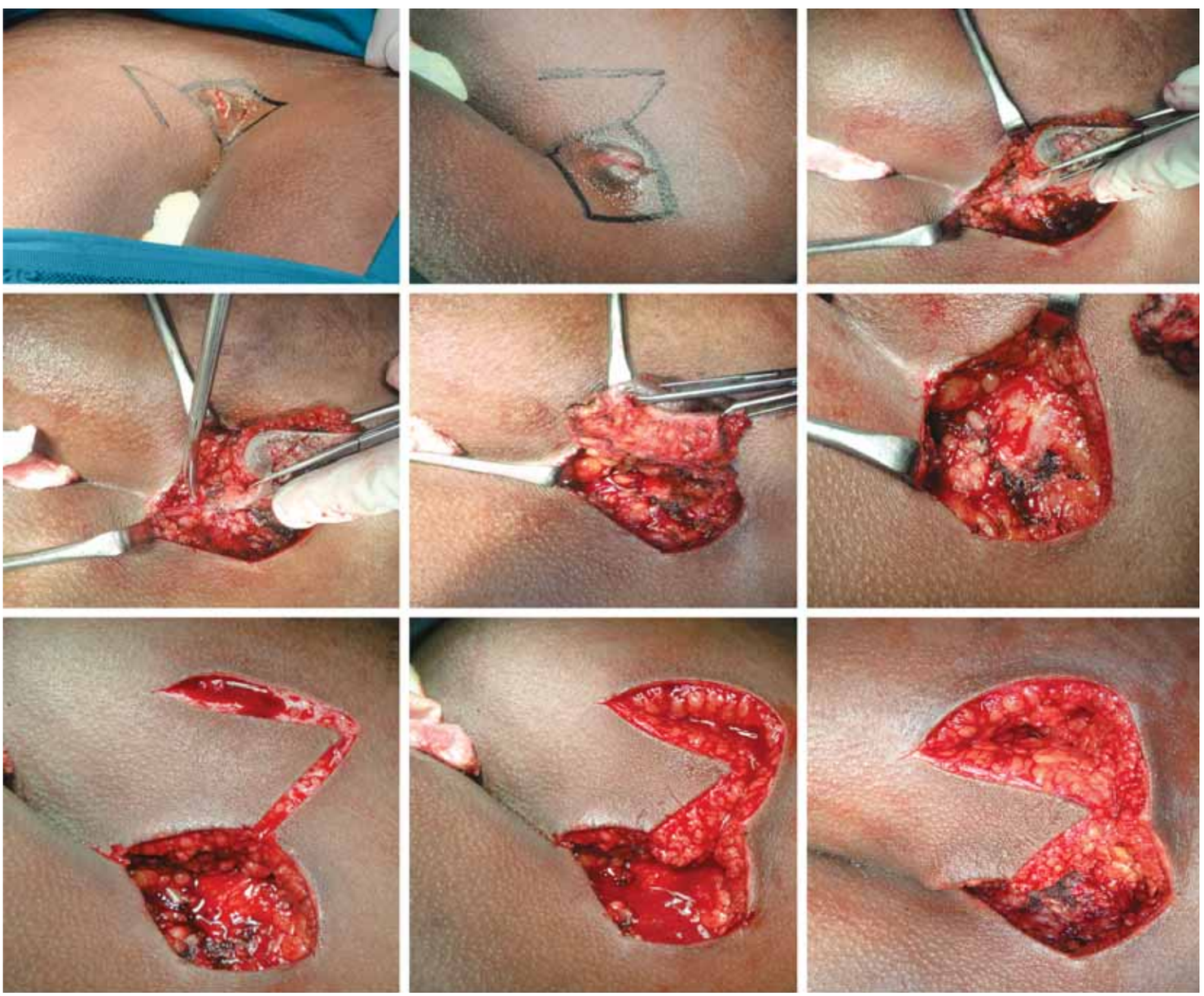
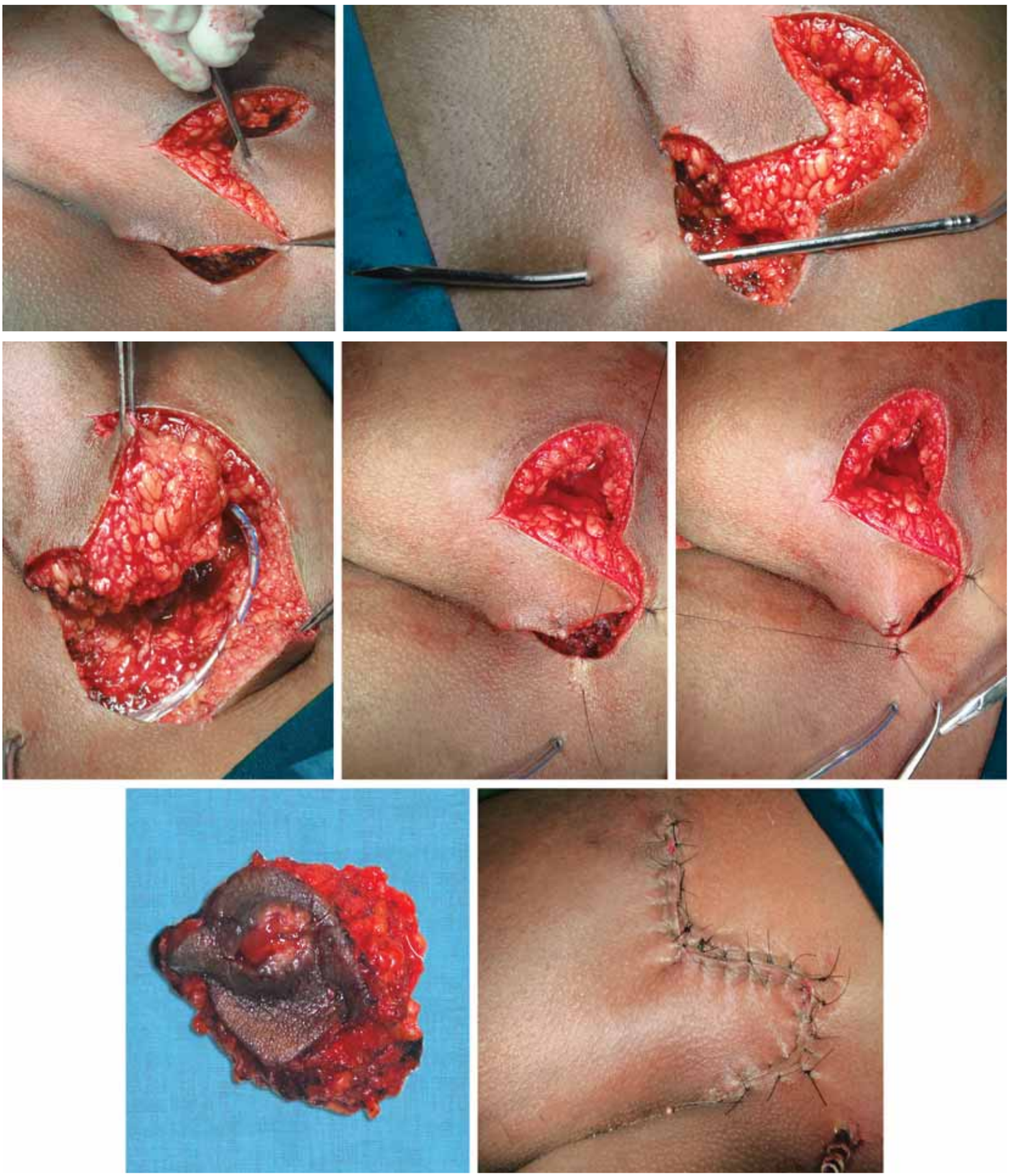


Fig. 25-41: Limberg-rhomboid flap used for pilonidal sinus.



Figs 25-42(1)



Figs 25-42(2)

Figs 25-42(1 and 2): Rhomboid flap for pilonidal sinus.

Fig. 25-43: Rhomboid flap after healing—scar will not be in midline.

incisions 2-4 mm sized sinus is approached and pus is drained; hairs are removed with only minimal excision of sinus. Cavity walls are not excised. Lateral small wounds are either sutured or left open for spontaneous healing. Procedure is done under general/local anaesthesia in prone Jackknife position. After cleaning and draping, small pits in the midline primary site are approached through tiny 3 mm diamond incisions and skin is excised. A probe is passed through one of these opened pits to identify the side towards which sinus tracks. A vertical 3 cm incision is made in the paramedian area deep enough to reach the sinus cavity. All unhealthy tissues including track and hairs are removed. Thorough wash is given. Fibrofatty flap is rotated towards midline. In modified Bascom technique this rotation is not done. Tiny diamond midline wounds are closed with subcuticular non-absorbable sutures. Lateral wound is left open to granulate on its own **(Fig. 25-44)**.

V-Y Gluteal Advancement Flap

V-Y gluteal advancement flap is useful in recurrent and wide area involvement.

Lahey and Cattell's Method

Lahey and Cattell's relaxing skin incisions on one buttock is done to relieve tension on main wound sutures with later closure of secondary wounds by sutures or advancement.

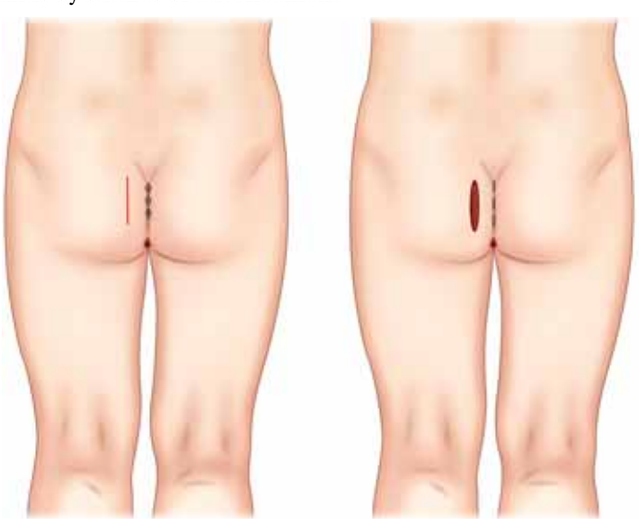


Fig. 25-44: Bascom technique.

Davies and Starr Buttock Skin Flap Rotation

Davies and Starr buttock skin flap rotation into the defect and secondary defect is closed at a later period.

After complete excision of entire sinus, wound is left open to granulate and heal by epithelialisation with regular dressings.

Buie's Marsupialisation

Buie's marsupialisation of the sinus track, 1944 —after making incision on the sinus track, edge of the laid opened area is sutured to the skin edge all round using silk or vicryl. This reduces healing time and promotes healing.

Lord and Millar's Limited Excision

Lord and Millar's limited excision of primary track for 0.5 cm depth with removal of tuft of hairs, debris and unhealthy granulation tissue using tiny brush and nylon bristle.

Excision with Primary Suturing

Excision with primary suturing is done only when disease is confined to midline; but creating a midline scar increases the chances of recurrence as hairs can penetrate midline scar easily.

Excision of all Granulation Tissues

Excision of all granulation and unhealthy tissues from both primary and secondary sinuses with *deroofing* and allowing it granulate and heal by secondary intention. It is better than primary closure. Problem is healing takes 6-8 weeks and creates wide scar which can breakdown. Present principle is to avoid any midline scar in pilonidal sinus surgery.

Injection of Phenol to the Track

Injection of phenol to the track destroys the epithelium after removal of the tufted hairs. Phenol is allowed to be in contact with epithelium for 3 minutes to create a blanch in the track orifice.

Nonoperative Treatment/Prevention of Recurrence after Surgery

Regular shaving of natal cleft to have meticulous hair control and proper perineal hygiene is essential. *Laser, depilatory cream, electrolysis* are other methods used.

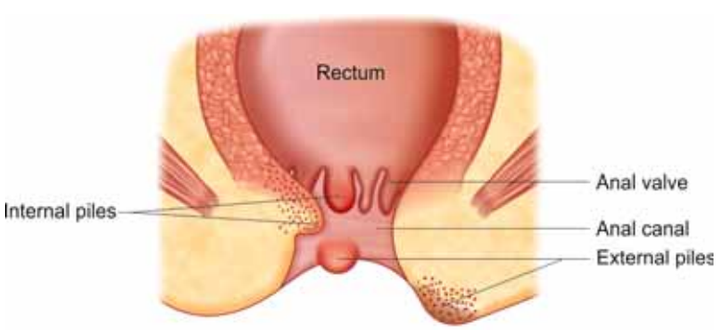


Fig. 25-45 (1)

Fig. 25-45: Parts of piles—internal and external.

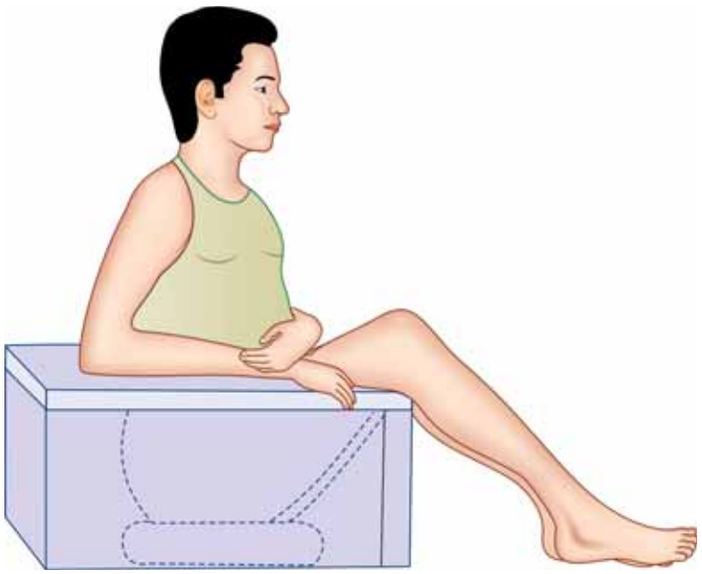


Fig. 25-46: Sitz bath.

Causes for High Recurrence Rate

Improper removal (technical); overlooking of existing diverticulum; entry of new tuft of hairs; breakage of scar. *Note*: Condition has got high recurrence rate (20%).

TREATMENT OF HAEMORRHOIDS

Parts of piles—pedicle (internal) and external component **(Fig. 25-45)**.

Preventive Therapeutic/Curative

Preventive	*Parasurgical*
Diet – more fibre/liquid Laxatives	• Sclerotherapy • Banding • Cryotherapy • Infrared coagulation (IRC) • Laser therapy • Doppler Guided Haemorrhoidal Artery Ligation (DGHAL)
Medical	*Surgical*
Local applications; Sitz bath, diet, laxatives, drugs – analgesics	• Open haemorrhoidectomy • Closed haemorrhoidectomy • Stapled haemorrhoidopexy • Anal stretching – Recamier, Lord's

Non-operative

Sitz bath—means the patient has to sit in warm water with the anal region dipped in water for 20 minutes, 2-3 times a day. This reduces the oedema, pain and promotes healing. Specialised toilet trays are available which can be placed over the commode on which patient can sit for Sitz bath **(Fig. 25-46)**.

Local applications to reduce pain, itching and oedema can be used. Antibiotics, laxatives, anti-inflammatory drugs are beneficial. Other different methods are—Fibre diet 35 gram/day, plenty of water; *Fibre alternatives* can be used to supplement a high-fibre diet; squatting position may reduce the incidence of piles; plenty of liquid intake; l*axatives* such as lactulose solution which soften bowel motions and relieve the constipation (bulk-forming agents, e.g. ispaghula husk, sterculia, methylcellulose); bulk laxatives such as psyllium mucilloid, Konsyl or polycarbophil may be necessary.

In Case of Inflamed, Permanently Prolapsed, Oedematous Piles

Initially, manual stretching of the anal canal sphincter is tried. In 1968, Lord proposed that increased anal pressure contributes the formation of the haemorrhoids; so dilatation of the anal reduces the anal pressure thereby controls the haemorrhoids. A constriction to the outlet is present in 3rd and 4th degree haemorrhoids which is relieved by gentle firm stretching of the lower rectum and anal canal until constriction disappears. Eight fingers are passed as high as possible to achieve this. This prevents congestion of anal cushions and relaxes the anal sphincter, as a result of which the prolapsed piles gets reduced—*Lord's dilatation (8 fingers)*. Once oedema subsides, in 1-2 weeks, formal procedure is done. **Complications of anal dilatation—** Incontinence—rectal—usually temporary; infection; haemorrhage/haematoma; prolapse rectum **(Fig. 25-47)**.

Note: Lord's dilatation is presently not accepted.

Fig. 25-47: Lord's dilatation – it is 8 finger dilatation of the anal canal; it may cause anal incontinence.

Injection-Sclerosant Therapy

It is done in first degree and early second degree piles (internal)—outpatient procedure. Using proctoscope and Gabriel syringe, 3-5 mL of 5% phenol in almond oil is injected into the submucosal plane just above the anorectal ring to the pedicle. All three piles can be injected separately—3-5 mL to each site in single sitting. Technique can be repeated after 6 weeks. This technique is not done in the presence of sepsis or prolapse. The drug causes fibrosis in the submucosal region (sclerosis leading to mucosal fixation on to deeper planes and occlusion of lakes) and thereby fixation of the anal cushions which do not prolapse, causes strengthening of the vessel wall and obliteration of the vessel lumen. It is quick and painless; gives 95% cure rate in first degree piles; done on OP basis. *Contraindications are*—thrombosed/prolapsed piles, presence of proctitis/fissure/fistula-in-ano, pregnancy and diabetes mellitus. Sclerotherapy has not gained popularity, oily solution is difficult to handle and inject. *Complications*—recurrenc e (15%), hypochondriac pain due to entry of drug into the portal system, tenesmus, mucosal sloughing/ulceration, submucosal abscess, anal canal pain, anal stricture.

Inadvertent deep injection can precipitate pelvic abscess, prostatitis, impotence, rectovaginal fistula **(Fig. 25-48)**.

Rubber Band Ligation/Banding

It is done for second degree piles. It causes ischaemic necrosis and piles fall off. At one time only two piles can be banded. Repeat banding can be done only after 3 weeks. Band should be placed 2 cm above the dentate line. Usually 2 bands are used for pile mass to take care of breakage. Tissue sloughs off in 1-2 weeks leaving an ulcer which heals by scarring. Equipment is inexpensive, simple to perform; done without anaesthesia on OP basis; results are consistent, stops bleeding and tackles the prolapsing anal cushion. Different Band ligators are available now. Barron's (1962), McGivney ligator, McGown one hand ligator, etc. **(Fig. 25-49)**.

It is contraindicated in fissure/fistula/proctitis.

Complications: If applied low into skin it causes severe pain; discomfort; secondary haemorrhage; ulceration; thrombosis; slippage; sepsis.

Fig. 25-48: Gabriel syringe—It is used for injection sclerotherapy for internal piles using 5% phenol in almond/olive oil (almond/vegetable oil acts as a vehicle which holds phenol for long period of action). It is a stainless steel syringe with two metallic finger brims near the proximal end. One more metallic finger brim is present on the proximal end of the piston to place thumb while injecting.

Fig. 25-49: Rubber band ligation instrument for first and early second degree piles.

Note:

Suction banding is used presently—Lurz Goltner suction ligator; O'Regan disposable suction banding system. Suction is used to suck the internal pile into the banding gun.

Cryosurgery

Using nitrous oxide (–98°) or liquid nitrogen (–196°), extreme cold temperature is used to coagulate and cause necrosis of piles which gets separated and falls off subsequently. It is relatively painless and can be done on OP basis. All masses can be tackled at one sitting. This is carried out with the help of a *cryoprobe*. Nitrous oxide is preferred since it produces adequate freezing. Nitrous oxide delivery system/cryoprobe does not require special rewarming circuit. Liquid nitrogen produces quick destruction and damage of sphincter muscle; also needs special rewarming circuit for its release and is costlier. Under lithotomy position, cryoprobe is applied in the longitudinal axis of internal pile above the dentate line; the pressure must be maintained above 700 lb continuously; rapid adhesion with freezing (white area formation on piles) occurs; traction and slight rotation in both directions is done to draw entire pile mass to come in contact with the probe; after entire tissue is frozen in 20-30 seconds, the probe is detached after warming (defrosting/thawing). Procedure is repeated on other pile masses **(Figs 25-50 and 25-51)**.

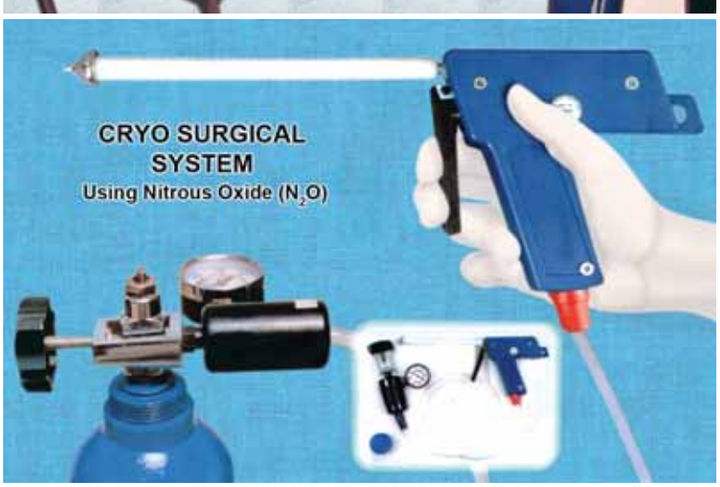


Fig. 25-50: Cryosurgery instrument set up for cryohaemorrhoidectomy.

Fig. 25-51: Cryosurgery for piles.

Advantages: It is reasonably painless, simple, safe, can be done on OP basis, with less bleeding.

Disadvantages: It causes *profuse watery discharge*, itching,pain if skin is frozen; marked oedema of adjacent skin, incontinence occasionally.

Infrared Coagulation

Here heat is used to burn the piles so as to allow it to fall off. Pulses of infrared radiation are applied through a handheld applicator. The specific infrared wavelengths produce chemical changes that cause blood coagulation within the haemorrhoid itself, which causes the haemorrhoid to seal, shrivel, shrink or slough off. Source of infrared rays of 14 volt Wolfram halogen lamp with a gold plated reflector rays are transmitted from fibre optic cable, which terminates in a probe or pistol for coagulation. In left lateral position, the probe is applied at the base of pedicle above the dentate line and bursts are given in clover leaf fashion. Timer is set at 2 secs giving a depth of 2 mm; total time taken is 2-5 minutes. It is done in first, second and third degree piles. It produces a discrete area of necrosis (coagulates tissue proteins and evaporates water from the cells), which heals to form a scar; reduces or eliminates blood flow through the haemorrhoid thereby shrinking it and mucosa becomes fixed to the underlying tissue. Often 3 or 4 sittings are needed at 1 month intervals. It does not cause noncontact coagulation; does not cause interference with electromagnetic devices such as pacemakers. It is *contraindicated* in external pile, proctitis. Long-term results are not good. Equipment is expensive; multiple sessions are needed.

Laser Therapy for Piles

It is used for third degree piles. Nd-YAG, diode and carbon dioxide lasers can be used but are expensive and tedious. The intense beam of light interacts with tissue and can be used to cut, coagulate or ablate the tissue, seal off nerves and tiny blood vessels. By sealing superficial nerve endings patients have minimum post-operative discomfort. Laser is used for dissecting and excising pile masses. It is done for internal haemorrhoids.

Advantages—less operative time; less intraoperative and post-operative bleed and pain; rapid healing; quick recovery; done under LA/SA; less complications; minimal pain, constipation and urinary retention.

Disadvantages—needs skill; sphincter should be taken care of; non-contact burning can occur; secondary haemorrhage can occur due to heat tissue destruction; and also injury to sphincter can occur **(Fig. 25-52)**.

Doppler Guided Haemorrhoidal Artery Ligation (DGHAL, Morinaga, 1995)

The DGHAL is an advanced instrument that works under Doppler guided ultrasound. It is painless, 20-minute procedure that cures all degrees of haemorrhoids. It causes choking and blocking of the blood supply of piles. It is done using proctoscope with an incorporated Doppler probe (modified proctoscope with built in ultrasound transducer, light and special window echo sounder). This proctoscope is inserted and used to locate the haemorrhoidal arteries by an audible signal. Once located, a needle holder is inserted into the lumen of the proctoscope and the artery ligated with a 'figure of eight' absorbable suture into the submucosa. The procedure is repeated until no more Doppler signals are identified. It is the transanal dearterialisation technique.

Advantages: Anaesthesia is not needed; blood loss, pain, residual problems are minimal; done as day care surgery; early return for work; may be safe in diabetic, cardiac, old age patients, and in pregnancy. It is under trial and too early to confirm the efficacy.

Ultroid

It is monopolar, low voltage device having a generator unit, an attachable handle, single use sterile probes, a grounding pad, nonconductive anoscope. Device acts by production of sodium hydroxide at the negative electrode. Probe tip is placed at the apex of the pile mass above the dentate line and amperage of 6-16 mA is passed. Probe is kept in position for 10 minutes until sound ceases. Only one pile mass is treated during one sitting. Technique is not popular.

Stapled Haemorrhoidopexy (Antonio Longo, 1998)

It is circumferential excision of the mucosa and sub-mucosa 4 cm above the dentate line using circular haemorrhoidal stapler passed per anally (MIPH—minimally invasive procedure for haemorrhoids; PPH—Procedure for Prolapse and Haemorrhoids). It is not called as stapled haemorrhoidectomy as neither anal mucosa nor haemorrhoidal tissues are removed.

Advantages are—it is less painful; less blood loss; faster recovery; short hospital stay and equally efficacious. It is done only for prolapsed piles **(Fig. 25-53)**.

This procedure avoids wound in the sensitive perianal skin thereby reducing the post-operative pain. Under spinal or general anaesthesia, circular anal dilator is passed (CAD 33) into the anal canal; it is anchored to skin; circular purse string suture anoscope is passed into the anal canal. It can be rotated so the purse string suture can be placed 4 cm above dentate line on the rectal mucosa. Small bites which are close together are taken from mucosa and submucosa; muscle layer should not be included in the bites. There should not be any gaps or dog ears in the purse string suture. Fully opened stapler head is inserted into the anal canal and through the purse string beyond it; purse string is tied with one throw knot; two tiles of the suture is passed through the lateral channels in the head of the anvil with the suture threader. External knotting of the suture tails is done. Stapler is closed completely and fired with continuous downwards traction on the purse string suture. Using stapling gun, a unique circular stapler which reduces the degree of prolapsed piles by excising a circumferential strip of mucosa from the proximal anal canal. The strip of mucosa and submucosa is excised circumferentially above the dentate line. The veins leading to the haemorrhoids are thus incorporated in this excision. Activation of the gun also simultaneously recovers the cut mucosa and submucosa by stapling the edges together.

Disadvantages: Need for experience, as it is advanced surgical skill; costlier; may cause a full-thickness excision of the rectal wall; may injure the anal sphincter. *Improper purse string* can cause incomplete doughnut leading to severe haemorrhage.

Contraindication: Associated anorectal disease like fissure, fistula in ano; full thickness complete rectal prolapse; anal stenosis; gangrene and abscess, acute thrombosis.

Fig. 25-52: Laser surgery for piles.

***Note*:**

Doughnut should be *sent for histology* for muscular layer; proper doughnut should not contain muscular layer.

Open Operative Methods: Still Gold Standard

Indications

Third degree piles; failure of nonoperative methods; fibrosed piles.

Haemorrhoidectomy is the best treatment for haemorrhoids. The haemorrhoidectomy is performed using an open or closed technique. The open technique is commonly used in UK and is known as *Milligan-Morgan operation*. The *closed technique (Hill Ferguson)* is more popular in USA. Both involve ligation and excision of the haemorrhoid, but in the open technique the anal mucosa and skin are left open to heal by second intention, and in the close technique, the wound is sutured. Efficacy of surgery is 95% with 2-5% recurrence rate **(Figs 25-54 and 25-55)**.

Methods

Ligation and excision of piles—commonly done procedures *(Milligan-Morgan) (Open method).*

Under anaesthesia, in lithotomy position (Few advocate initially sphincter dilatation/stretching to reduce the post-operative pain. But it is not necessary). Skin (V shaped), adjacent anal mucosal strip

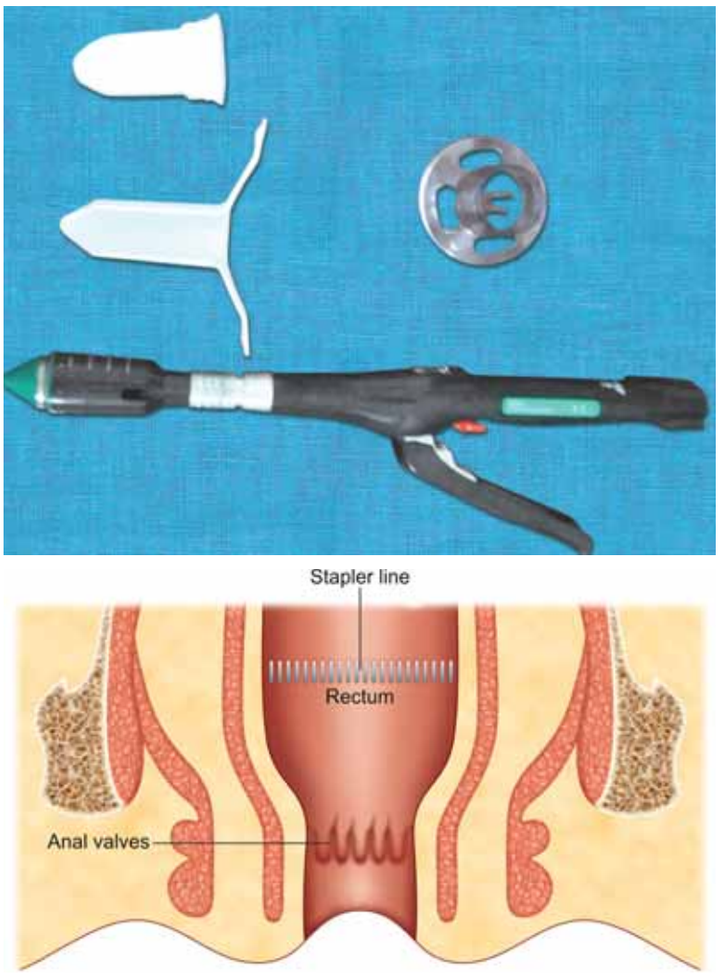


Fig. 25-53: Stapled haemorrhoidopexy. It is minimally invasive procedure for haemorrhoids. It is high mucosal rim excision including vascular pedicles using circular (single use) staplers. It is done for prolapsed piles.

Fig. 25-54: Holding pile mass for haemorrhoidectomy.

Fig. 25-55: Holding the pile and incising the skin – 'V' cut.

with haemorrhoidal plexus underneath (i.e. entire haemorrhoidal complex) is excised. Preliminary proctoscopy is a must and sigmoidoscopy should be done when in doubt. Later skin is held with Allis or artery forceps forceps, internal pile (mucosal component) is held with artery forceps **(Fig. 25-56)**.

Skin is cut in "V' shaped manner using curved scissor or diathermy (cutting monopolar); entire skin edge has to be incised across the anoderm up to the anal mucosa; incision is deepened; bleeding is common while dissecting in the deeper plane which usually stops on its own but often may require bipolar cautery and internal sphincter is separated and pushed up. Pedicle is dissected from the internal

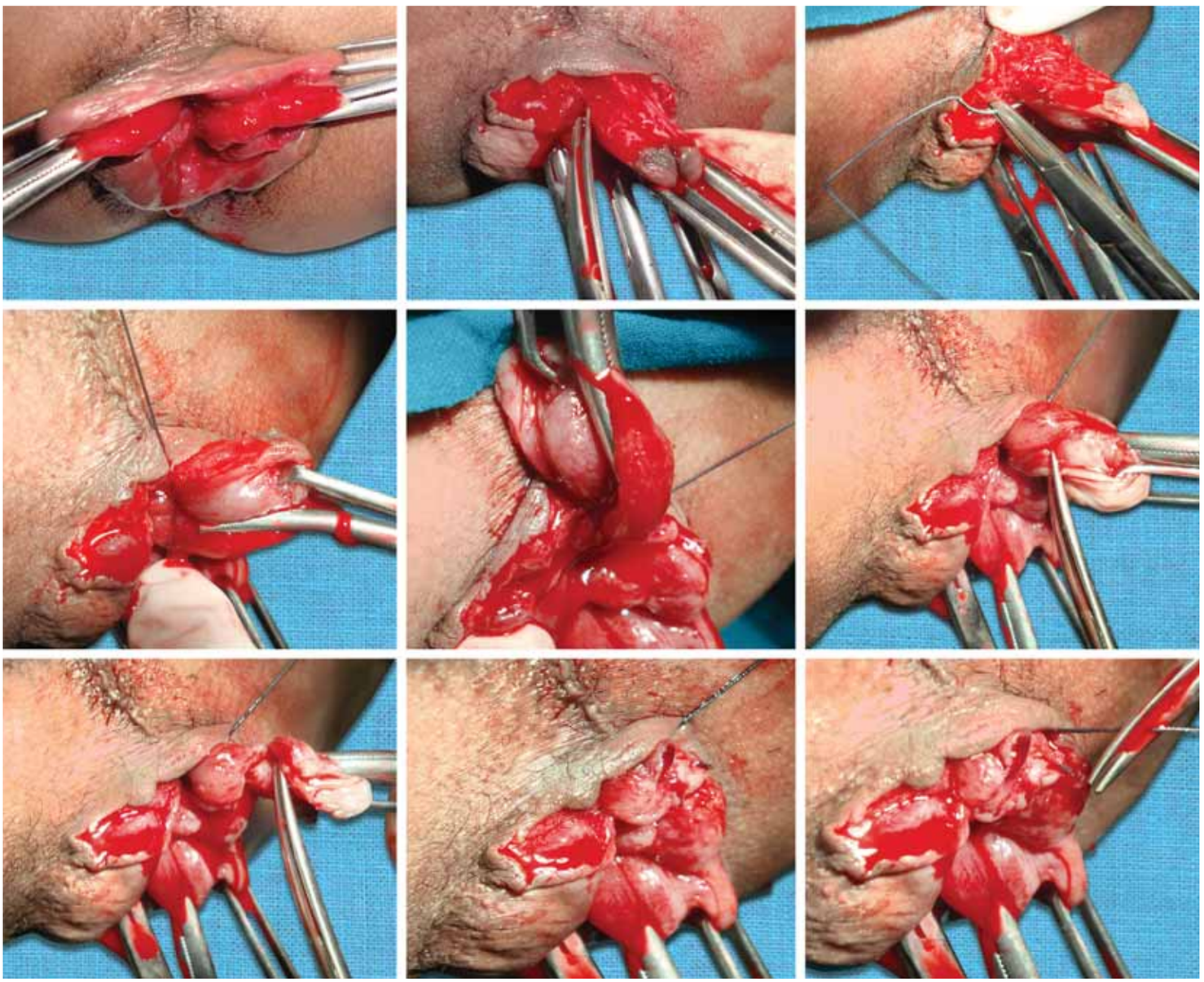


Fig. 25-56: Transfixation of the pile mass.

sphincter so the only haemorrhoidal plexus with mucosa is present in the pedicle base. Pedicle is transfixed with vicryl or catgut and distal part is excised. All the three piles can be dealt in a single sitting. Instead of transfixing the haemorrhoidal pedicle base it is divided after proper fulguration using cautery **(Figs 25-57 and 25-58)**.

Wound is not sutured but left open. Adequate bridges of the skin, anoderm and mucosa are retained; it prevents anal stenosis. Pack is placed (pack can be avoided if bleeding is controlled using bipolar cautery). Here haemorrhoid is excised radially. Dressing and 'T' bandage is applied. Post-operatively, *Sitz bath*, antibiotics, laxatives, analgesics, local applications are given. Pack should be removed in 12 hours. Often few finger dilatation of the anal canal is required to prevent stenosis. In the Hill – Ferguson method – procedure is similar but after completion, skin edges of the each pile mass is sutured using absorbable sutures (3 zero vicryl).

Submucosal Haemorrhoidectomy of 'Parks'

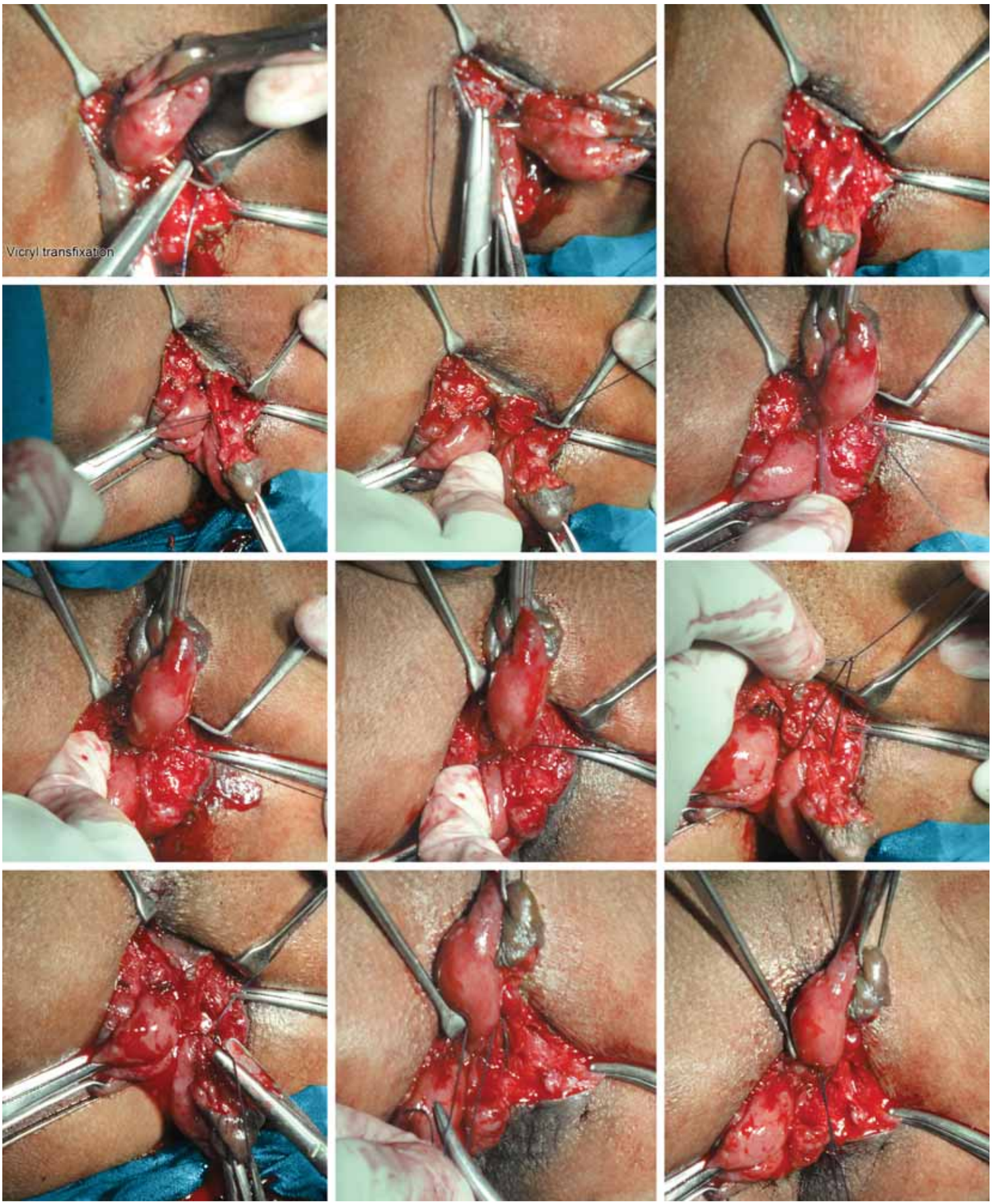
Approach here is above the skin through submucosal plane. Radial incision is made along the haemorrhoidal complex proximally along

Fig. 25-57: Cautery can be used carefully for fulgurating pedicle and also to make skin incision.

Lithotomy position
Cleaning and draping
Digital examination
V shaped incision

Figs 25-58(1)

Figs 25-58(2)



Figs 25-58(3)

Figs 25-58(4)

Figs 25-58(1 to 4): During haemorrhoidectomy, skin part is held with Allis forceps; internal pedicle is held with artery forceps. A 'V' cut is placed over the outer skin up to mucocutaneous junction. Dissection is deepened to visualise the internal sphincter. Once pedicle is dissected, it is transfixed using vicryl suture material. Distal tissue is excised. Technique is repeated on other sites also.

the anoderm and anal mucosa; dissection is deepened to separate internal sphincter; pedicle is transfixed and ligated using 2 zero vicryl. Incision edges are partially sutured back using 3 zero vicryl. There is no tissue loss and so stricture will not occur; but external component and redundant mucosa is not addressed and so this procedure has not become popular **(Fig. 25-59)**.

Hill-Ferguson Closed Method

Here patient in prone position, under general/caudal anaesthesia, retraction is done using Hill-Ferguson retractor. Incision is made around pile mass, pedicle is dissected to its proximal base; it is ligated with transfixation using 2 zero vicryl or silk; mucosa and anal skin is sutured using 3 zero vicryl/dexon after proper haemostasis using cautery.

Whitehead (Whitehead, England, 1882) Haemorrhoidectomy

Here mucosa is sutured to the anal canal above the pectinate line through a circumferential incision. It is technically difficult, causes mucosal ectropion (wet anus, Whitehead deformity). Procedure is rarely done now.

Management of Strangulated/Thrombosed/ Gangrenous Piles

Here initially conservative treatment is done using warm water Sitz bath; antibiotics; elevation; bed rest; saline compression dressing; analgesics. This reduces the oedema and piles shrink. Later in 15-20 days haemorrhoidectomy is done. Doing haemorrhoidectomy immediately may precipitate portal pyaemia, bleeding and also increases risk of developing anal stricture **(Fig. 25-60)**.

Newer Methods

Using ultrasound or controlled electric energy (Harmonic scalpel or ligasure or laser), haemorrhoidectomy can be done with less post-operative pain. But tissue charring may precipitate secondary haemorrhage. Sentinel pile often requires excision under local anaesthesia **(Figs 25-61 and 25-62)**.

Post-procedure Complications

Pain—due to spasm, nerve irritation, muscle injury; retention of urine—commonest—50%.

Reactionary or secondary haemorrhage—secondary haemorrhage is more problematic as infected friable granulation tissues will bleed torrentially and it is not possible to cauterize or ligate the bed; blood transfusions is often required; antibiotics, inflating the balloon of a 30 French Foley's catheter inside the canal is tried.

Anal stricture is not uncommon; needs regular dilatation by patient himself; usually done two times a day for 6-8 weeks will stretch the anal canal correcting the stricture. Severe cases need stretching under general anaesthesia or anoplasty to rectify the problem **(Fig. 25-63)**.

Anal fissure due to breakdown of the anoderm.

Recurrence is not very high—2-5%.

Anal discharge for sometime which usually subsides in 2 weeks.

Incontinence for faeces or gas is common; but subsides in 4-6 weeks.

Ectropion (Whitehead deformity) of the anal mucosa; it commonly regresses once healing occurs as mucosa will be drawn upwards towards the muscle.

TREATMENT OF ANAL FISSURE

General Measures for Anal Fissure

Adequate fluid intake (6-8 glasses of liquids); fibre rich diet (vegetables, fruits, brown rice); bulk forming agents (psyllium husk, bran); stool softeners (lactulose); local anaesthetic agents (lignocaine 5%); Sitz bath; avoid constipation; once recovers, regular anal dilatation **(Fig. 25-64)**.

In an Acute Case

Lord's Dilatation

It is done under general anaesthesia to relax the sphincter. It is the *manual dilatation* (Lord, 1968-1969) of the anus under general anaesthesia with relaxation using *four fingers of each hand* (*8 fingers*) to cause vigorous stretching of the anal canal to break the circular constricting band in the wall of the anorectum. It is found that it causes tear of levator ani reducing its tone and so it is not universally accepted even though it gives early pain relief; but incidence of symptomatic incontinence is surprisingly not very much. Later, use of laxatives, xylocaine surface anaesthetic application, and anal dilatation with finger can be carried out for certain period**.** Bed rest; 2% nifedepine ointment.

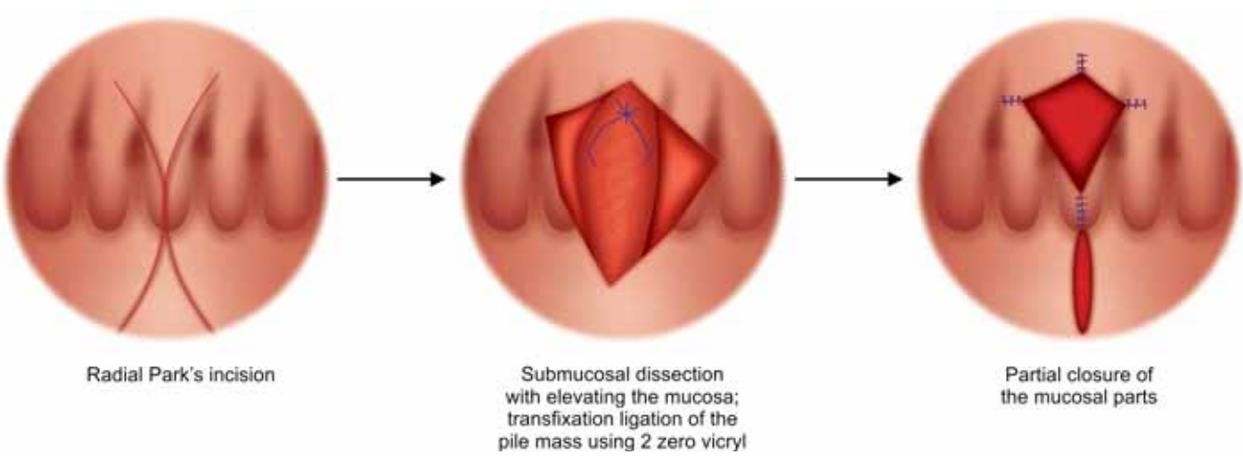

Radial Park's incision
Submucosal dissection with elevating the mucosa; transfixation ligation of the pile mass using 2 zero vicryl
Partial closure of the mucosal parts

Fig. 25-59: Parks submucosal haemorrhoidectomy.

Fig. 25-60: Prolapsed thrombosed pile. It needs initial conservative treatment and later definitive treatment. Anal sphincter stretching may be useful.

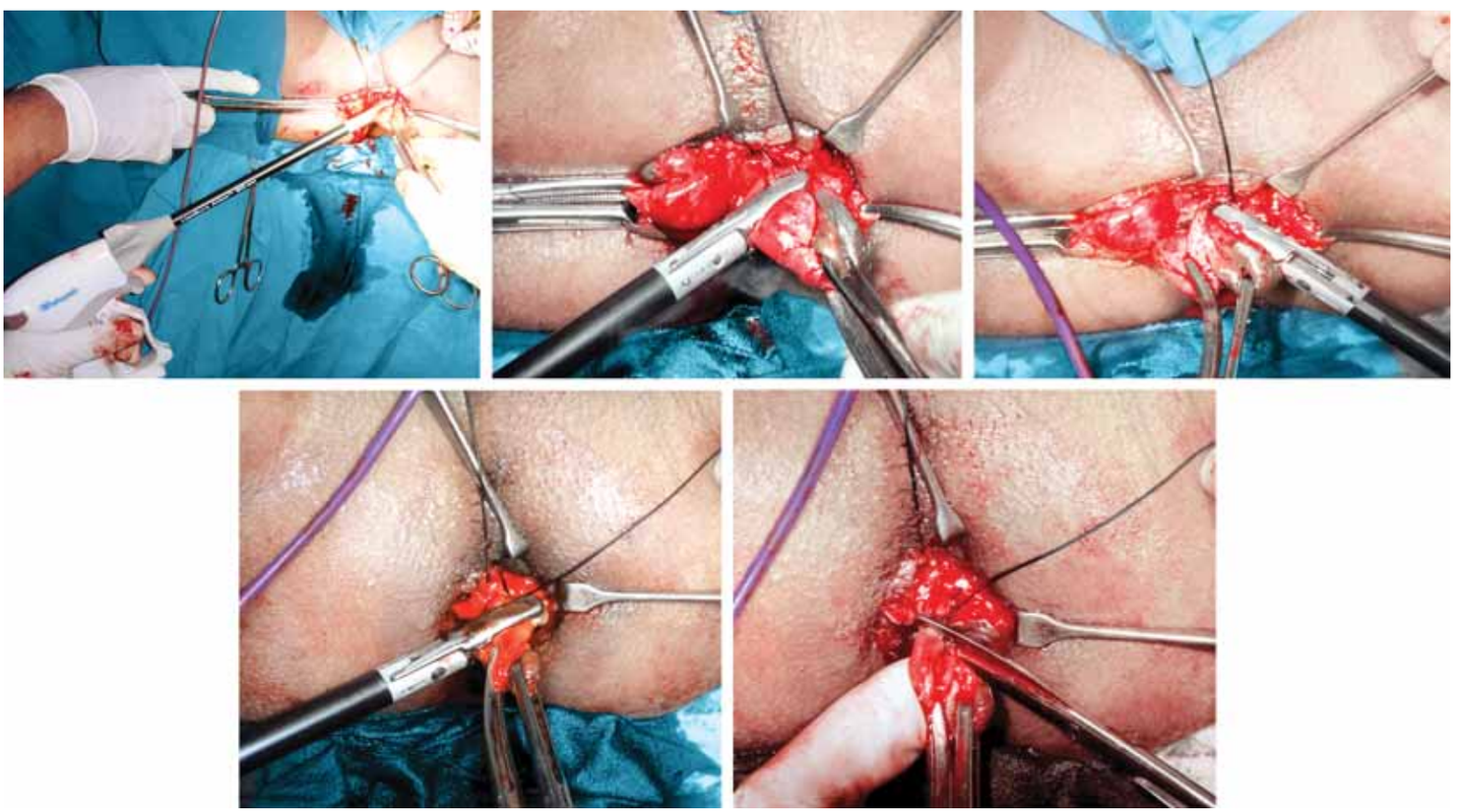


Fig. 25-61: Ligasure is often used in haemorrhoidectomy; it avoids suture ligation of the pedicle.

Stretching of the anal sphincter (Recamier, 1829) using *two fingers of each hand* (*4 fingers*) under anaesthesia is also an alternative one. It is better than Lord's dilatation as complications are less. Fingers are passed into the anal canal one by one up to 4 fingers; gradual persistent stretching is done. In males stretching is done anteroposteriorly and in females transversely **(Fig. 25-65)**.

For Chronic Fissure (Fig. 25-66)

Lateral anal sphincterotomy (Subcutaneous lateral internal sphincterotomy): Here internal sphincter is divided partially away from the fissure either in right or left lateral positions (also gives a good result).

Here *closed or open methods* are used. Sphincterotomy is done below the dentate line. Brodie did first anal sphincterotomy in 1839. In 1863, Hilton popularized it; but was not sure which structure is torn. Miles later said pectin band is divided. In 1951, Eisenhammer understood that it is internal sphincter, which is truly divided partially in this procedure. In olden days, posterior midline sphincterotomy was in practice; but it was causing keyhole deformity with flatus incontinence (34%) and faecal soiling. In 1969, Eisenhammer again modified the technique into lateral sphincterotomy.

In *closed method* (Notaras, 1969), bivalved retractor is passed first to stretch the sphincter gently so as to make it taut which facilitated its cutting easier; no 11 blade is inserted into the intersphincteric

Fig. 25-62: Sentinel pile often requires excision under local anaesthesia.

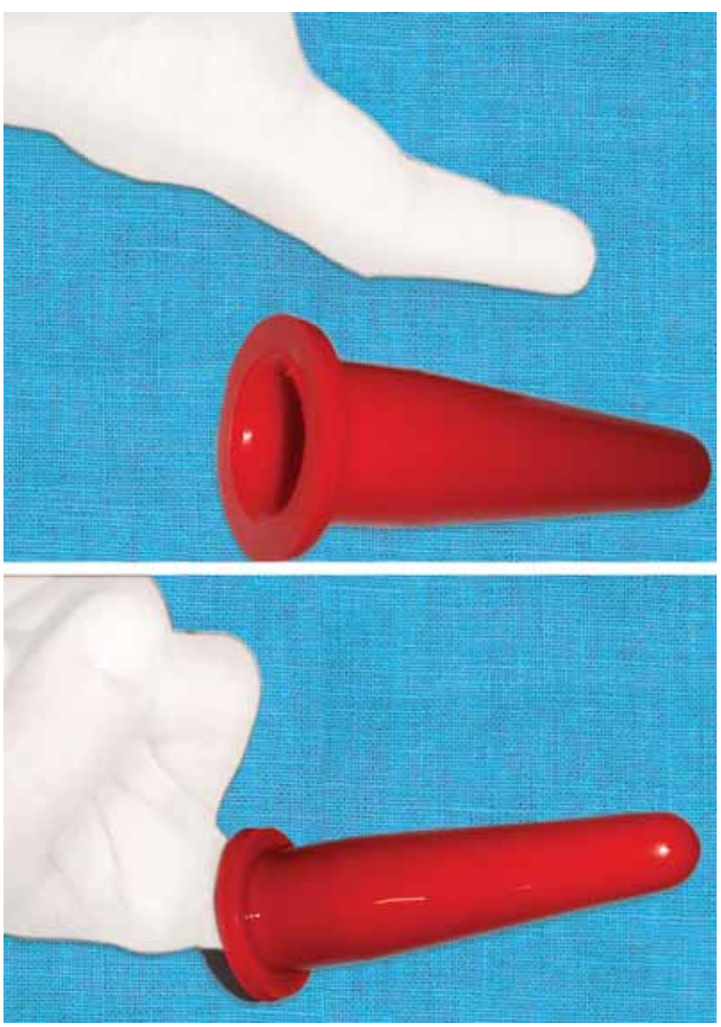


Fig. 25-63: Anal dilator. Many anorectal surgeries require regular anal dilatation post-operatively. Note how to hold the dilator to pass into the anus after applying lubricant.

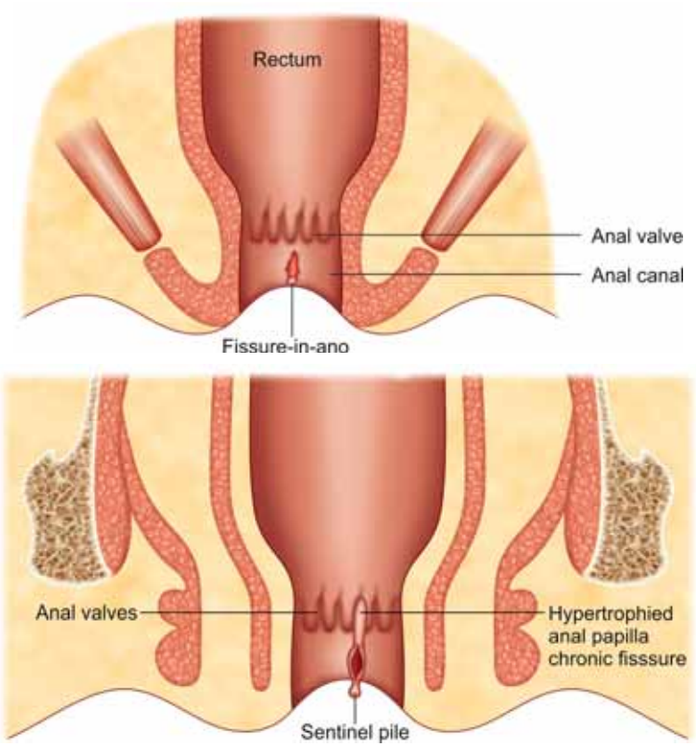


Fig. 25-64: Fissure in ano and its surgical anatomy.

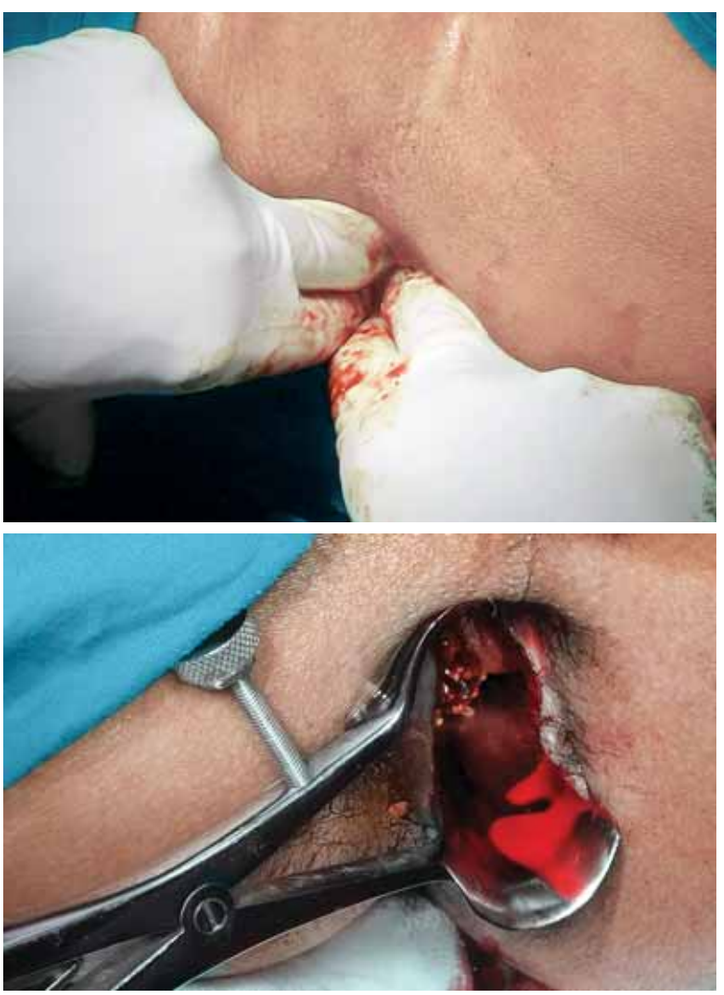


Fig. 25-65: Stretching of the anal canal is done using four fingers (two fingers of each hand). Instrument stretching can be done.

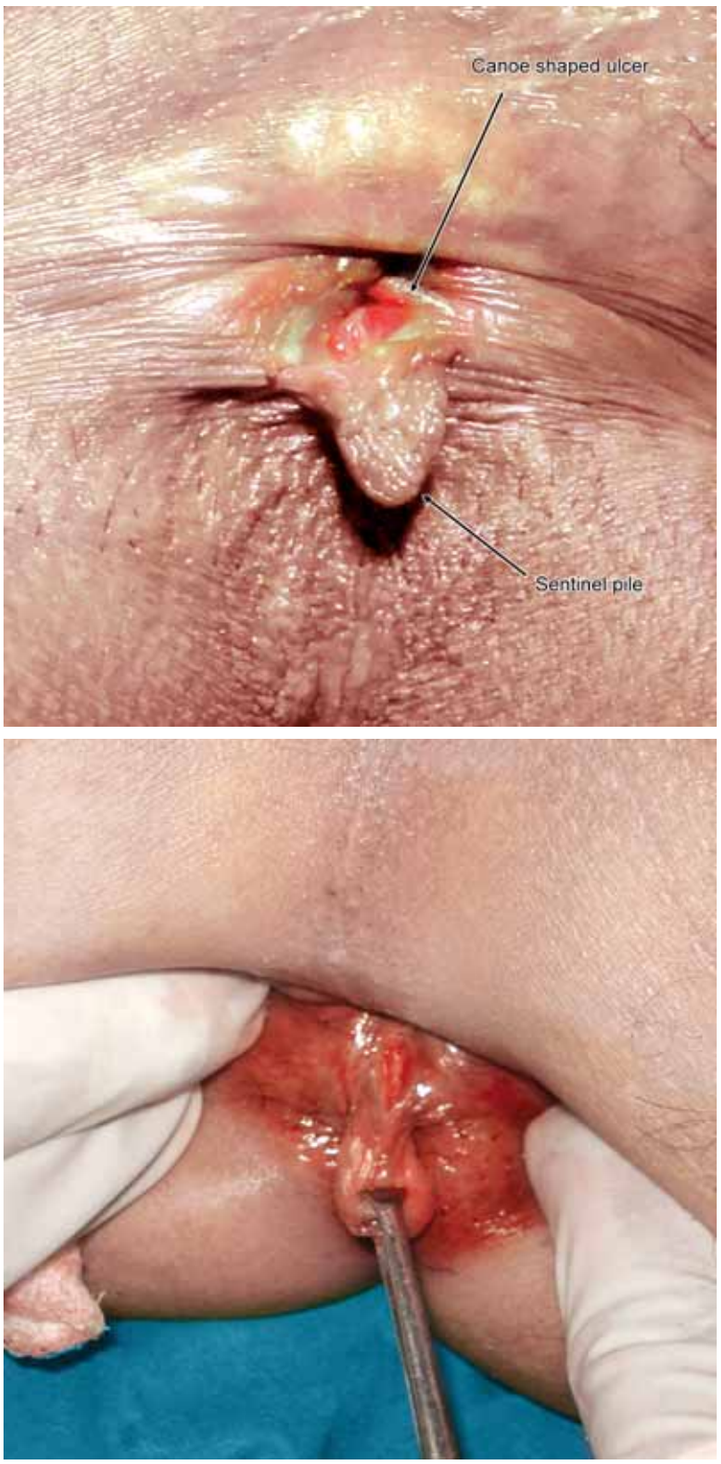


Fig. 25-66: Chronic fissure in ano and its parts.

groove to pass upwards. Blade is moved medially to cut lower 1/3 or 1/2 of the internal sphincter. Cataract surgery knife (Beaver cataract blade, 25.5 × 2.2 mm) is better instrument (Notaras). Hook knife is also used. External sentinel pile and inner fibroepithelial polyp on the inner end is excised. Closed method is simple but effective method. It can very well be done under local anaesthesia with 1:2,00,000 adrenaline as office or day care surgery. Lateral, prone jackknife or lithotomy positions are used. Right lateral 9 O'clock position is the preferred site/point/area than left (In left side 3 O'clock position left haemeorrhoidal vessels are located. So, chances of haematoma are more); but right hand surgeon finds difficult to give a backhand cut on the sphincter than left hand surgeon; so many right hand surgeons prefer to do on left side. Digital examination of the rectum is done; intersphincteric groove is identified; retractor can be placed gently if needed; after sphincterotomy residual sphincter fibres can be broken using finger. Reintroduction of blade should be avoided **(Fig. 25-67)**.

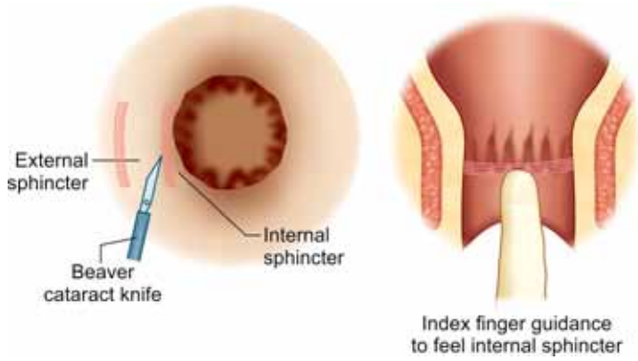


Fig. 25-67: Closed method of lateral sphincterotomy.

In *open method,* skin is incised laterally circumferentially for 2 cm at 9 O'clock position (radial incision also can be used); free edge of the internal sphincter is dissected external to anal verge. Hypertrophied band of lower part of internal sphincter (free lower edge) is dissected and divided. If wound has to be closed absorbable 4 zero vicryl should be used. Wound may be left open to allow it to granulate. Haematoma, ecchymosis, perianal abscess, bruising, fistula, incontinence are the complications of lateral sphincterotomy. Flatus incontinence is more common in women. Recurrence rate of sphincterotomy is 2-4%. Complications are little less in closed approach but recurrence rates are same in both.

Dorsal fissurectomy with sphincterotomy is done under anaesthesia. Specimen should be sent for biopsy to rule out carcinoma, tuberculosis, Crohn's disease, etc. Here, transverse lower fibres of internal sphincter are divided in the floor of the fissure. Keyhole deformity is a troublesome effect of fissurectomy. But for *chronic fibrotic anal fissure, fissurectomy has to be the treatment* along with sphincterotomy. Sphincterotomy can be done in the fissure floor after excision or lateral sphincterotomy can be added.

Topical nitroglycerine 0.2% can also be used to relax the sphincter. It causes severe headache. Botulinum toxin 25 units injected into the internal sphincter. It causes temporary denervation of the internal sphincter; reducing its tone, improving the blood supply and controlling ischaemia. It causes temporary incontinence for flatus (10%). Diltiazem (2%), and L arginine are the other agents that can be used. Regular anal dilatation is also important to prevent recurrence.

ANORECTAL ABSCESS

Most common causative organism is *E. coli (60%)*. Others are *Staphylococcus, Bacteroides, Streptococcus, B. proteus.* Commonly occurs due to infection of anal gland in perianal region. 95% of anorectal abscesses are due to infection of anal glands in relation to crypts—*cryptoglandular* disease. Common in diabetics and immunosuppressed **(Fig. 25-68)**.

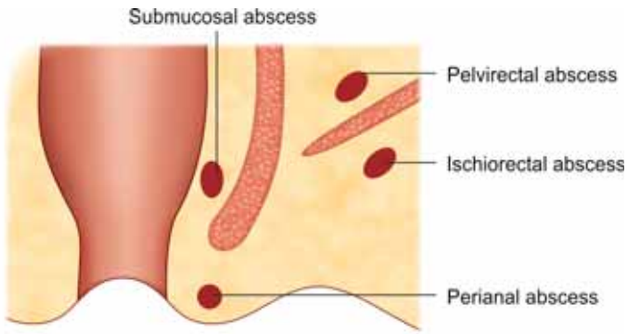


Fig. 25-68: Anatomy of anorectal abscess.

Other Causes

Injury to anorectum; cutaneous infection (e.g. Boil); blood borne infections; many anorectal abscesses are associated with anal fistulas; fissure-in-ano; perianal haematoma; post-anorectal surgery; Crohn's disease; tuberculosis **(Fig. 25-69)**.

Differential diagnosis of anorectal abscess: Periurethral abscess; Bartholin abscess; tuberculous abscess.

Fig. 25-69: Perianal haematoma and its drainage. It can be done under local anaesthesia.

Investigations

MRI is the *investigation* of *choice* for anorectal abscess; *perineal and anal US* is also very useful; investigations relevant to specific cause may be done; proctosigmoidoscopy is needed to identify secondary cause in anorectum.

Classification

1. Perianal.
2. Ischiorectal.
3. Submucous.
4. Pelvirectal.
5. *Fissure abscess* (in relation to fissure-in-ano).

Perianal Abscess (60%)

This usually results due to suppuration of anal gland or suppuration of thrombosed external pile or any infected perianal condition. It lies in the region of subcutaneous portion of external sphincter. After drainage under general anaesthesia, pus should be sent for culture. Patient should be re-examined in 2 weeks with proctosigmoidoscopy. If patient develops abscess later which should be warned to the patient before hand then fistulotomy or fistulectomy should be done at a later period. Anal fistula is not recognised at the time of drainage of the fistula; so usually fistulotomy is delayed until fistula manifests **(Fig. 25-70)**.

Ischiorectal Abscess (30%)

Ischiorectal fossa (pyramidal shape 5 cm depth and 2 cm width) lies between anal skin and levator ani. Right and left communicates with each other. Laterally, it is related to fascia covering obturator internus; medially to levator ani and external sphincter; posteriorly sacrotuberous ligament and gluteus maximus; anteriorly urogenital diaphragm; below, the floor by skin. Above, it is related to lunate fascia and pudendal neurovascular bundle in pudendal canal (Alcock's canal). Commonly, it is due to extension of low intermuscular anal abscess, laterally through external sphincter. But often it can be blood or lymphatic borne. Fat in the fossa is more prone for infection because it is least vascularised. Fossa communicates with that of opposite side through post-sphincteric space and so *horse-shoe like* abscess can occur. When swelling is pressed just prior to making incision, if pus exudes per anal canal it means there is an internal opening and patient is likely to develop a trans-sphincteric fistula. Abscess presents with tender, indurated, brawny swelling in the skin over the ischiorectal fossa with high fever. *Swelling is not well-localised and fluctuation is absent in ischiorectal abscess.*

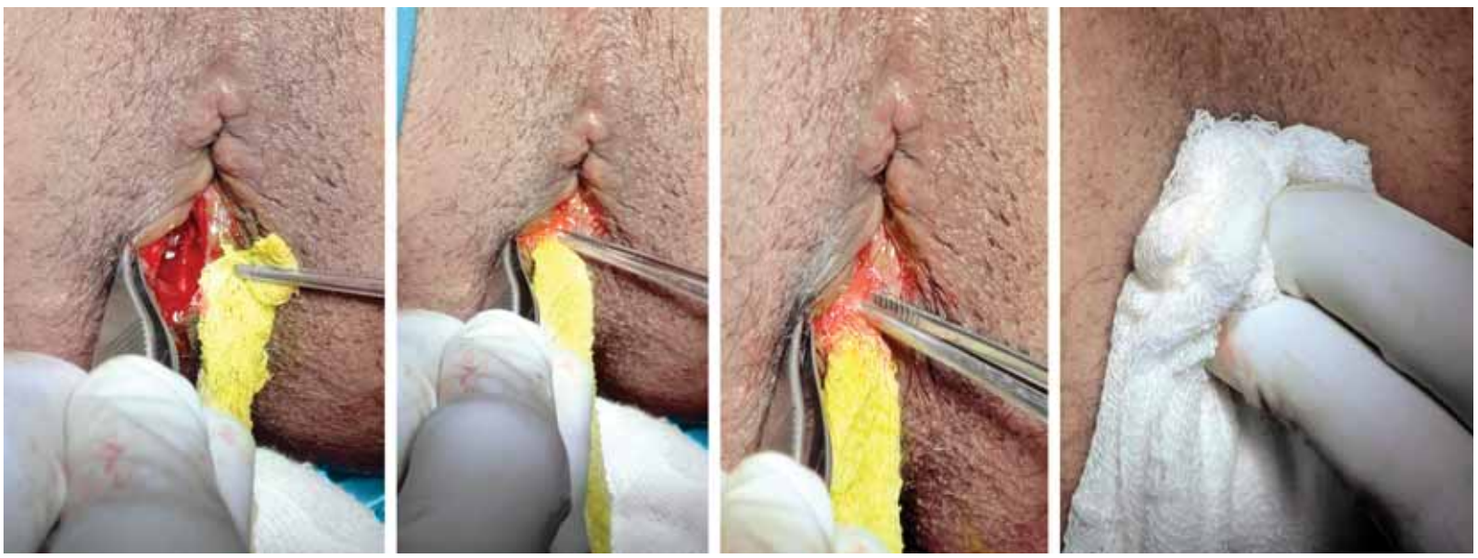
Treatment

Under general anaesthesia in lithotomy position, through a cruciate incision a portion of skin is excised (de roofing) and pus is drained. Cruciate incision should be placed close to the anal verge as subsequent fistula if formed will be having short track. Pus is sent for C/S and presence of any internal opening to rectum should be looked for (for possibility of an existing fistula). Presently, there is a debate whether cruciate incision is needed or not **(Figs 25-71 and 25-72)**.

Submucous Abscess (5%)

It occurs above the dentate line, which can be drained with sinus forceps, through a proctoscope; aching pain in the anorectum with

Figs 25-70(1)



Figs 25-70(2)

Figs 25-70(1 and 2): Drainage of perianal abscess.

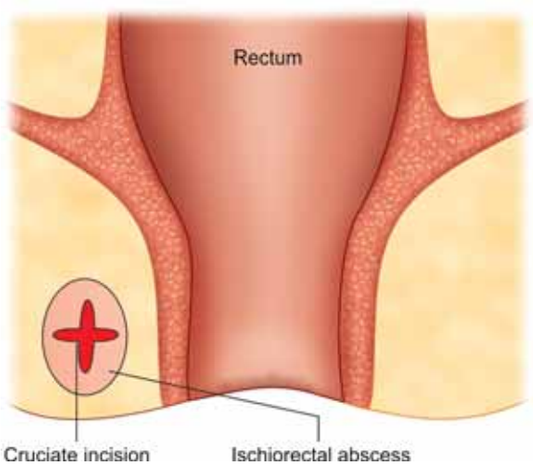


Fig. 25-71: Cruciate incision is used for drainage of ischiorectal abscess.

significant perineal discomfort. On digital examination (P/R), tender, soft, smooth swelling in the lower rectum and anal canal. It may be missed clinically as there is no obvious swelling externally. It is called as deep post-anal abscess if it originates from posterior crypt above the external sphincter in front of and below the coccyx. *Treatment* is proper antibiotics; incision and drainage under general anaesthesia. Drainage of deep post-anal abscess requires division of the external sphincter by passing a probe the invariably existing primary opening in the posterior midline (Hanley).

Intersphincteric Abscess (2%)

It begins in a cryptogland in the intersphincteric plane, which burrows cephalad to present as a mass in the lower rectum. Abscess differs from submucous abscess as it is not in the submucosa plane but it is in the intersphincteric plane. Features are anorectal pain which is exacerbated during defaecation; rectal examination reveals a tender mass. It requires admission and hospital treatment under general anaesthesia. Abscess wall should be marsupialised along with excision of the part of the internal sphincter with crypt. Abscess cavity is allowed to drain into the lumen.

Pelvirectal Abscess

It is situated between the upper surface of levator ani and pelvic peritoneum. It is almost like a pelvic abscess; develops secondary to appendicitis, salpingitis, diverticulitis, Crohn's. Ultrasonography of abdomen is done to rule out the above factors. Treated accordingly, after thorough investigations for diabetes, Crohn's and other conditions. Occasionally, it can develop as in continuity cephalad extension of a trans-sphincteric or retrosphincteric abscess. US abdomen and pelvis or CT scan is must. MRI may be needed if there is intersphincteric pathology. Usually, it is treated like a pelvic abscess drained under general anaesthesia either per rectally in males or per vaginally (posterior fornix) in females. Malecot or Foley's catheter is placed. External drainage is rarely done; it is done only in few occasions' like Crohn's disease with abscess where long term drainage is needed. Through intersphincteric space after placing an incision close to the anal canal, abscess is reached and Malecot's catheter is placed.

Problems with anorectal abscess: Recurrent abscess formation; fistula formation is common. Other than this in diabetic patients anorectal abscess may cause necrotizing fasciitis or Fournier's gangrene. Perianal abscess may be often associated with leukaemia, neutropenia (neutrophil count less than 500/mm^3).

FISTULA-IN-ANO

It is a track lined by granulation tissue which connects perianal skin superficially to anal canal; anorectum or rectum deeply. It usually occurs in a pre-existing anorectal abscess which rupture spontaneously **(Fig. 25-73)**.

Fistula-in-ano

Cryptoglandular or Non-cryptoglandular

Non-cryptoglandular (other causes)—10%—Tuberculosis, carcinoma, Crohn's disease, ulcerative colitis, lymphogranuloma venereum, hydradenitis suppurative, traumatic.

Fig. 25-72: Drainage of ischiorectal abscess. Cruciate incision can be used; but its need is a debate. Packing the cavity to drain is a must.

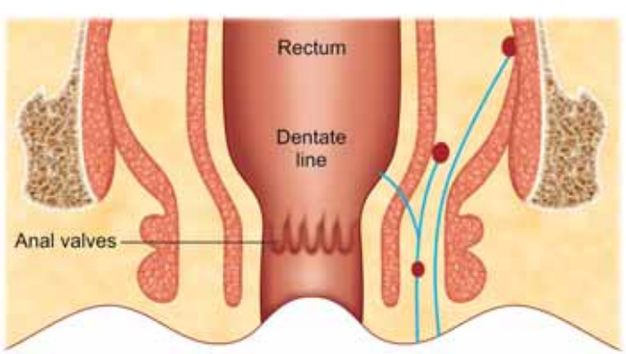


Fig. 25-73: Anatomy of fistula in ano.

Cryptoglandular Hypothesis (90%)

The intersphincteric space is the surgical plane between the internal and external sphincters and is found between the longitudinal muscle and external sphincter, where it exists as a sheet of fat containing loose areolar tissue. The fat-filled ischioanal fossa lies lateral to the sphincter complex and is traversed by a network of fibroelastic connective tissue. Proximal half of the anal canal is characterised by longitudinal mucosal folds, the anal columns of Morgagni. The distal aspect of each column is linked to its neighbour by a small semilunar fold (the anal valves), which in turn forms small pockets (the anal sinuses, or *crypts of Morgagni*). The distal undulating limit of these valves is the dentate (pectinate) line, which also marks the most distal aspect of the anal transitional zone, a histologic junction between anal squamous and rectal columnar epithelium. The dentate line lies 2 cm proximal to the anal verge and is important landmark in fistula in ano because the anal glands empty into the crypts that lie proximal to the valves. These glands secrete mucus to lubricate anus, and are the source of infection. These glands present in the subepithelium, internal sphincter, and two-thirds of these glands are located within the intersphincteric space. The infection of these intersphincteric glands initiates the fistula in ano, known as the "*cryptoglandular hypothesis*".

These glandular infection leads into an intersphincteric abscess due to blockage of the draining duct by infected debris. This abscess may resolve by spontaneous drainage into the anal canal or may progress to an acute anorectal abscess. Treatment of this abscess is incision and drainage; but source of infection in the intersphincteric space persists, leading into development of a fistula in ano. Acute anorectal abscess and fistula in ano are believed to be acute and chronic manifestations, respectively of the same disease.

While most fistulas start as a *simple single primary tract*, recurrent infection eventually causes formation of *extensions (secondary tracts)*. Extensions may be intersphincteric, ischioanal, or supralevator (pararectal). The ischioanal fossa is the commonest site for an extension. Extensions also can occur in the horizontal plane known as "horseshoe" if there is ramification each side of the internal opening **(Fig. 25-74)**.

Classification (Figs 25-75 to 25-77)

Standard (Milligan Morgan, 1934; Goligher 1975)	*Park`s classification (1976)*
• Subcutaneous—commonest • Low anal—common • Submucous • High anal • Pelvirectal	• Intersphincteric—commonest 70% • Trans-sphincteric 25% • Supralevator/suprasphincteric 4% • Extrasphincteric 1%

Fistula can be:

1. ***Low level fistulas***—*these open into the anal canal below the internal ring.*
2. ***High level fistulas***—*these open into the anal canal at or above the internal ring.*

Fistula can be

- *Simple fistula* without extensions.
- *Complex fistula* with extensions **(Figs 25-78 and 25-79)**.

Fistula can be with

Single external opening.

Multiple external openings which are often seen in tuberculosis, ulcerative colitis, Crohn's disease, LGV, hidradenitis suppurativa, actinomycosis **(Fig. 25-81)**.

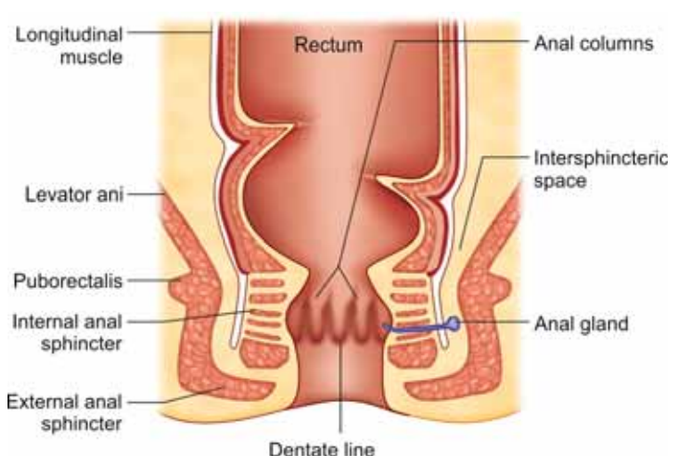


Fig. 25-74: Anatomy of anal glands (Cryptoglands of Morgagni).

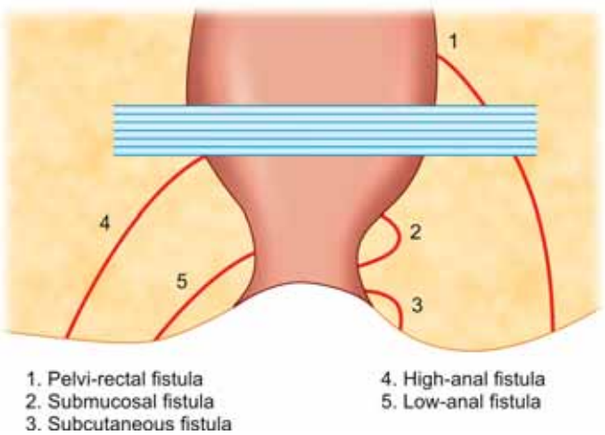


Fig. 25-75: Standard classification of fistula in ano.

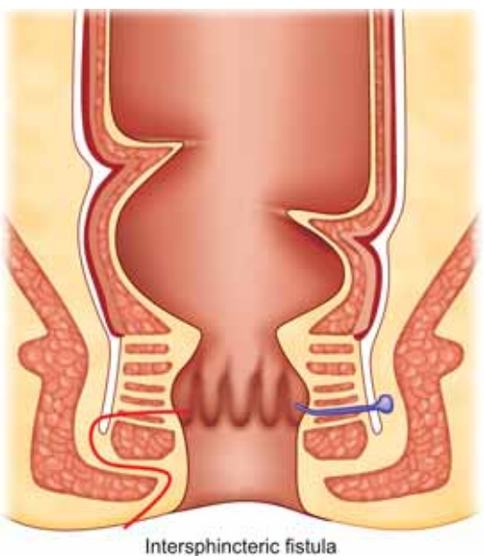


Fig. 25-76: Intersphincteric fistula is the commonest type.

Low-level Fistulas

It has a prevalence of 0.01% and is common in young adult males (2:1, male to female). It presents with seropurulent discharge (65%), along with skin irritation and one or more external opening may be present with induration of the surrounding skin. Often it may heal superficially but pus may collect beneath forming an abscess, which again discharges through same or new opening.

Ischiorectal fossa on each side, most often communicates with each other behind the anus causing *horseshoe* fistula.

Goodsall's (England, 1900) Rule

Fistulas with an external opening in relation to the anterior half of the anus is of *direct type.* Fistulas with external openings in relation to posterior half of the anus, has a curved track may be of horse-shoe type, opens in the midline posteriorly and may present with multiple external opening all connected to a single internal opening **(Fig. 25-82)**. *P/R examination shows indurated internal opening usually in the midline posteriorly***.** Most of the fistulas are on posterior half of anus.

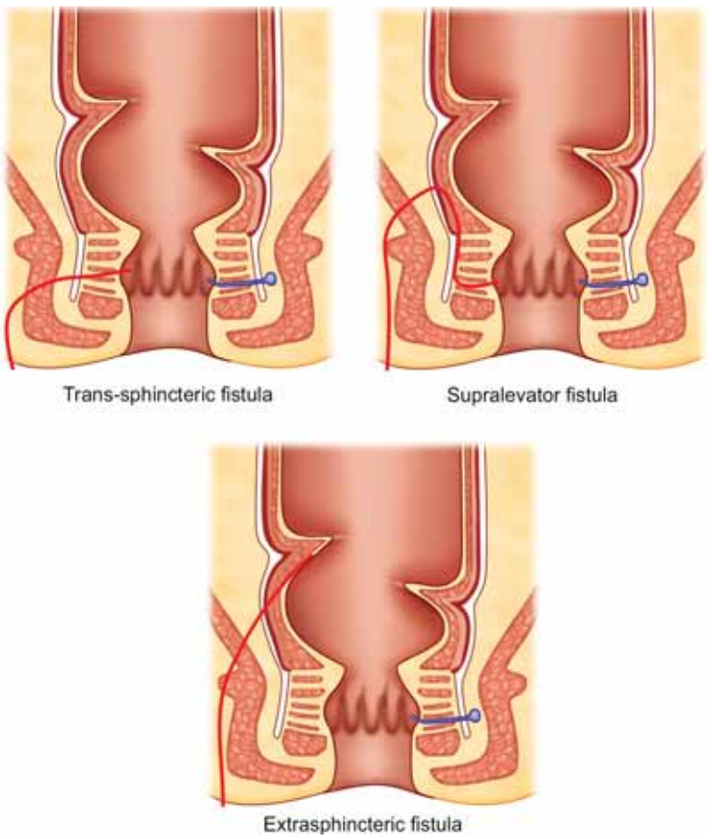


Fig. 25-77: Trans-sphincteric, supralevator, extrasphincteric types of fistulas.

Fig. 25-78: Simple fistula in ano.

Investigations

Chest X-ray, ESR and barium enema X-ray; *if required fistulogram is done only under anaesthesia.* MRI/MR fistulogram ideal. Endorectal US (US perineum) is useful to assess deeper plane. Discharge study, methylene blue dye study, biopsy. Colonoscopy often when ulcerative colitis/Crohn's is suspected. Specific blood tests and colonoscopy if needed should be done **(Figs 25-83 to 25-85)**.

Fig. 25-79: Complex fistula in ano.

Fig. 25-80: Multiple fistula in ano.

Fig. 25-81: Probing of fistula should be done in operation theatre prior to surgery.

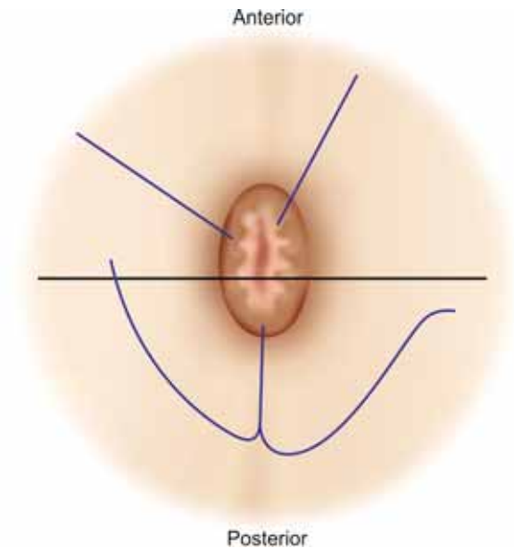


Fig. 25-82: Goodsall's rule.

Note: *Probing and fistulogram in the ward* before surgery using *Lipiodol* is not advisable as it may cause recrudescence of inflammation. It can be with adequate precaution in the operation theatre under general anaesthesia otherwise it can *create extensions*.

Differential diagnosis for fistula-in-ano: Urethral fistula in male; chronically infected Bartholin's gland; pilonidal sinus; hidradenitis suppurative; carcinoma; Crohn's disease; tuberculosis, ulcerative colitis.

Treatment of Fistula in Ano

Principles in management	*Procedures*
• Identify the cause – cryptoglandular or other • Delineate exactly the fistula in ano by – MRI/EUS • Identify relation of fistula to anal sphincter • Drain all sites of infection • Eradicate track and secondary extensions • Preserve anal continence of function The *primary objectives* are to eradicate the tract and drain all associated sites of infection while simultaneously preserving anal continence.	• Laying open of fistula – fistulotomy with curetting • Fistulectomy • Gluing of fistula – not much useful • Mucosal flap procedure • Fistulectomy with primary repair • Fistulectomy with primary repair with episiorectopexy • Fistulectomy with secondary repair • Anal Fistula Plug repair (AFP) • LIFT Technique (Ligation of Intersphincteric Fistula Track) • Seton technique (Latin – seta – a bristle) • Colostomy- lay open, fistulectomy, later closure of colostomy – for high type • VAAFT procedure (Video Assisted Anal Fistula Track ligation)

Principles in management

- Delineate exactly the fistula anatomy—MRI/EUS
- Identify the cause—cryptoglandular or other
- Methylene blue injection on table
- Fine ureteric catheter may be placed into the track
- Drain all sites of infection
- Eradicate track and secondary extensions
- Preserve anal continence function
- Fistula surgery should be done in a dry field
- Careful use of cautery is ideal

Fig. 25-83: Methylene blue injection study in fistula in ano. It is usually done on table prior to surgery to identify track.

Fig. 25-84: Fistulogram for fistula in ano.

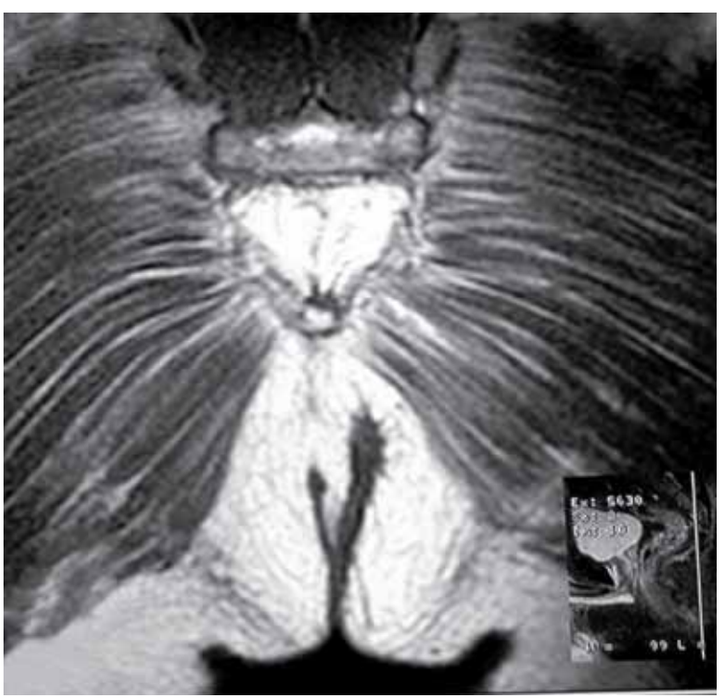


Fig. 25-85: MR fistulogram.

One should remember that

- It is not easy to treat fistula
- Needs proper assessment and planning
- Right method to right type
- High, complex fistula—a risky one
- MR fistulogram with EUS may be ideal to delineate track
- Beware of high recurrence rate and specific causes

Fistulotomy

It is done in low anal fistula. It is technically easier. Methylene blue solution may be injected to the external opening. Track is identified. After passing the probe through the entire fistulous track, incision is made over the probe to cut and lay open the fistulous track. It is allowed to granulate and heal from the floor/surface. Technique is safe, easy and can be done on outpatient basis. Only outer part of the track is excised for histology purpose. External opening part is widened as skin part will heal more rapidly than mucosal part. Anal opening (only, not mucosal) is sutured to the internal sphincter for haemostasis as an optional technique. Dressing is done. Post-operative pain is very less. There is not much difference in outcome between fistulotomy and fistulectomy. Fistulotomy wound heals faster **(Figs 25-86 and 25-87)**.

Advancement Flaps

They are used occasionally to get better result—mucosal flap procedure. Procedure is done per anally under spinal anaesthesia. Lithotomy position is used. Flap of mucosa with underlying internal sphincter with its blood supply is mobilised to cover the internal opening of the fistula properly and securely. Advancement can be done from above or from below. Problems are—it is technically demanding; flap failure; incontinence; it needs expertise to do.

Gluing of the Fistula Track

It is tried but success rate is not good. Fibrin glue is a multicomponent system containing mainly human plasma fibrinogen and thrombin. Once prepared, it is injected into the fistula track, which hardens in few minutes and fills the entire track. Success rate is 70%.

Anal Fistula Plug (AFP) Repair

Surgisis anal fistula plug (*porcine small intestine submucosa, SIS*) is used with 85% success rate in simple fistula. It contains naturally derived extracellular matrix which acts as scaffolding, ingrowth of tissue, remodeling **(Fig. 25-88)**.

LIFT Technique (Ligation of Intersphincteric Fistula Track):

It is high ligation of the fistula track with lateral approach. Here fistula tract is securely close to the internal sphincter, which probably avoids the reinfection of the intersphincteric space. Further resection of the intersphincteric tract and curettage of the remaining outer tract eliminates the diseased cryptoglandular tissue; distal tract when closed prevents its re-infection. Under anaesthesia in lithotomy position, methylene blue is injected into the track; fine ureteric catheter is passed gently through the fistula track from the external opening; intersphincteric space is reached through a 2-cm transverse incision in the intersphincteric groove adjacent to the fistula site. Fistula running across is identified and is clamped on the inner side with a haemostat; part of the fistula track in the groove is excised and sent for histology. Clamped fistula track on the inner side is suture ligated very close to the internal sphincter using 3 zero vicryl securely. External opening and the fistula track up to the intersphincteric space is gently curetted to clear all infected granulation tissue **(Fig. 25-89)**.

Track opening in the intersphincteric space towards the external sphincter is sutured using 3 zero vicryl. Dissected external sphincter and transverse incision in the intersphincteric groove is also sutured

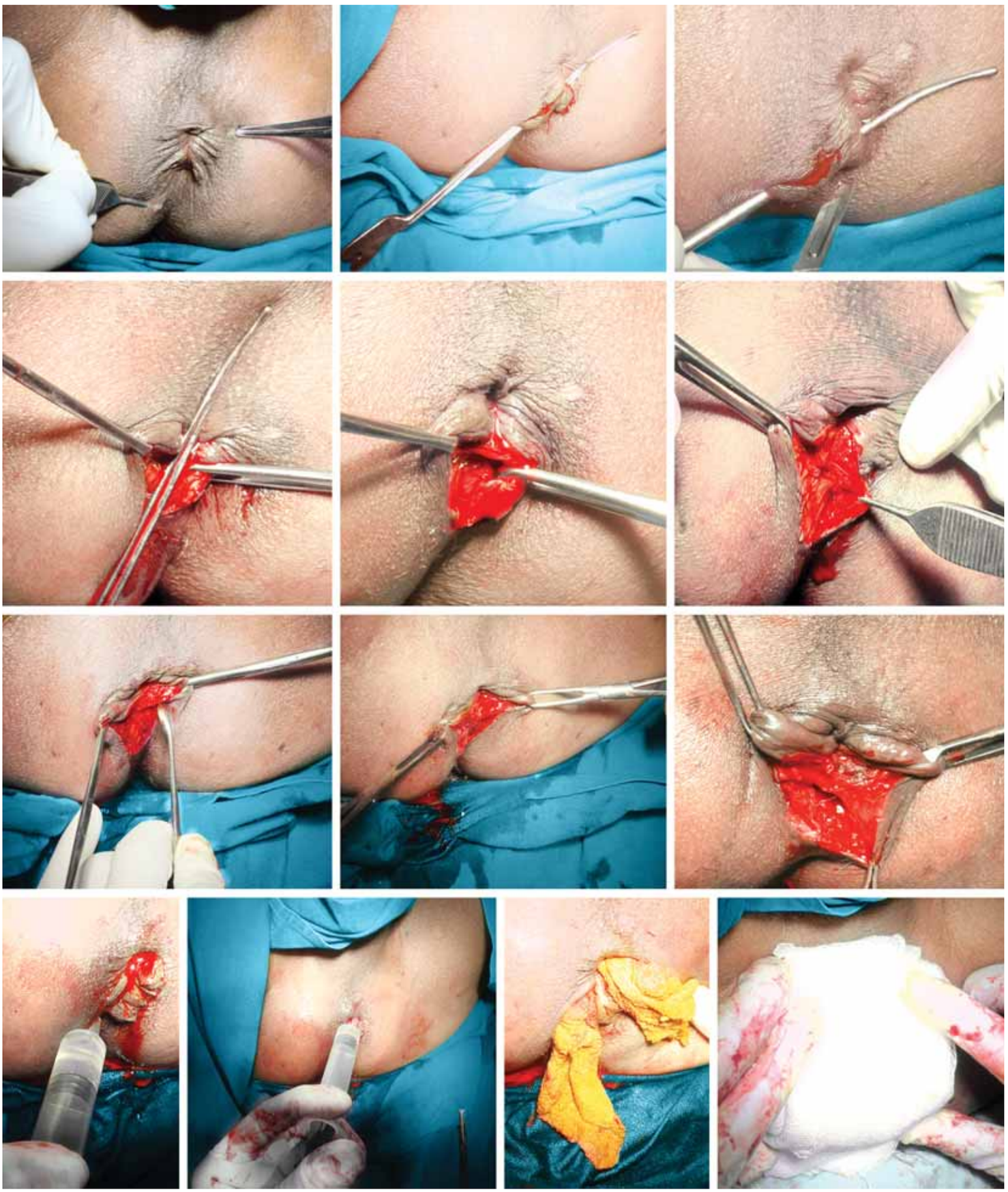


Fig. 25-86: Fistulotomy—laying open of the fistula track is the commonly done procedure.

Fig. 25-87: Fistulotomy set needed for fistulotomy.

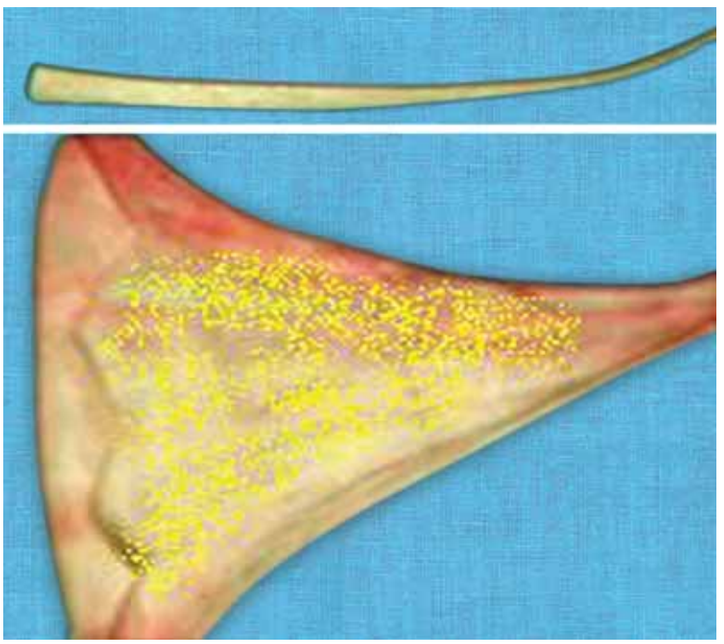


Fig. 25-88: Anal fistula plug.

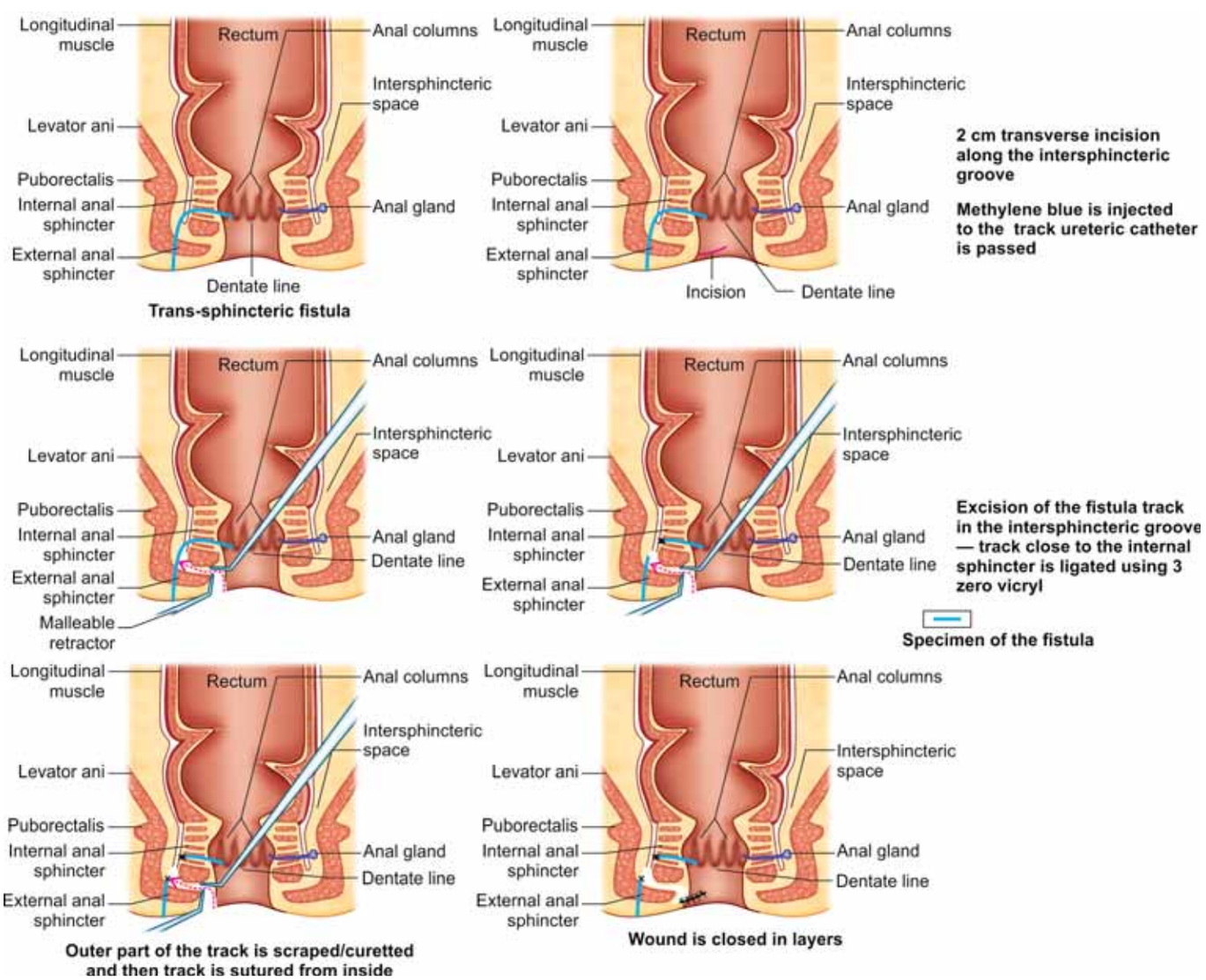

Longitudinal muscle
Rectum
Anal columns
Intersphincteric space
Levator ani
Puborectalis
Internal anal sphincter
Anal gland
External anal sphincter
Dentate line
Trans-sphincteric fistula
Incision
2 cm transverse incision along the intersphincteric groove
Methylene blue is injected to the track ureteric catheter is passed
Malleable retractor
Excision of the fistula track in the intersphincteric groove — track close to the internal sphincter is ligated using 3 zero vicryl
Specimen of the fistula
Outer part of the track is scraped/curetted and then track is sutured from inside
Wound is closed in layers

Fig. 25-89: Ligation of intersphincteric fistula track (LIFT).

using interrupted 3 zero vicryl sutures. LIFT avoids incontinence as it is sphincter saving technique. (This procedure was developed by Thai colorectal surgeon, Arun Rojanasakul, Colorectal Division Department of Surgery, Chulalongkorn University in Bangkok, Thailand, 2005). Initially in 1993, Matos et al described this intersphincteric approach to excise the infected gland.

VAAFT procedure (Video Assisted Anal Fistula Track ligation):
Fine specialized endoscope is passed through the external opening into the fistula track; with continuous irrigation fistula track is cleaned and wall is cauterized. Inner opening is ligated through vicryl from luminal side.

Treatment of Horseshoe Fistula

It is commonly trans-sphincteric but can be intersphincteric also. It has got multiple external openings with a subcutaneous communication in U or horseshoe shape with arms anteriorly and internal opening in posterior midline. All openings should be excised in horseshoe fistula and laid open widely. It is allowed to granulate and heal by secondary intention. Most important part in the horseshoe fistula is excision of the internal opening; if internal opening is removed then external openings will close (Hanley). It requires unfolding of the posterior midline to drain the deep post-anal space adequately. External openings and their tracks in such situation are individually approached, curetted and packed. Laid open deep post-anal space is also packed **(Fig. 25-90)**.

Fistulectomy

Under general or spinal anaesthesia, probe is passed through external opening up to the internal opening, which is felt as an induration. Fistula is opened along the probe using a knife. Fibrous track along with unhealthy granulation tissue and additional external openings are excised. Specimen is always sent for histopathology. *Fistulectomy for low level fistulas do not cause rectal incontinence.* Proper curetting of the infected anal gland area is essential. It is done in recurrent, chronic fibrotic fistulas **(Fig. 25-91)**.

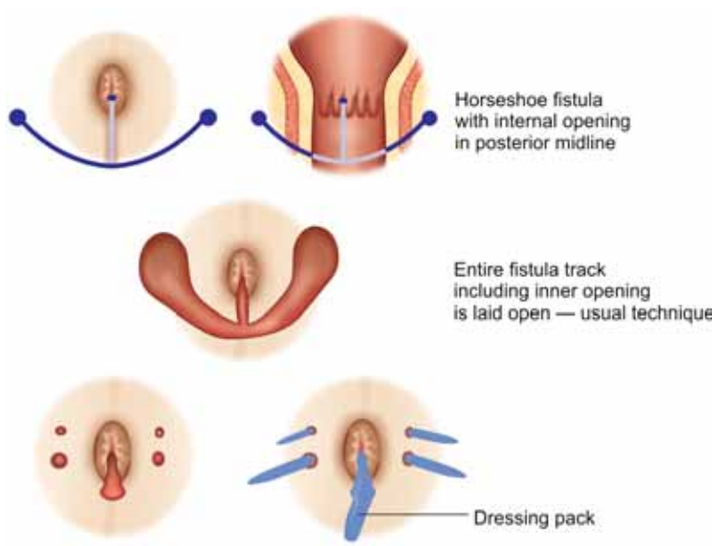

Horseshoe fistula
with internal opening
in posterior midline
Entire fistula track
including inner opening
is laid open — usual technique
Dressing pack
Interanl opening is laid open widely along deep post - anal space and is packed;
each external opening and track is curetted and packed — Hanley's method

Fig. 25-90: Management of horseshoe fistula in ano. Both sides are laid open including the internal opening. When there are multiple external openings, they are individually curetted; internal opening is laid open properly.

Multiple Fistulae in Ano

It means usually multiple external openings; but occasionally can have more than one internal opening. All external and internal openings should be laid open. Sphincter should be taken care of. Non-cryptoglandular causes should be thought of like tuberculosis, Crohn's, ulcerative colitis, HIV infection **(Fig. 25-92)**.

Seton Technique

A silk or linen or braided nylon ligature is passed across the fistula and left in place with a tie. *Striated muscle* superficial to fistula track is encircled with Seton material and tied securely and left in situ to create ischaemic necrosis, dividing the muscle slowly without allowing it to spring apart avoiding gutter deformity. Even though internal sphincter is divided, causing adequate laying open of entire fistula track, the sphincter function and pressure will be well preserved. This allows the fistula to granulate and heal from above and to close completely. Usually takes longer duration to heal. It is done for intermediate and intersphincteric fistula. It is used prior to definitive procedures like fistulectomy or advancement flap.

Seton can be kept for 3 months. It can be regularly replaced by new silk or any material by rail road technique without anaesthesia **(Fig. 25-93)**.

Two types of setons are present. Loose setons are used mainly to drain for long period in recurrent/post-operative fistulas and due to specific causes like Crohn's. There is no tension in seton. Soft braided nylon is used.

Cutting setons are used when enclosed muscle is needed to cut (cheese wiring through ice effect). It is placed tight. It is used as a definitive treatment. It divides the sphincters slowly and track progressively becomes lower until seton falls out on its own. So, sphincter is divided part by part so that time is given for healing to the divided part prior to the next portion of the sphincter is divided. It is said to retain the sphincter function and so continence.

Other Methods

There are still many more methods for treating fistula. As recurrence rate is higher and is common disease, more and more procedures will evolutes – like laser, etc. Their real advantages over standard technique is not sure **(Figs 25-94)**.

Postoperative Care

Sitz bath, antibiotics, analgesics, laxatives are given. Regular dressing is done. Wound usually granulates well and seals.

Complications

Fistula surgery is demanding and needs meticulous approach otherwise complications will occur. Incontinence for flatus and often faeces are the main complications. Infection, discharge, delayed healing, spread of infection are other complications.

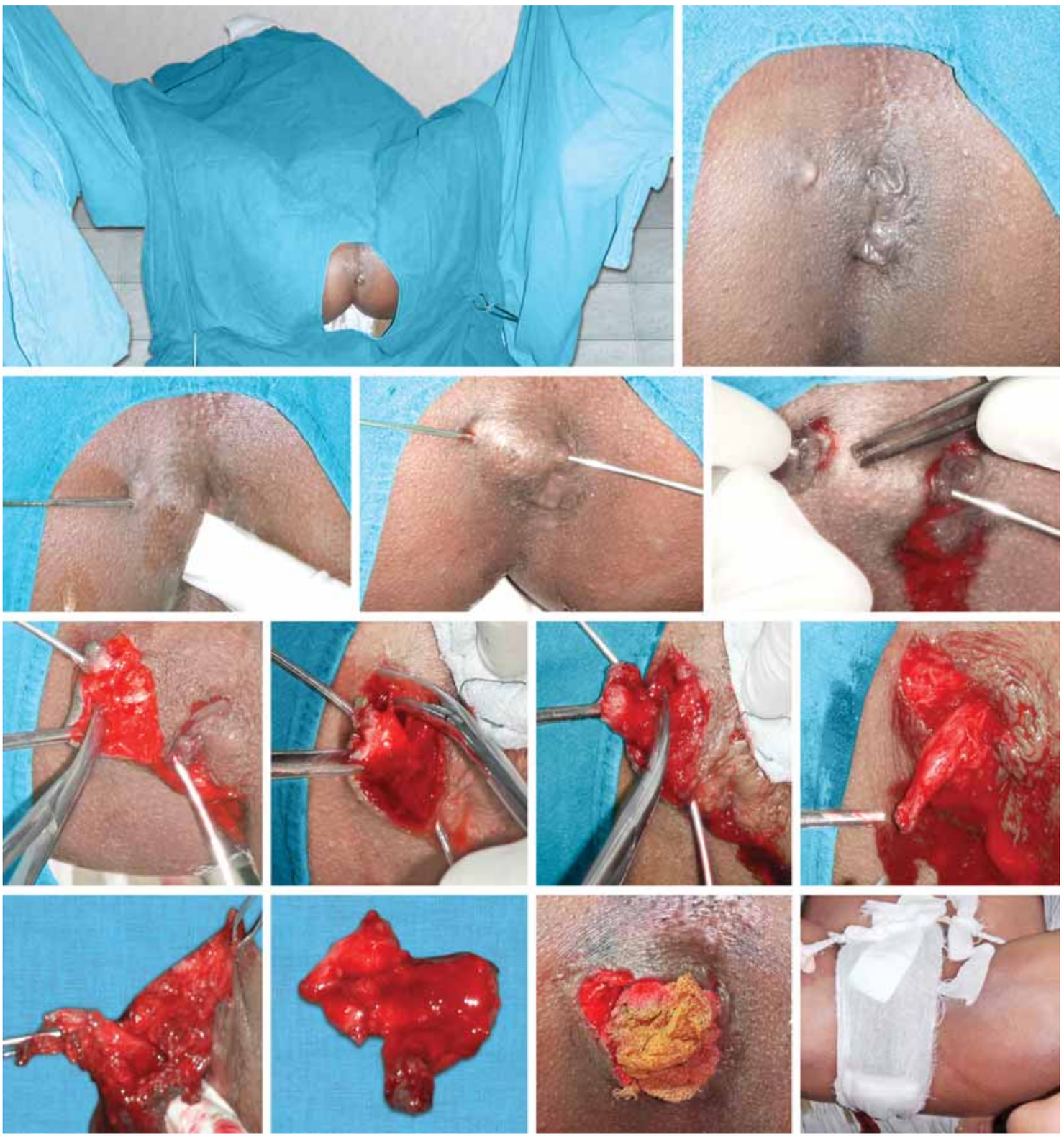


Fig. 25-91: Fistulectomy technique for fistula in ano. Entire track is removed and bed is curetted and left open; healing is slower in fistulectomy compared to fistulotomy.

Fig. 25-92: In managing multiple fisutlae, all external and internal openings including extensions should be laid open and curetted.

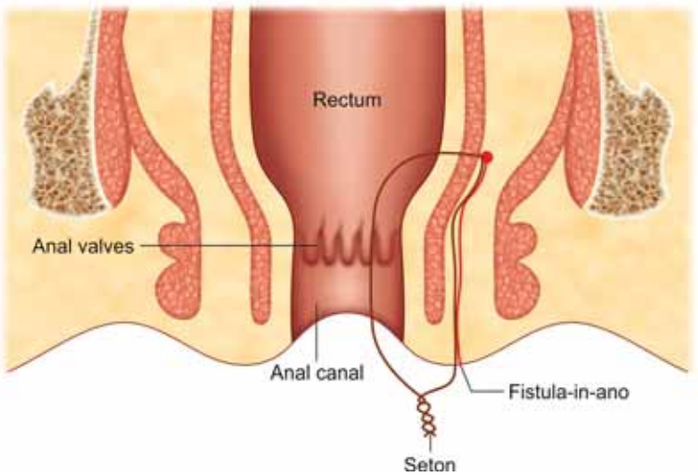


Fig. 25-93: Seton technique.

Fig. 25-94: Laser in fistula surgery. It controls bleeding well.

Chapter

26

Retroperitoneal Surgeries

SURGICAL ANATOMY

This is the space between the peritoneal cavity and posterior abdominal wall. It is bounded anteriorly by posterior parietal peritoneum and contents of the peritoneal cavity; posteriorly by vertebral column, psoas, iliacus, quadratus lumborum muscles, and tendinous portion of transversus abdominis muscles; superiorly by diaphragm; inferiorly by pelvic levator muscles (by Ackerman). It is real potential space **(Fig. 26-1)**.

Three spaces are defined in the retroperitoneum. *Anterior paranephric space* is located between the parietal peritoneum and Gerota's fascia. *Middle perinephric space* is bounded in front by Gerota'a fascia and behind by Zuckerkandl's fascia; it contains kidney, adrenal, renal pelvis and proximal ureter and renal vessels. *Posterior paranephric space* is located between Zuckerkandl's fascia and transversalis fascia.

Retroperitoneum contains vessels (aorta, IVC, portal veins); kidney and ureters; pancreas, duodenum, parts of colon, rectosigmoid; lymphatics, cisterna chyli and thoracic duct; celiac, superior and inferior hypogastric, sacral sympathetic chains; ilioinguinal, iliohypogastric, lateral cutaneous, femoral, genitofemoral, obturator, sciatic and pudendal.

Retroperitoneal tumours, secondaries, aneurysms, retroperitoneal haematoma, abscess, retroperitoneal fibrosis (Ormond's) are different conditions which can occur in this space. It is an extensive space. Dissection in this space is tedious, bleeds from major or small vessels torrentially **(Fig. 26-2)**.

APPROACHES FOR RETROPERITONEUM

Transperitoneal lengthy midline incision is very useful approach for both sides of the retroperitoneum.

Loin incision extraperitoneally like approaches to kidney and ureter **(Fig. 26-3)**.

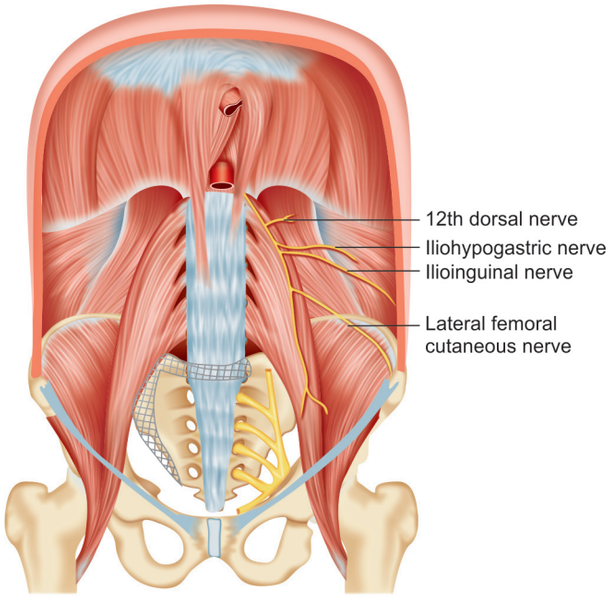


Fig. 26-1: Retroperitoneal anatomy.

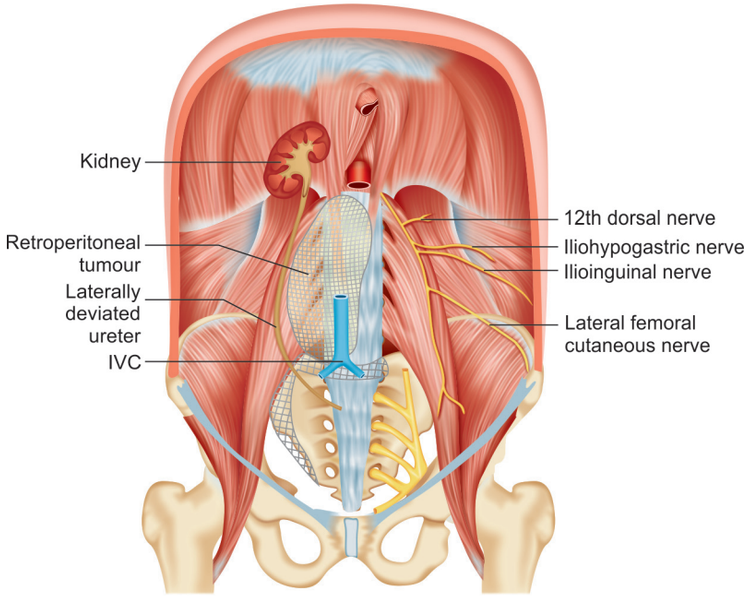


Fig. 26-2: Retroperitoneal tumour.

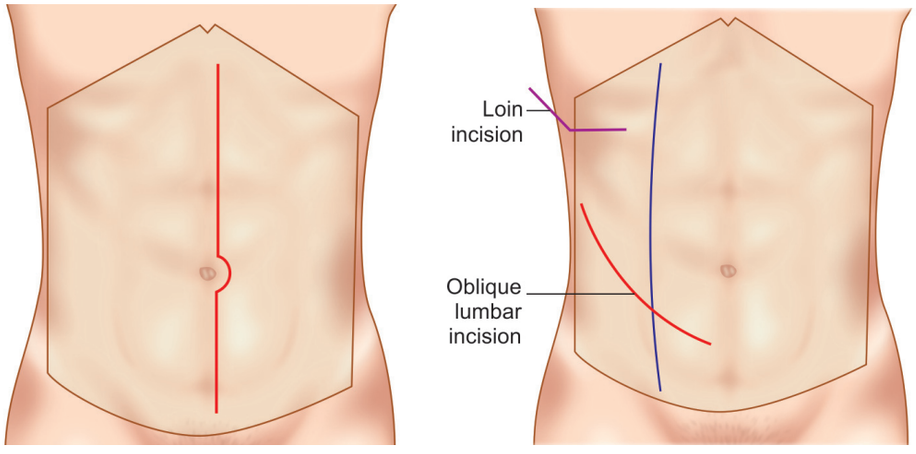


Fig. 26-3: Approaches for retroperitoneum—lengthy midline; oblique loin or loin incision in lateral position.

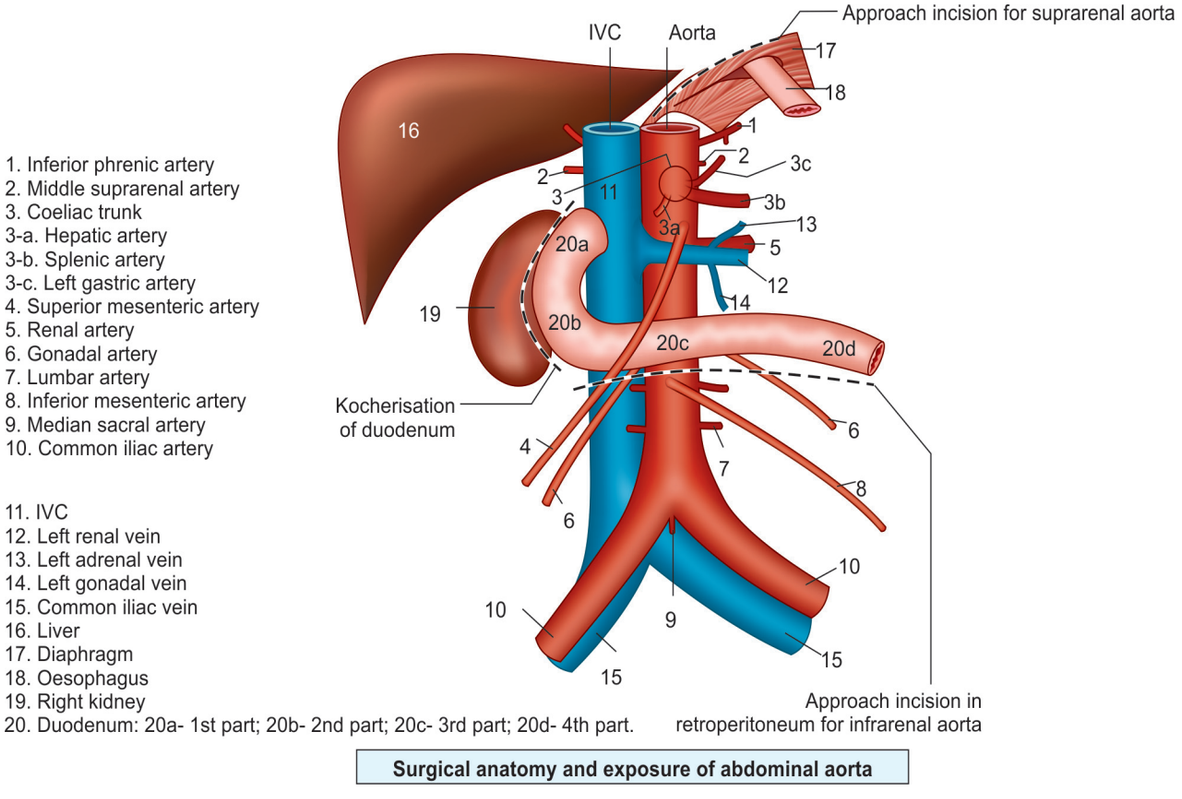


Fig. 26-4: Retroperitoneal approaches for aorta and lymph nodes.

Laparoscopic approach is very good to do retroperitoneal lymph node dissection.

Robotic assisted laparoscopic RPLND.

Structures approached through retroperitoneum (other than kidneys and ureters) are (Fig. 26-4):

- Aorta and its major branches.
- Retroperitoneal lymph nodes.
- Retroperitoneal tumour.
- Inferior vena cava and portal veins.
- Lumbar sympathetic chains.

RETROPERITONEAL LYMPH NODE DISSSECTION (RPLND)

RPLND is specifically commonly done for testicular and ovarian tumours. It is often also done in other malignancies also like carcinoma cervix, endometrium, rectum, etc. Nonseminomatous germ cell tumour of stage I and IIa shows good benefit. RPLND is used for staging as well as for therapy.

Both open and laparoscopic approaches are used. Laparoscopic approach is better as magnification and dissection is better. Nerve sparing is better.

Right-sided RPLND includes complete dissection above the inferior mesenteric artery up to renal vessels; laterally up to both ureters; below along the bifurcation of the common iliac vessels on same side (right). *Left-sided RPLND* includes complete dissection above the inferior mesenteric artery up to renal vessels; laterally on left side up to left ureter; towards right up to the right margin of the IVC; below along the aortic bifurcation/bifurcation of common iliac vessels on same side. In certain conditions bilateral RPLND is also done.

Preoperative Preparation

Patient should undergo complete metastatic work up as if there is blood spread or peritoneal spread RPLND is contraindicated. Peritoneal infection also temporarily preludes the surgery. Blood should be kept ready. Mechanical bowel preparation is needed. Nasogastric tube and Foley's catheter is passed.

Principles

Principles in RPLND are adequate exposure; meticulous dissection; haemostasis; use of bipolar cautery, proper retraction, safeguarding the bowel.

Technique

Right-sided RPLND—Right peritoneal fold (Toldt's line) is incised from hepatic flexure to medial umbilical ligament; colon is retracted medially by sharp dissection; colorenal and hepatorenal ligaments are divided by sharp dissection. Kocher's duodenal mobilization is done. Great vessels are exposed. Right spermatic cord and internal inguinal ring is identified. Vas deferens crossing ureter and iliac vessels is dissected, clipped and transected. External, iliac vessels should be safeguarded. Gonadal vein is dissected up to its joining to IVC; gonadal artery is dissected up to a point where it crosses and joins aorta. Gonadal vein is clipped and divided at its joining to IVC. Adventitia overlying the IVC is dissected carefully from renal vein level above and common iliac vessels level below. Right ureter is gently retracted laterally and lymphatics are dissected and retracted laterally. Ureter is dissected distally up to the point where it crosses the iliac vessels. Lymphatics with nodes are dissected and swept upwards. Sympathetic chain is identified and lymph nodes are dissected from behind without injuring the lymphatic chain. Inferior mesenteric artery and left renal artery is identified. Lumbar veins are identified and clipped before division. Intercavoaortic nodes should be cleared. Accessory renal artery and retroaortic renal vein may get confused and ligated inadvertently; this should be avoided. IVC is retracted gently in front and tissues are dissected and brought towards specimen. Dissection up to the left ureter should be done right RPLND **(Fig. 26-5)**.

Left-sided RPLND—Dissection here is above up to left renal vein; left ureter laterally; bifurcation of left common iliac veins below; right margin of IVC towards right side. Left paracolic gutter peritoneum is incised. Left colon is mobilized including splenic flexure by dividing left renocolic, phrenocolic, splenocolic, gastrocolic and pancreaticocolic ligaments; left renal vein is identified and dissected. Below up to the bifurcation of the common iliac vessels dissection is done. Colon, spleen above mobilized medially; left internal inguinal ring and left vas deferens is identified; left vas deferens is divided after clipping. Left gonadal vein is dissected up to its joining into the left renal vein. Aorta and left ureter is identified and dissected to clear paraaortic lymph nodes. Dissection from aorta above towards iliac vessels downwards along the origin of inferior mesenteric artery is carried out to clear all lymph nodes. Lymphatics along the intercavoaortic region from renal vein level to IMA level are cleared. IVC is dissected and retracted towards right to identify lumbar veins which are ligated and all tissues are swept towards left specimen side **(Fig. 26-6)**.

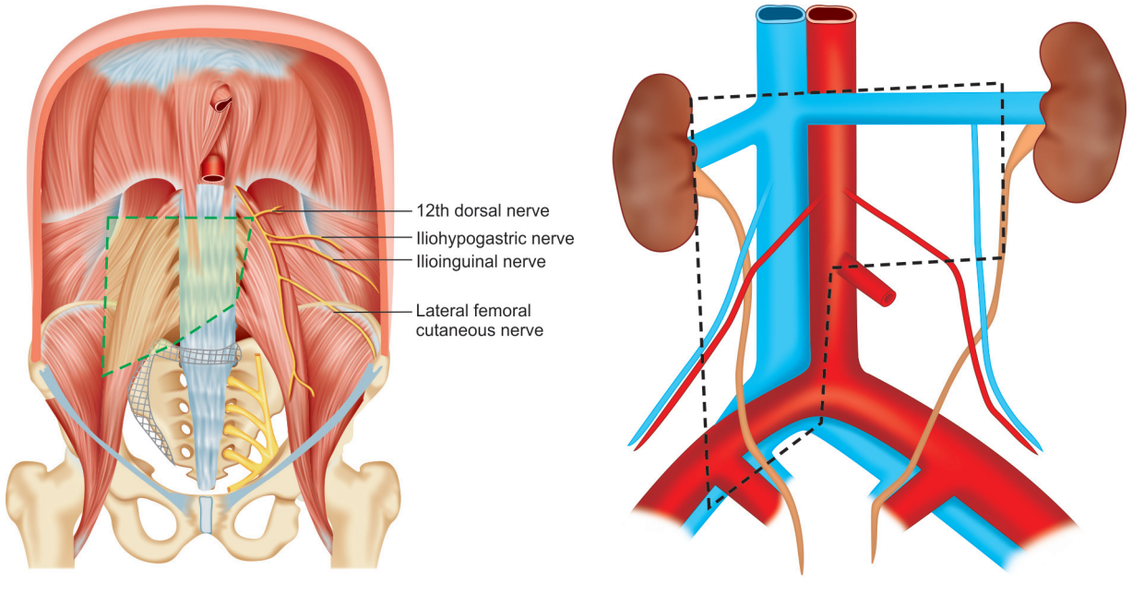


Fig. 26-5: Template for RPLND right-side.

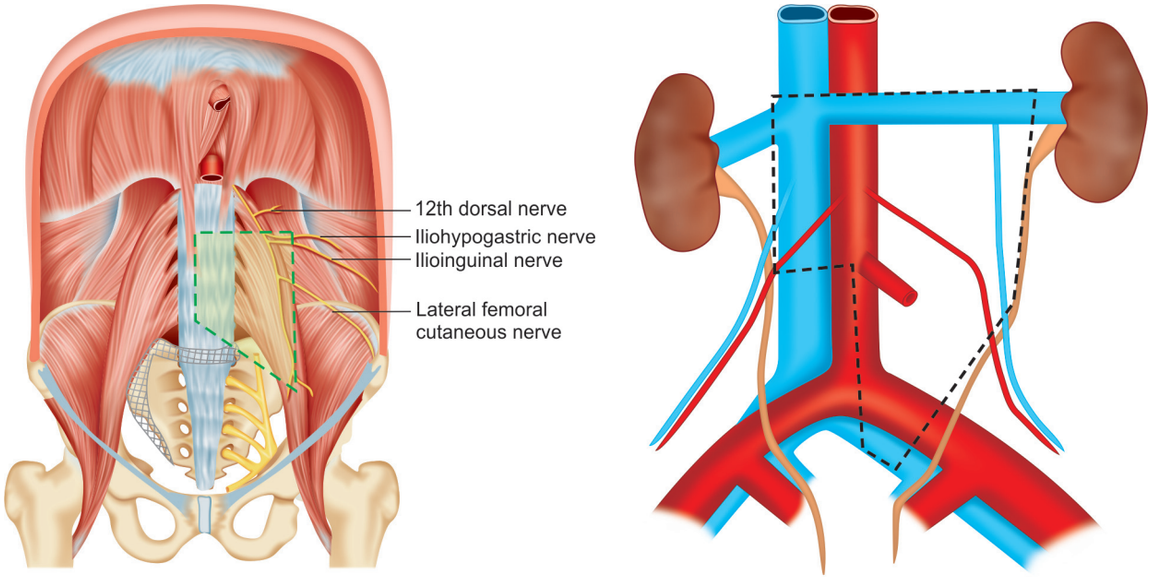


Fig. 26-6: Template for RPLND left-side.

Complications

Haemorrhage occurs while dissecting and mobilising the IVC especially from its tributaries. Clipping the vessels is better way to prevent the haemorrhage.

Injury to ureter, stricture ureter (5%), and hydronephrosis due to surgical trauma can occur.

Lymphocele, chylous ascites due to lymphatic dissection is likely to develop often (3%).

Retrograde ejaculation due to sympathetic nerve damage can occur (5%). Nerve sparing surgery, avoiding monopolar cautery close to the sympathetic chain prevents this.

Contd...

Contd...

Paralytic ileus is common due to retroperitoneal dissection. If it persists long time one should suspect haematoma, pancreatitis, urinary extravasation.

Sepsis is not uncommon – retroperitoneal or intraabdominal abscess formation can occur. It is diagnosed by CT scan, usually responds with higher generation antibiotics; may require guided catheter drainage; occasionally only needs open drainage.

Chapter

27

Urologic Surgeries

SURGICAL ANATOMY OF KIDNEY

They are a pair of excretory organs situated retroperitoneally, on the posterior abdominal wall; one on each side of vertebral column. Vertically it extends from the upper border of T12 vertebra to the centre of the body of L3 vertebra. The right kidney is slightly lower than the left, left kidney is slightly nearer to the median plane. Each kidney is about 11 cm long, 6 cm broad, and 3 cm thick; 150 gram in weight; reddish brown in colour. Lateral border is convex. Medial border is concave with a hilum. Structures seen in the hilum are (from anterior to posterior)—(1) renal vein, (2) renal artery, (3) renal pelvis. Upper pole is related to suprarenal gland; lower pole lies 1 inch above the iliac crest. Capacity of renal pelvis is 10 ml. The angle between the 12th rib and the outer border of the sacrospinalis is the kidney/renal angle. Fetal kidney has got 12 lobules which fuse after birth to become smooth. Hepatorenal pouch (Morrison's kidney pouch) is a peritoneum lined deep recess, related to the upper pole of kidney. It is the lowest site when the body is in horizontal position, excluding the pelvis. Collection of extravasated fluid is likely to occur in this pouch following surgeries to liver and biliary tract.

Kidney occupies lumbar, epigastric, hypochondriac, umbilical region. It extends vertically from upper border of 12th thoracic vertebrae to the centre of the body of 3rd lumbar vertebra. Right is lower than left; left is more medial than right. Upper pole is more medial than lower as long axis is directed downwards and laterally. Transpyloric plane passes through the upper part of the right renal hilum and lower part of left renal hilum. Hilum lies opposite the lower border of the 1st lumbar spine; right hilum is lower **(Fig. 27-1)**.

Morris parallelogram is surface marking drawn from behind; two horizontal lines are drawn one at the level of the 11th thoracic spine, other at the level of 3rd lumbar spine; two vertical lines are drawn one 2.5 cm and other 9 cm from the midline. From front on the right side hilum lies 5 cm from the median plane below on the left side above the transpyloric plane; medial to the tip of the 9th costal cartilage. Upper pole lies midway between xiphisternum and transpyloric plane 5 cm from midline; lower pole 7 cm from midline at umbilical plane on the right side and at subcostal plane (little above) on the left side. Lower pole is 2.5 cm above the iliac crest.

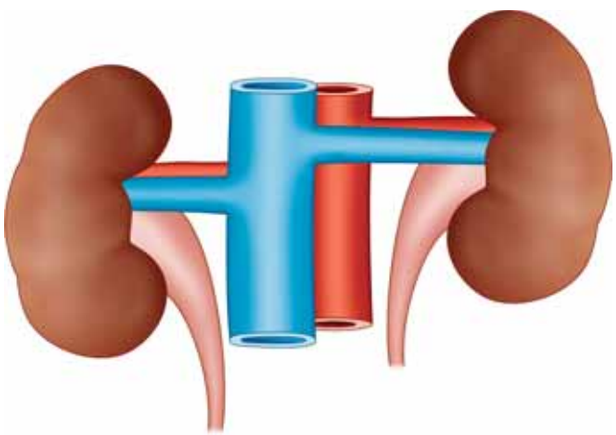


Fig. 27-1: Location of both kidneys and configuration. Right kidney is lower than left. Left renal vein is longer and runs in front of the aorta and behind the SMA.

Relations of Kidney

Posterior relations—Diaphragm, medial and lateral arcuate ligaments; psoas major muscle; quadratus lumborum; transversus abdominis; subcostal vessels; subcostal, iliohypogastric, and ilioinguinal nerves. Right kidney is related 12th rib; left one to 11th and 12th ribs **(Fig. 27-2)**.

Anterior relations—Right-Right adrenal gland; 2nd part of the duodenum; right flexure of the colon; small bowel; partly covered by peritoneum at hepatic and bowel parts. *Left*-Left adrenal gland; spleen; stomach; pancreas; splenic vessels; left colonic flexure; descending colon; jejunum. Gastric, splenic and jejunal surfaces are covered by peritoneum.

Capsules of Kidney

Proper fibrous capsule—It is fibrous membrane which can easily be stripped off from the organ. This is a thin membrane which closely invests the kidney and lines the renal pelvis.

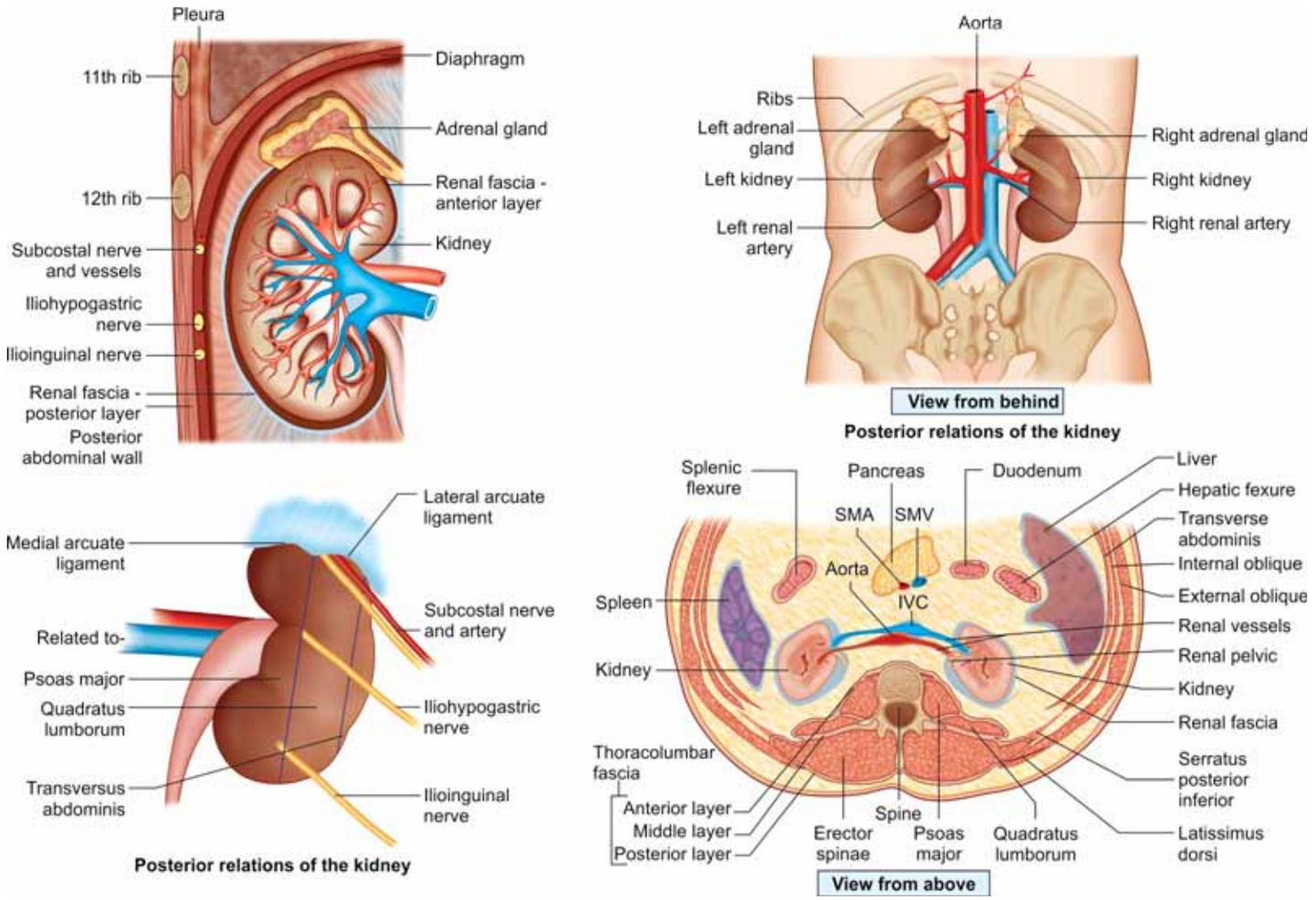


Fig. 27-2: Relations of kidney.

Perirenal/perinephric fat is in the space of Gerota – it is the layer of fat outside the fibrous capsule.

Renal fascia of Gerota— It is fibroareolar sheath which covers the kidney and perinephric fat. It has got anterior layer *(Fascia of Toldt)* and posterior layer *(Fascia of Zuckerkandl)*. Many trabeculae runs in this plane from fibrous capsule to the renal fascia. Above two layers of renal fascia encloses the adrenal gland as a separate compartment and fuse each other; continuing with fascia under the diaphragm. Below two layers are separate enclosing the ureter; anterior layer merges with the connective tissue of the iliac fossa; posterior layer blends with the fascia iliaca. Laterally two layers fuse to continue as fascia transversalis. Medially anterior layer passes in front of the renal vessels and merges with the connective tissue around the aorta and IVC. The posterior layer gets fused with the fascia covering the quadratus lumborum and psoas major; to the vertebra and intervertebral disc. Medially it forms a septum to get pierced by renal vessels preventing perirenal fluid to cross to opposite side.

Pararenal/paranephric body of fat is fat lying outside the renal fascia more on backside and lower pole filling paravertebral gutter to create a cushion for kidney.

Structure of Kidney

Gross

Coronal section shows outer brownish cortex, inner pale medulla, and renal sinus. Renal sinus is a space that extends into the kidney from hilum. It contains (1) branches of renal artery, (2) branches of renal vein, (3) renal pelvis.

The pelvis divides into 2-3 major calyces which in turn divide into 7-13 minor calyces.

Histology

Each kidney is composed of 1-3 millions of uriniferous tubules; each of which has a collecting part *(collecting tubules)* and secretory part *(nephron)*.

Blood Supply

Arterial Supply

It is from renal artery, which arises from the aorta at right angles, at the level of intervertebral discs between L1 and L2 vertebrae just below the

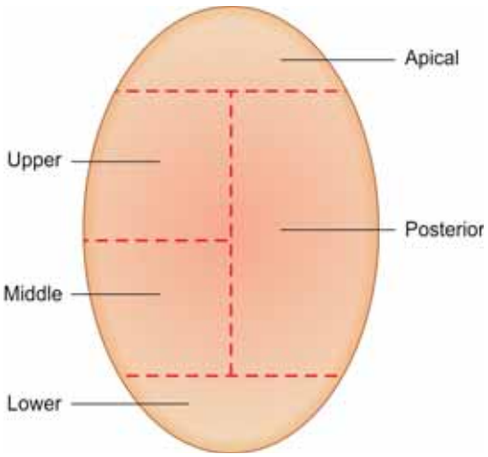


Fig. 27-3: Segments of kidney.

level of the origin of the SMA. Right renal artery passes laterally behind the IVC and head of the pancreas to reach the right renal hilum. Left renal artery runs behind the left renal vein, splenic vein, body of the pancreas and duodenojejunal flexure. Each renal artery gives inferior adrenal artery and ureteral branches. About 95% of abdominal aortic aneurysm arises below the level of origin of renal artery **(Fig. 27-3)**.

The kidney is divided into anatomic segments based on blood supply. In the hilum, the main artery, divides into anterior and posterior divisions. The anterior division supplies the apical, upper, middle and lower segments; posterior segment is supplied by the posterior division. The knowledge of this is important in the operation of anatrophic nephrolithotomy, where a functionally *avascular plane* (*Brodel*) between the posterior segment and the upper and middle segments exist on the posterior half of the kidney, about two-thirds of the way from the hilum to the lateral margin of the kidney. There is no collateral circulation between segments of the kidney but veins will communicate freely between segments.

Main renal artery → division → segmental artery → lobar artery to each pyramid → 2 interlobar arteries run on each side of the pyramid → 2 arcuate arteries interlobular arteries run radially to cortex → afferent arteriole to glomeruli and also branches to renal capsule which forms capsular plexus. Afferent glomerular arteriole → glomerulus → efferent glomerular arteriole → peritubular glomerular plexus. Renal medulla derives its blood supply from efferent arterioles. Free circulation in the cortex is glomerular; restricted circulation in the medulla bypasses cortical glomeruli which is more rapid **(Fig. 27-4)**.

Accessory renal artery (30%) may arise from aorta running parallel to renal artery entering the kidney either at poles or at hilum.

Venous Drainage

Peritubular capillary plexus → interlobular veins → arcuate veins → interlobar veins → renal vein at renal sinus → join IVC just below the transpyloric plane. Left renal vein is longer than right one. Renal vein lies in front of the renal artery. Right renal vein lies behind the second part of the duodenum. Left renal vein crosses in front of the aorta lying behind the pancreas and splenic vein. Tributaries of left renal vein are left adrenal and left gonadal veins.

Nerve Supply

T10,11,12 through the lesser and lower splanchnic nerves.

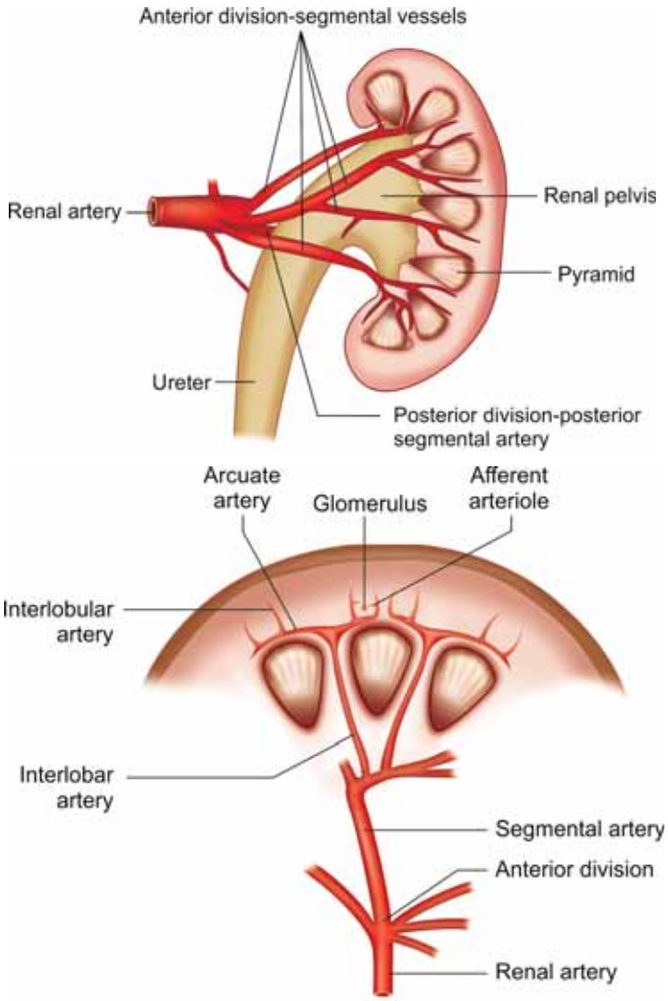


Fig. 27-4: Arterial segments and their distribution in the kidney.

Lymphatics

They are drained into para-aortic (lateral aortic) nodes. Perinephric fat is removed during nephrectomy (for malignancies), as intrarenal lymphatics freely communicates with the plexus in the perinephric fat.

SURGICAL ANATOMY OF THE URETER

Each ureter is 25-30 cm long. It begins within the renal sinus as a funnel-shaped dilatation called renal pelvis. It enters the bladder wall obliquely to open at the lateral angle of the trigone. It lies in the retroperitoneal space not attached to any fixed structures, so can be displaced or obstructed by retroperitoneal masses like tumours or aneurysms. Abdominal portion of ureter lies on the medial portion of psoas major muscle near the tips of transverse processes of lumbar vertebra (which is very well seen in IVP). The ureter enters the pelvis crossing the end of common iliac or beginning of external iliac artery. In females, uterine artery crosses the ureter from lateral to medial side, about 2 cm lateral to the cervix (this has to be remembered while ligating the uterine arteries in hysterectomy).

Ureter is marked by a line running downwards and medially from the tip of the 9th costal cartilage to the pubic tubercle; behind it is marked by a line running vertically downwards from the 2nd lumbar spine till the posterior superior iliac spine.

Ureter runs downwards and medially on the psoas major muscle and enters the pelvis by crossing the common iliac artery in front near its bifurcation. In the true pelvis ureter runs downwards, backwards and laterally along the anterior margin of the greater sciatic notch; opposite the ischial spine it runs forwards and medially to reach the base of the urinary bladder. It enters the bladder obliquely to open at trigone.

Normal sites of constrictions: (1) PUJ, (2) At the brim of lesser pelvis, (3) Along its passage through the bladder wall.

Abdominal Part of Ureter

Right Side

It is related to 3rd part of the duodenum; right colic, ileocolic, right gonadal vessels; root of the mesentery; terminal part of the ileum. Right ureter is related medially to IVC.

Left Side

Left ureter is related to gonadal artery (not gonadal vein but it is adjacent and medial to left ureter), left colic vessels, sigmoid colon, sigmoid mesocolon. Posteriorly the ureter lies on psoas major, tips of transverse processes of lumbar vertebrae; genitofemoral nerve. Left ureter is related to left gonadal vein medially.

Pelvic Part of Ureter

Initial Part

Initially it runs forward. Here it is related behind to internal iliac artery, origin of its anterior trunk, internal iliac vein, lumbosacral trunk, sacroiliac joint. It is related laterally to superior vesical artery, obturator nerve, obturator artery and vein, inferior vesical vein, middle rectal artery, in females it is posterior boundary of the ovarian fossa.

Later Part

Later it runs forward. In males – vas deferens crosses the ureter above from lateral to medial side, the seminal vesicle lies below and behind the ureter, vesical veins surround its terminal part. In females it lies in the lower medial part of the broad ligament of the uterus. Uterine artery lies initially above and in front, later it crosses the ureter from lateral to medial side "water under the bridge", ureter lies 2 cm lateral to the supravaginal portion of the cervix, then above the lateral fornix of the vagina and end lies in front of the vagina. Interureteric distance of the ureters inside the bladder is 5 cm in full bladder and 2.5 cm in empty bladder.

Arterial Supply

Upper segment of ureter receives blood supply from branches of renal, gonadal and adrenal arteries; the middle portion from the aorta and branches of arteries of posterior abdominal wall; the pelvic portion from the branches of internal iliac arteries. Vessels reach the abdominal portion of ureter on the medial side; whereas the pelvic portion receives on the lateral side (This has to be remembered while mobilising the ureter). The vessels form an anastomotic plexus in the adventitia of the ureter, which is found to be deficient in 10-15% of individuals leading to necrosis of cut ends of ureter following extensive mobilisation. Arteries divide into ascending and descending branches which first form a plexus on the surface of ureter.

Nerve Supply of Ureter

Sympathetic comes from T10-L1 segments and parasympathetic from S2-S4 nerves. It arises from renal, aortic and hypogastric plexuses.

ANATOMY OF URINARY BLADDER

It is a muscular reservoir of urine situated in the pelvis, posterior to the pubic bone from which it is separated by the retropubic space. The size, shape, position of bladder depends on the amount of urine it contains. In females, the peritoneum is reflected from the superior surface of the bladder onto the anterior wall of the uterus close to the junction of the body of uterus and cervix. In males, the peritoneum is reflected from the superior surface of the bladder over the superior surface of the ductus deferens and seminal vesicles. The neck of the bladder is the most fixed part, lies 3-4 cm behind the pubic symphysis. In males it lies on the prostate and in females it rests on the anterior vaginal wall which is also supported by the levator ani muscle **(Fig. 27-5)**.

Structure of the Bladder

The bladder wall consists of interlacing fibres of smooth muscle. The urothelium consists of transitional epithelium which is loosely

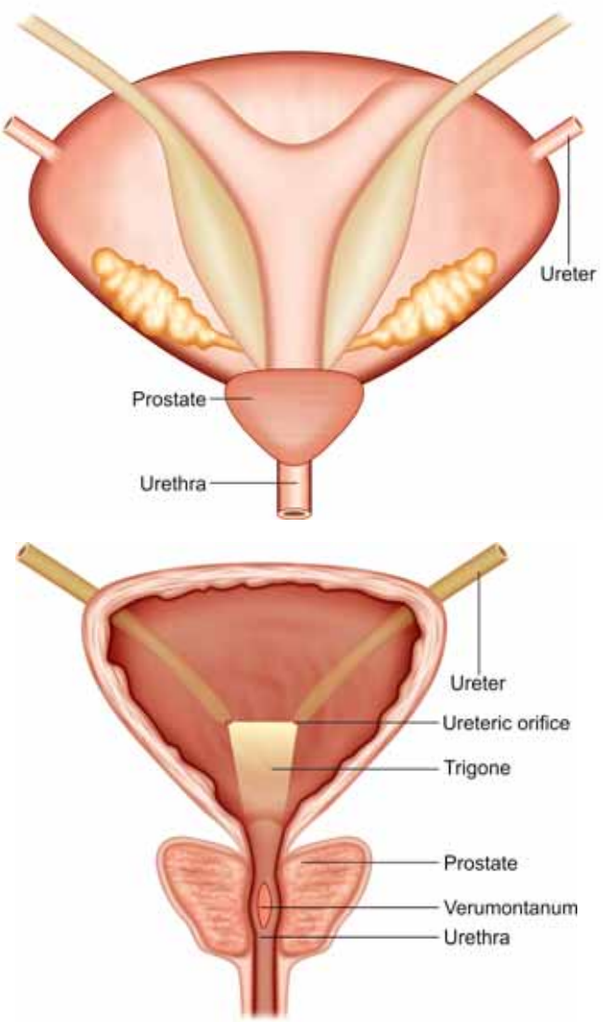


Fig. 27-5: Anatomy of urinary bladder—posterior aspect and interior part.

attached and easily separated from the bladder wall except over the *trigone*. *Trigone* is a triangular area over the lower part of the base of the bladder. The ureters open into the posterolateral angles of the trigone. The internal urethral orifice opens at the inferior angle of trigone.

Sphincters

Internal sphincter: Smooth muscle, situated at the neck of the bladder, micturition follows its relaxation. It is innervated by autonomic nervous system.

External sphincter: It consists of striated muscle, innervated by the perineal branch of pudendal nerve (S2,S3).

ANATOMY OF PROSTATE

It is an accessory gland of male reproductive system. It is composed of glandular tissue embedded in fibromuscular stroma. It surrounds the first 3 cm of the urethra.

Lobes

It is composed of 5 lobes—anterior, posterior, 2 lateral, 1 middle/median lobe. Primary carcinoma is said to begin in posterior lobe. Middle lobe produces an elevation in the lower part of the trigone of bladder *(uvula vesicae)*. Adenoma is more common here due to more amount of glandular tissue **(Fig. 27-6)**.

Capsules

1. *True capsule*: Formed by the condensation of the peripheral part of the gland; continues with the stroma of the gland.
2. *False capsule*: Derived from the pelvic fascia. On each side prostatic venous plexus are embedded in it.

McNeal Divided Prostate into Three Zones

1. *Peripheral zone*—prone for carcinoma.
2. *Periurethral transition zone* where BPH arises.
3. *Central zone*.

Note: Prostate carcinoma develops in prostatic gland proper; BPH develops in submucosal glands.

Blood Supply

Superior and inferior vesical arteries, branches of anterior division internal iliac artery, obturator and inferior gluteal arteries supply the bladder. In females uterine and vaginal arteries supply the bladder instead of inferior vesical artery.

Venous drainage is by the vesical plexus of veins, which drains into the internal iliac veins. These veins connect directly to veins of hip bones, the heads of femoral and vertebral bodies. This accounts for the site of occurrence of bony metastasis in carcinoma of the bladder and prostate.

ANATOMY OF URETHRA

Male Urethra

Male urethra is 20 cm long and is S-shaped. It extends from internal urethral orifice (neck of the bladder) to external urinary meatus (tip of penis).

Posterior urethra:
- Prostatic urethra.
- Membranous urethra.

Anterior urethra:
- Bulbar urethra.
- Penile urethra.

Prostatic urethra is 3 cm in length runs vertically downwards from internal urethral orifice through the anterior part of the prostate. It is widest part of the male urethra (mainly in its middle). It is most dilatable also. It joins membranous urethra. Its orifice is star-shaped; posterior mucosa contains median longitudinal mucosal ridge as urethral crest/verumontanum; in the middle of this crest an elevation called as colliculus seminalis is present. Prostatic utricle opens into the urethra into a slit like orifice on this elevation. Prostatic utricle is a blind sac of 6 mm length in the prostate directing upwards and behind between median and posterior lobes. Opening of ejaculatory ducts are present on both sides of this slit. Two vertical grooves one on each side of this crest are called as prostatic sinuses. Around 30 prostatic glands open into these sinuses.

Membranous urethra is 2 cm in length runs downwards and forward through the deep perineal space; pierces the perineal membrane

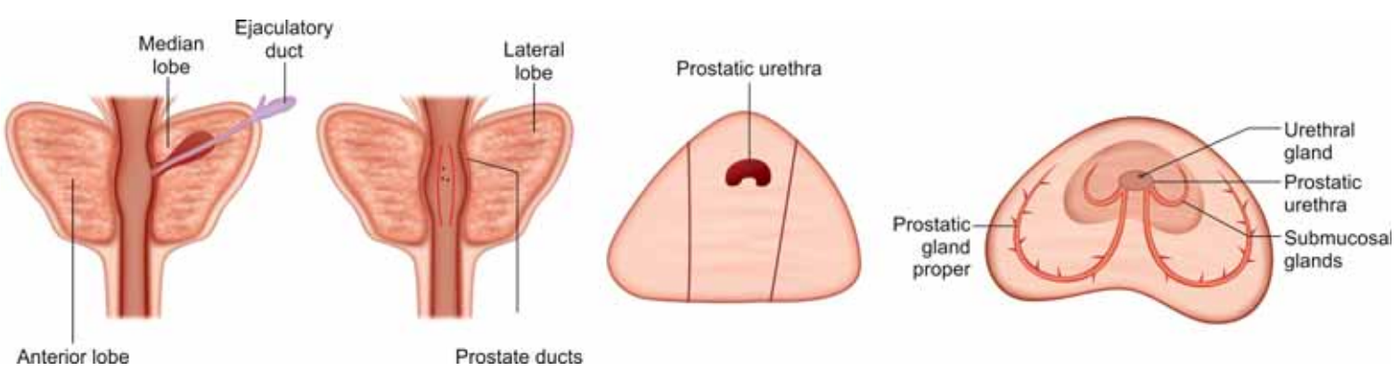


Fig. 27-6: Anatomy of prostate.

about 2.5 cm below the pubic symphysis. It is the narrowest part of the urethra in males. It is surrounded by external urethral sphincter. Many urethral glands open into this urethra. *Cowper's bulbourethral glands* are located one on each side of this urethra. Their ducts travel down and open into the spongy part of the urethra after piercing the perineal membrane.

Penile/spongy urethra is 15 cm in length has got *proximal bulbar urethra* running forward and upward in the bulb of penis; later it bends downwards in front of the lower part of the pubic symphysis to run in the corpus spongiosum of penis. Diameter of penile urethra is 6 mm in diameter and is narrow; in its beginning beyond the membranous urethra it is dilated to form intrabulbar fossa which bulges into the floor on each side; terminal navicular fossa in the glans bulges into the roof on each side. External meatus 6 mm sagittal slit bounded by tiny labium on each side. Cowper's bulbourethral gland ducts open into penile urethra one on each side. Plenty of urethral glands of Littre open into penile urethra with their openings facing forward. Many small lacunae of Morgagni open obliquely forwards; biggest lacuna on the roof of the navicular fossa is called as sinus of Guerin **(Fig. 27-7)**.

Internal urethral involuntary sphincter contains smooth muscles, elastic and collagen fibers which is supplied by sympathetic nerves (supply above the level of the ejaculatory duct).

External voluntary urethral sphincter controls the membranous urethra and is supplied by the perineal branch of the pudendal nerve (S2,3,4).

Female Urethra

Female urethra is 4 cm long and 6 mm in diameter. It corresponds to the prostatic urethra of male above the level of prostatic utricle. It starts at internal urethral orifice 5 cm behind the pubic symphysis running downwards and forwards embedded in the anterior wall of the vagina crosses the urogenital diaphragm ending at the external urethral orifice in the vestibule. Proximally it is crescentic; middle it is star-shaped; transverse distally. External meatus is sagittal. Skene's paraurethral glands are collection of mucous glands on each side in the proximal part corresponds to prostate in males.

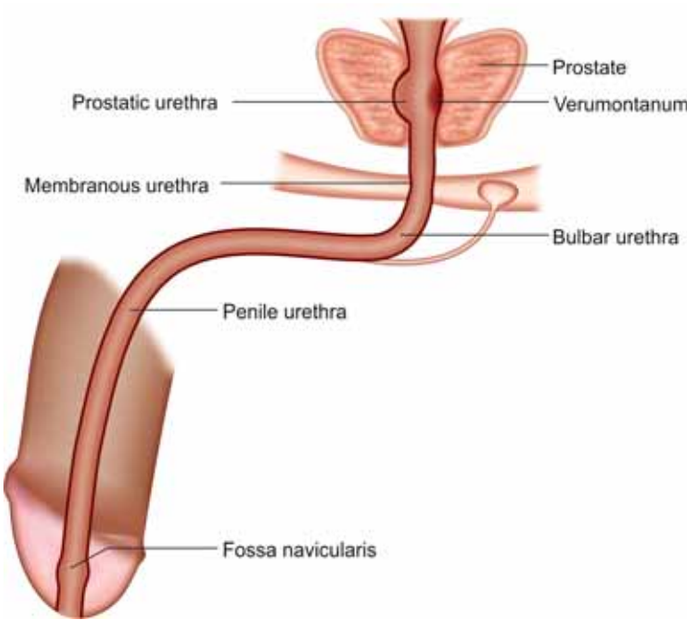


Fig. 27-7: Anatomy of male urethra.

APPROACHES TO KIDNEY

Approaches may be posterior (loin) or anterior (per abdomen) or thoracoabdominal **(Figs 27-8 and 27-9)**.

Loin approach is the standard approach. It is retroperitoneal approach. It is posterior subcostal with oblique lumbar incision. It is useful for pyeloplasty, nephrectomy for benign conditions like pyonephrosis with nonfunctioning kidney, tuberculous kidney, nephron sparing nephrectomies. Loin approach is in lateral position; with raised kidney bridge (or sand bags under the loin); with one knee flexed; large flat pillow between two legs; Mayo's table to keep instrument; arm is abducted and placed on an arm rest; with proper cotton padding to all pressure areas. Patient should be fixed to the table with tying belt and side supports. 12th rib excision is often required. 11th rib excision approach is done whenever 12th rib is rudimentary or absent.

11th rib with the 12th excision achieving extensive loin approach is called as *Nagamatsu approach* is used for large renal tumours.

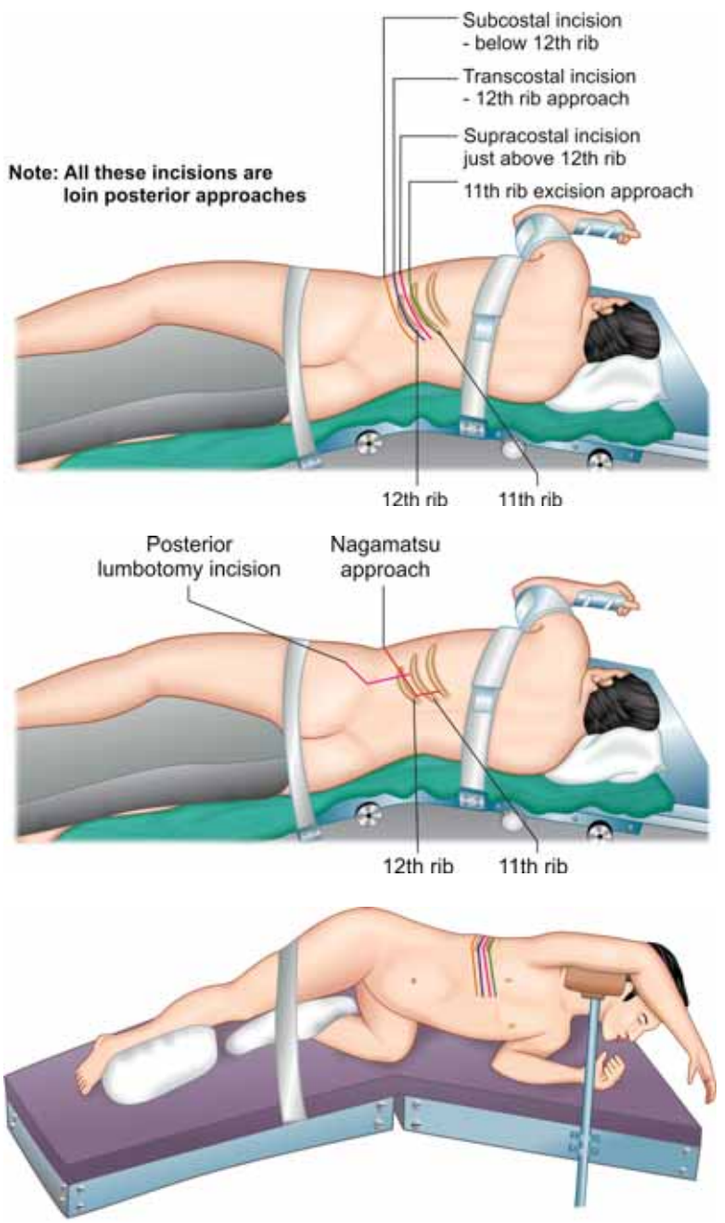


Fig. 27-8: Different approaches to kidney.

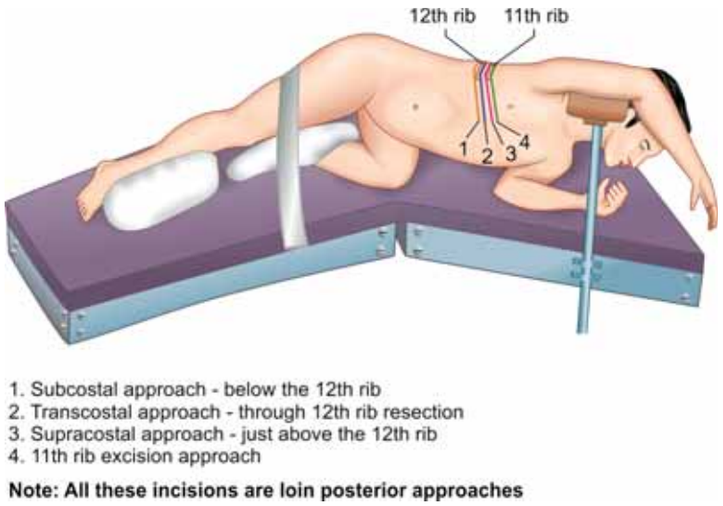

12th rib
11th rib
1
2
3
4
1. Subcostal approach - below the 12th rib
2. Transcostal approach - through 12th rib resection
3. Supracostal approach - just above the 12th rib
4. 11th rib excision approach
Note: All these incisions are loin posterior approaches

Fig. 27-9: Posterior loin approaches as viewed from front of the patient.

Fig. 27-11: Laparoscopy is very well accepted for most of the urologic surgeries; becoming standard also. But technique and principles are same as open method.

Transperitoneal abdominal approach (anterior approach) is useful in renal malignancies.

Thoracoabdominal approach may be needed in large upper pole tumours. Patient is placed in supine position with two sandbags one under the shoulder and another under the buttock of the side of the surgery. Incision runs along the 10th or 9th rib extending from posterior axillary line to the midline and continuing downwards as midline incision. Hyperextension is provided by breaking the table. Posteriorly latissimus dorsi, serratus posterior inferior are incised using diathermy; 10th rib is resected (instead intercostal muscles may be cut above the rib); external oblique, internal oblique and rectus muscles are cut; costovertebral ligament behind and costal cartilage in front are cut. Pleura is identified and opened along the line of incision. Lung is retracted upwards; diaphragm is cut in the line of incision. Rectus sheath and peritoneum is opened up to the lower end of the incision. Large self retaining retractors are used to retract wound edges to expose the field. While closing the wound, peritoneum is closed first; diaphragm is sutured using polypropylene or vicryl (no. 1); ribs are approximated using no. 1 polypropylene; pleura and intercostal muscles are sutured after placing a intercostal tube to the pleural cavity through the 6th intercostal space in the midaxillary line. Loin muscles are sutured – latissimus dorsi, serratus posterior inferior and external oblique are sutured. Other layers of the abdomen are closed. Skin is apposed using skin staplers **(Fig. 27-10)**.

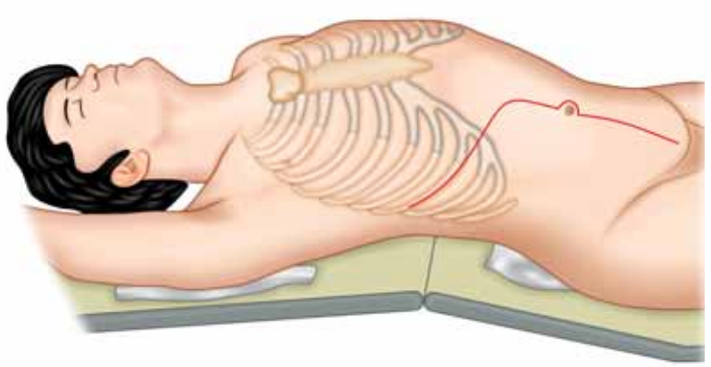


Fig. 27-10: Thoracoabdominal approach for kidney is done for large tumours.

Anterior supine paramedian vertical extraperitoneal approach is also popular for approaching while managing the benign conditions.

Laparoscopic approach is said to be ideal for many diseases including nephrectomy **(Fig. 27-11)**.

Retroperitoneoscopic approach is often used; but laparoscopic approach gives more space to work on it.

Posterior lumbotomy approach in prone position is no longer advocated.

Loin Incision (Posterior Approach; Morris Incision, Sir Henry Morris London)

Loin position is usual position used for renal surgeries. It can be subcostal (classical Morris incision is subcostal type); transcostal (12th rib); supracostal (above the 12th rib in the intercostal space). Subcostal is used for the benign diseases and lower pole diseases. Transcostal, supracostal and 11th rib excision approach is for difficult cases and upper pole tumours.

Patient is placed in loin position. It is usually transcostal 12th rib excision loin approach. Full lateral position with kidney bridge raise (to break the table 40° to horizontal) with flexion of the knee of the leg which is on the theatre table is done (lower side leg - 90°). Flat wide pillow should be kept between legs. Arm facing upwards is positioned towards head end with a support (cradle support). Patient is strapped firmly to table to prevent tilting or changing of the position during surgery. Back support is often needed. Mayo's table is placed on the leg side which facilitates to keep instruments safely after draping **(Fig. 27-12)**. Anaesthetist should observe blood pressure as it may drop after raising the kidney bridge by compression on the IVC.

After cleaning and draping, incision begins posteriorly behind the posterior axillary line in posterior subcostal line extending forward towards the outer margin of the rectus muscle. It usually marks angle of the 12th rib posteriorly to 15 cm beyond the tip of 12th rib. Rectus is usually not cut. Skin, subcutaneous tissue and superficial fascia are cut. Posteriorly latissimus dorsi, serratus posterior inferior and quadratus lumborum are cut; anteriorly external and internal oblique muscles are cut. Usually 12th or 11th is cut. Rib is identified. Incision is made over its periosteum. Periosteum is reflected using periosteal elevator and rib raspatory. Care should be taken to avoid injury

Fig. 27-12: Position of the patient for loin incision to approach kidney.

to vessels underneath which often need proper ligation. Rib after mobilisation, is cut using bone cutter. Cut end is often smoothened using bone file. Pleura is very close to the rib which should not be opened. If openes pneumothorax develops; which is usually managed by placing vicryl sutures to pleura while anaesthetist keeps ventilating the lung with adequate expansion. Usually intercostal tube is not necessary. Postoperative check X-ray is needed for the evidence of pneumothorax. Transverse abdominis muscle is usually split from posterior to anterior. Peritoneum is adherent to the abdominal wall in front. So care should be taken not to tear on the anterior aspect. Peritoneum is swept forward to reach the Gerota's fascia **(Figs 27-13 and 27-14)**.

Nagamatsu approach gives excellent exposure of the kidney and its pedicle. It is done in same lateral loin position. Incision extends initially vertically from above at its angle inferiorly to the angle of the 12th rib and then running obliquely forward along the 12th rib towards umbilicus just lateral to the rectus muscle. Periosteum of the both 11th and 12th ribs are removed and ribs are excised.

Note: In supracostal and transcostal approaches, diaphragmatic and pleural attachments are released; pleura is pushed upwards carefully without opening it. Costo vertebral ligament should be divided. Iliohypogastric nerve should be mobilised below; subcostal nerve superiorly. Due to lateral position with raise of kidney bridge or breaking of the table venous return to heart decreases as due to IVC compression. One should inform anaesthetist while positioning the patient **(Fig. 27-15)**.

For many procedures of the kidney like nephron sparing nephrectomy, anatrophic pyelolithotomy ice packs are placed on the kidney surface for 20 minutes to increase the cold ischaemic time **(Fig. 27-16)**.

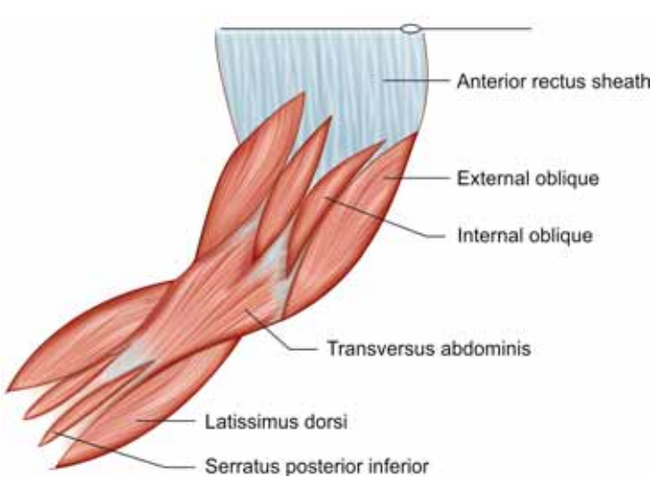
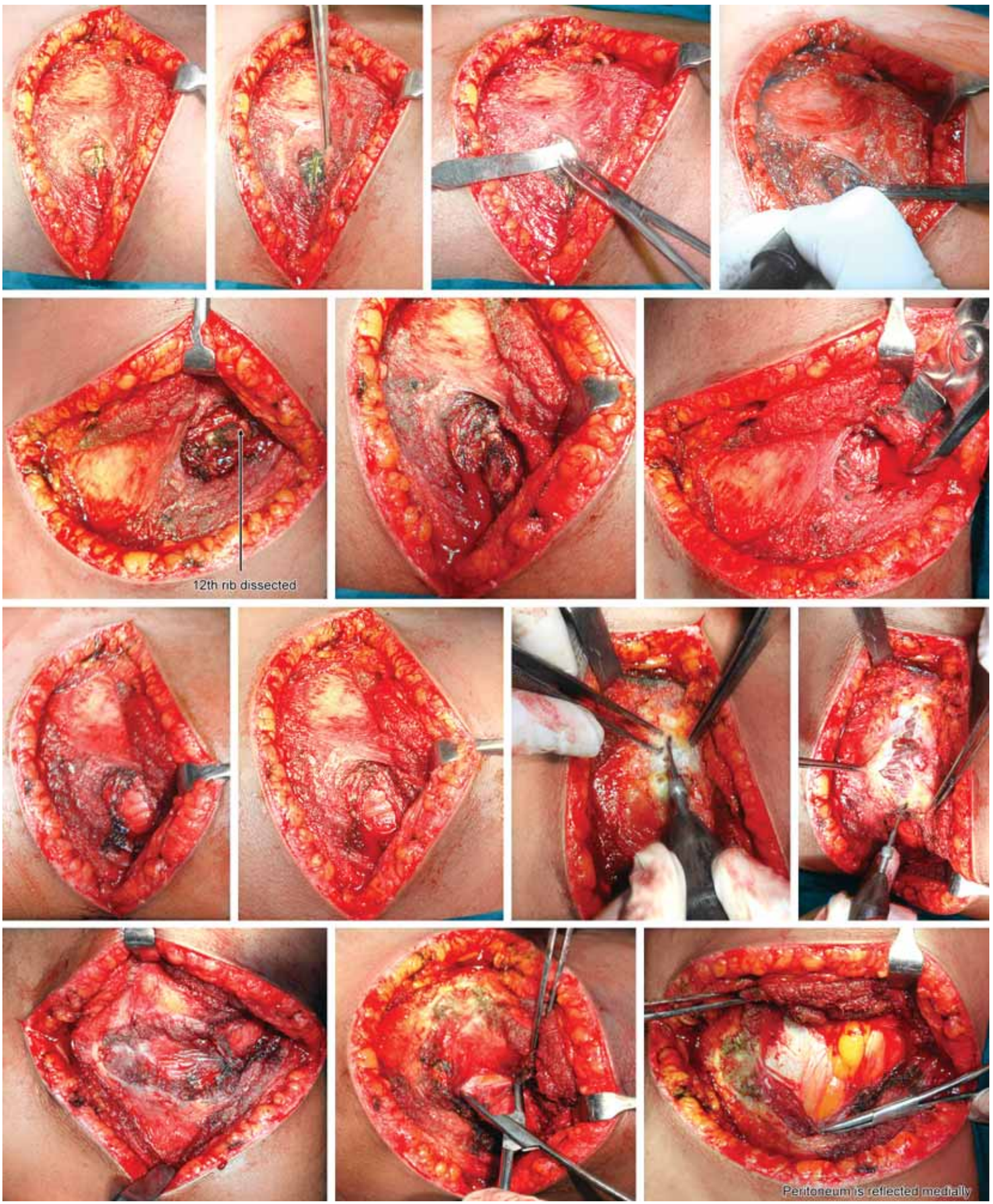


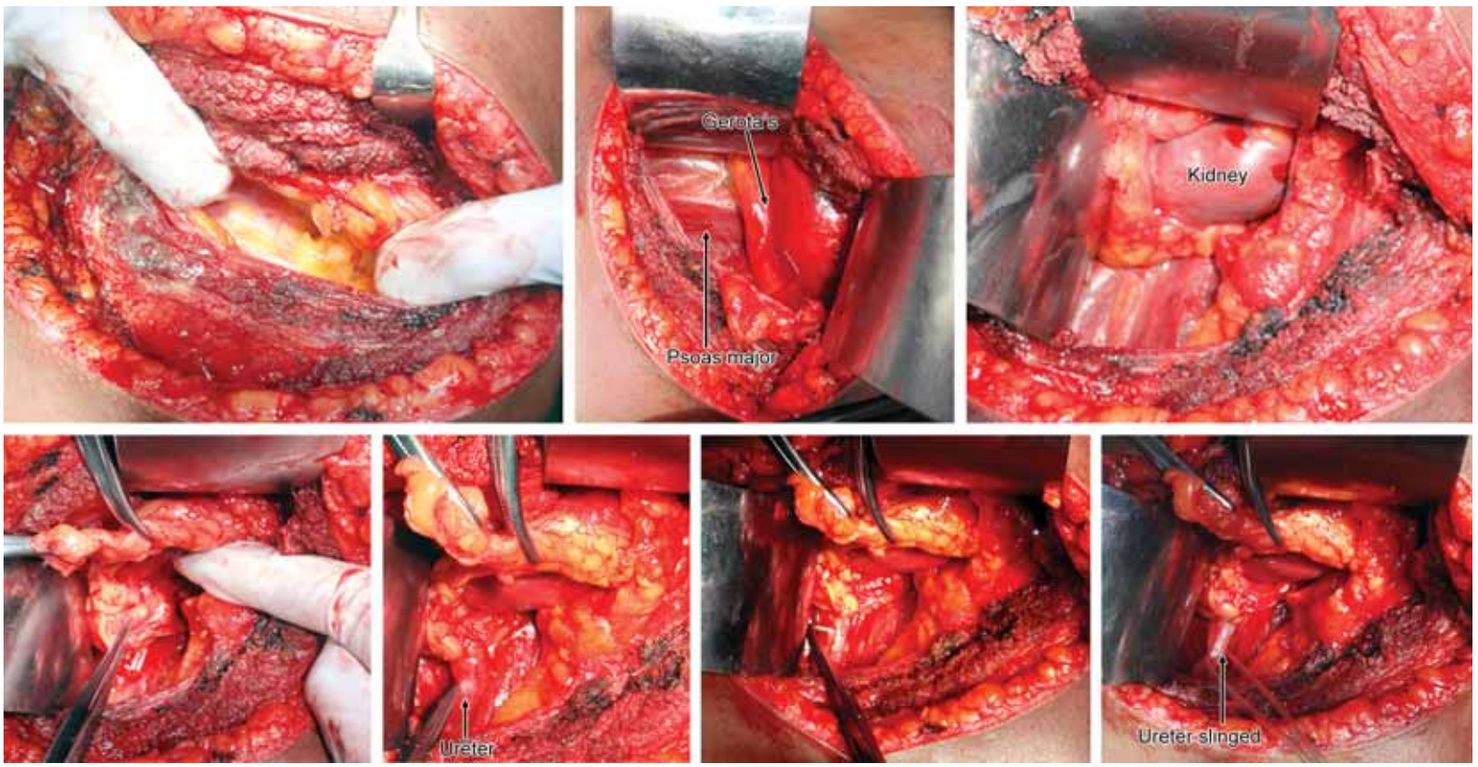
Fig. 27-13: Muscle and fascial layers which come across during posterior approach to kidney.

Kidney bridge of the table is elevated
Incision
External oblique
Incision over the 12th rib
Periosteal elevator

Figs 27-14(1)



Figs 27-14(2)



Figs 27-14(3)

Figs 27-14(1 to 3): Transcostal approach to kidney.

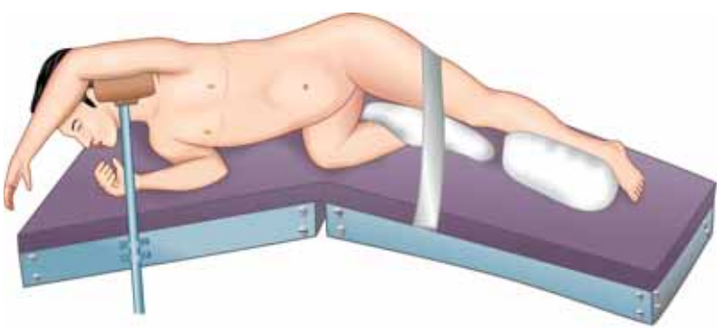


Fig. 27-15: Position of the patient usually used for loin approach for all common procedures including laparoscopic surgeries.

Closure of the Loin Wound

It is done in two layers. Transversus abdominis and internal oblique muscles are closed using continuous vicryl suture as inner layer. External oblique is closed using nonabsorbable or delayed absorbable continuous suture as outer layer. Covering fascia should be included in the bite which is stronger than muscle itself. Drain when needed should be kept below the lower margin of the wound and on the anterior aspect in front of the level of the anterior superior iliac spine; through a separate stab incision.

Incision can be extended into the thorax or into the peritoneal cavity as needed.

High 11th rib excision approach (both 12th and 11ribs are excised subperiosteally) is called as *Nagamatsu approach* which is used in approaching upper pole renal cell carcinoma (RCC).

Problems with Loin Incision

It is more painful, time consuming to open and close. Pleural and peritoneal opining is problematic in this approach. However, it is the most commonly used open approach for surgical interventions of the kidney.

Lumbotomy Incision (Gil-Vernet)

It is done in prone position for both sides; lateral position is possible for unilateral lumbotomy incision, two separate incisions can be placed on both sides in bilateral approach. It is used in bilateral partial nephrectomies, bilateral adrenalectomies. Unilateral lumbotomy incision can be placed in loin position; but it is more painful and retraction is difficult.

It is vertical posterior incision from 12 rib level to lilac crest. Incision is along the lateral border of the sacrospinalis. It extends from the upper border of 12th rib at lateral side of erector spinae downwards and forwards to the level of iliac crest for about 10 cm. It is deepened through latissimus dorsi, serratus posterior inferior, lumbosacral fascia, quadratus lumborum. Subcostal neurovascular bundle and 11th intercostal nerve should be mobilised and preserved. Gerota's fascia is visible; kidney is approached. If needed 12th rib or 12th and 11th ribs need to be excised to have better access. Pleura should not be injured.

Anterior Approaches

Anterior transperitoneal approach—It is done by lengthy midline or paramedian incision. Once laparotomy is done abdomen is explored;

Fig. 27-16: Ice crystals placement on the kidney.

paracolic gutter is incised; colon is mobilised medially; Gerota's fascia is identified; ureter is identified by its location, peristalsis (elicited by tapping), feel, vascular pattern. Pelviureteric junction (PUJ) is identified; gonadal vessels are identified which crosses the ureter from front. IVC is identified and exposed for its full length while doing nephrectomy and vascular ligations.

Anterior extraperitoneal approach may be used—Here paramedian incision is placed; anterior rectus sheath is incised vertically; rectus muscle is retracted laterally; posterior rectus sheath is incised vertically without opening the peritoneum; peritoneum is reflected by finger dissection medially to reach the retroperitoneum renal area.

Thoracoabdominal approach is also anterior approach.

DISSECTION OF THE KIDNEY

It is always better to identify and dissect the vessels to have vascular control prior to dissecting the kidney. In benign diseases Gerota's fascia is opened to reach the kidney, pelvis and upper 1/3rd ureter. In malignancy Gerota's fascia is not opened except in nephron sparing surgeries. It is always better to keep Satisnky vascular clamp ready in the theatre table during nephrectomy.

Right Sided Kidney Dissection

Right side faces challenges due to presence of the IVC, liver and right adrenal vein. Peritoneum is swept by blunt finger dissection medially; right colon will be located deeper to the peritoneum; after mobilisng it medially Gerota's will be exposed fully. Below ureter is identified by finger and cautery dissection. It is slinged using fine polythene tube or infant feeding tube. Gonadals crossing the right ureter is identified. Right gonadal vein joins the IVC behind the duodenum; right gonadal artery crosses the ureter and arises from aorta above the origin of the inferior mesenteric artery at the lateral margin of the aorta. Ureter below crosses the junction of common iliac artery and its branches in front of it. IVC is dissected fully from common iliac vein junction to the duodenum level. Duodenum is mobilised medially. Renal vessels are identified; right renal vein variations are common in its location, and branches. Sometimes double right renal veins may be present. Renal vein is carefully dissected using right angle instrument. It is not ligated but gently kept aside; right renal artery which is deeper and above is identified by its pulsation, isolated and doubly ligated using vicryl no. 1 or divided after transfixation. Aberrant renal artery is identified, dissected and ligated if present. Renal vein is ligated doubly using vicryl no. 1 and divided. Prior division between clamps followed by ligation should not be done because if clamp slips torrential haemorrhage can occur. It is always better to keep the Satinsky vascular clamp ready in case needed. Often tumour extends close to the IVC and it is difficult to dissect in such situation; right renal artery is identified between aorta and IVC, as after its origin it runs behind the IVC to reach the right kidney and is ligated and divided at this juncture.

Tumour thrombus may extend across the renal vein into the IVC. If such thrombus is of short length in the IVC then after applying oblique Satinsky vascular clamps IVC is opened vertically to remove all tumour thrombus, and later venotomy in the IVC is sutured using

3 zero polypropylene continuous suture. If thrombus extends still more proximally extensively then veno cardiac bypass has to be done to achieve complete clearance of the tumour thrombus.

Often tear can occur in the IVC causing torrential haemorrhage (*Pack; Patience; Plan; Proceed* whenever there is bleed); tear should be occluded with thumb and Satinsky clamp should be applied obliquely and IVC is sutured with continuous 4 zero polypropylene sutures.

Left Side Kidney Dissection

Approach is left loin posterior one. All layers are opened to reach the kidney. Peritoneum is usually not breached. Descending colon and splenic flexure is separated by dividing splenocolic ligament and mobilised fully medially to expose the entire left side Gerota's fascia and also left renal pedicle. This also requires dividing the lienorenal ligament. Renal pedicle is dissected; renal vein is in front of the renal artery. Renal vein is carefully dissected and kept aside. Often initially there will be more than one tributaries of the renal vein, in such situation each is isolated and kept aside. By palpating with the finger for pulsation, left renal artery is identified, dissected and doubly ligated. Clips, haemoclips, vascular staplers can be used. Left adrenal vein joins the left renal vein vertically from above; it often needs ligation otherwise torrential haemorrhage can occur. Left inferior phrenic vein joins left adrenal vein which is also should be taken care off. Tail of the pancreas and splenic vein are very close to the upper part of the left kidney and its hilum; they are in front of the kidney. Care should be taken not to injure them which are separated by gentle finger dissection. Once left kidney is dissected fully medially with proper vascular control then only lateral dissection should be done in carcinoma kidney. In benign conditions like pyeloplasty pedicle dissection is not needed; Gerota's fascia is opened to reach the kidney and renal pelvis.

Different types of nephrectomies

Nephroureterectomy – It is done in transitional cell carcinoma of kidney pelvis wherein entire kidney with Gerota's fascia is removed along with entire length of the ureter up to the ureteric orifice.

Nephrectomy – It is done in benign conditions with kidney not functioning – non functioning hydronephrotic kidney (DTPA scan shows function less than 20%).

Radical nephrectomy – It is removing the entire kidney, Gerota's fascia, fat, adrenal gland, lymph nodes, and entire ureter. Presently adrenal gland is removed only if it is invaded by RCC. Lymph node clearance is done only if imaging shows lymph nodes or on table lymph nodes are found.

Subcapsular nephrectomy – It is done in nonfunctioning benign/infective kidney like pyonephrosis wherein kidney is removed at subcapsular plane. As dissection outside capsule is impossible due to dense inflammatory adhesions; if attempted likely to injure the major vessels like IVC to land in disaster.

Heminephrectomy – It is done in duplex kidney wherein one part is totally separate from other anatomically and functionally even though they are covered by a single capsule. Non functioning part is removed after pedicle dissection to identify the specific vessels of that particular part/moiety; those vessels are ligated securely. Dissection through the parenchyma after vascular ligation is very easy as plane is entirely avascular.

Nephron sparing nephrectomy – It is becoming more popular and acceptable method of treatment to surface RCC which is small and well localised wherein kidney is salvaged. Only diseased part with clearance margin is removed and frozen section biopsy is done to confirm the clearance.

Partial nephrectomy – It is removal of one of the poles of the kidney retaining the other pole. It is done when disease is limited to that particular pole only.

Donor nephrectomy – It is done in renal transplantation. Usually left kidney is used as left renal vein is longer.

APPROACHES TO URETER

Oblique Iliac Incision (Abbernethy's/Modified Gibson's)

It is used for *extraperitoneal approach* for ureteric stone, urinary bladder, lumbar sympathectomy. It is muscle cutting incision. It can be used as transperitoneal also.

Position is partial or complete lateral one depending on the side the surgery is needed. Incision is placed from mid-axillary line at the level of the umbilicus directing downwards and forwards towards pubic symphysis up to the lateral margin of the rectus muscle. Skin, subcutaneous fat, superficial fascia, external oblique muscle and aponeurosis below are incised layer by layer in the line of incision. Internal oblique and transverse abdominis muscles are also cut in the line of incision. Under transversalis fascia extraperitoneal fat and peritoneum is visualized. In extraperitoneal approach, peritoneum is swept forward from behind by blunt finger dissection. Psoas major muscle, genitofemoral nerve and inferior vena cava are identified. Ureter with its typical look and peristalsis (*vermiculations*) is also identified. Depending on the type of surgery further procedure is undertaken. Muscle is retracted using self retaining retractor. Peritoneum if inadvertently opened, it can be sutured using 2 zero vicryl **(Fig. 27-17)**.

Paramedian extraperitoneal approach also can be used.

Transperitoneal approach is used when additional abdominal procedures are also warranted.

Laparoscopic and retroperitoneoscopic approaches are good other alternatives.

TREATMENT OF RENAL TUBERCULOSIS

Antitubercular therapy is started. INH, rifampicin, ethambutol and pyrazinamide. Duration of treatment is *one year* **(Fig. 27-18)**.

Surgeries

After 6-12 weeks of drug therapy, surgical treatment is planned. Kidney is exposed. Pyocalyx is drained. Cut edge of the capsule is sutured—*Hanley's renal cavernostomy.*

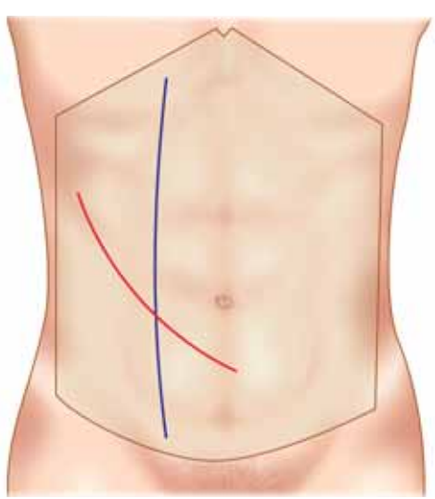


Fig. 27-17: Oblique iliac incision (Modified Gibson's).

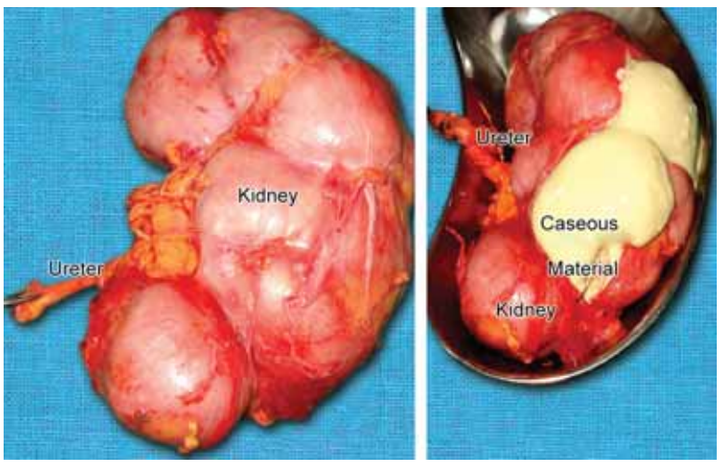


Fig. 27-18: Renal tuberculosis.

Hydronephrosis—*Anderson Hynes* operation or nephrostomy or stenting ("J" stent) of ureter is done.

Renal tuberculous abscess not resolving for 2 weeks should be drained.

Ureteral stricture—stenting/reimplantation of the ureter into the bladder/psoas hitch/Boari's flap/ileal conduit (*Koch's ileal conduit*).

Thimble bladder—hydraulic dilatation/ileocystoplasty/caecocystoplasty/sigmoid colocystoplasty is done.

In unilateral lesion, with gross impairment of renal function—*nephroureterectomy* is done. Indications for nephroureterectomy are - Nonfunctioning kidney; disease extensively involving the kidney; disease causing hypertension and severe obstruction; tuberculous pyonephrosis; coexisting renal cell carcinoma.

TREATMENT FOR HYDRONEPHROSIS

Always conservative surgeries which are aimed at conserving the kidneys are done. Nephrectomy is not done unless indicated **(Figs 27-19 to 27-21)**.

The cause is treated: Stone, congenital anomaly, aberrant renal vessels, stricture urethra (dilatation, urethrotomy, urethroplasty); phimosis (circumcision); BPH (TURP); posterior urethral valve (cystoscopic fulguration of valve).

Pyeloplasty may be dismembered or nondismembered; open or laparoscopic approach. In bilateral cases side which is functioning well should be operated first; after 6 weeks opposite side is operated.

Anderson-Hyne's Operation (Dismembered Pyeloplasty)

This procedure was first done in 1847 for retrocaval ureter. In congenital PUJ obstruction, the spasmodic segment and redundant pelvis are excised. A new pelvis is created and the cut end of pelvis is anastomosed to the ureter in the *dependent* position. Vascular, funnel shaped, dependent, tension free anastomosis should be done. Open approach is usually through loin in lateral position. Once peritoneum is pushed medially; colon is also pushed medially adequately. Ureter in the middle is identified; stent if present in the ureter will guide the identification easier; otherwise it can be identified by its look, peristalsis, location. Peristalsis can be elicited on it. Ureter is dissected and slinged. Proximally dissection is continued towards renal pelvis. PUJ with pelvis and lower pole kidney is identified and dissected properly. Small bleeders in the junction are cauterized using bipolar

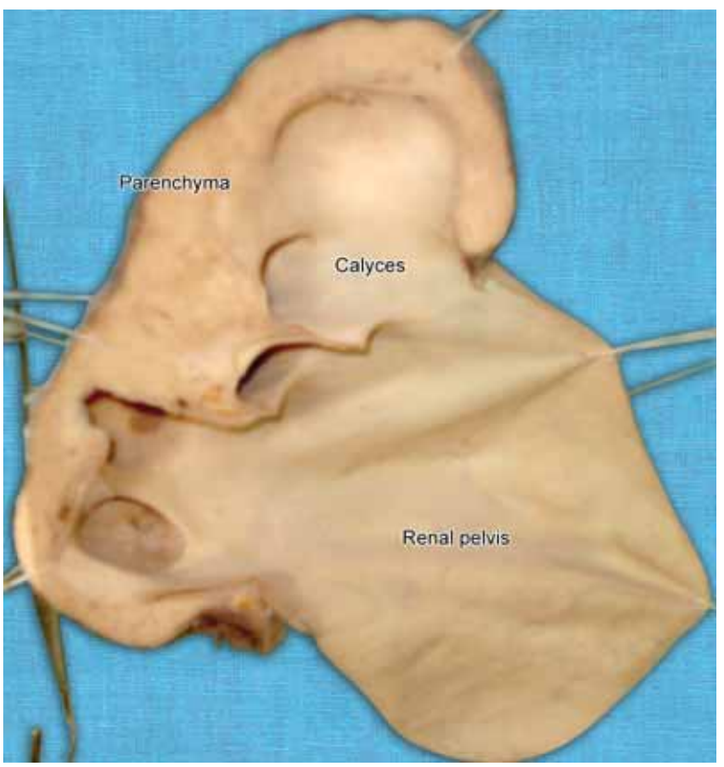


Fig. 27-19: Specimen of kidney showing hydronephrosis.

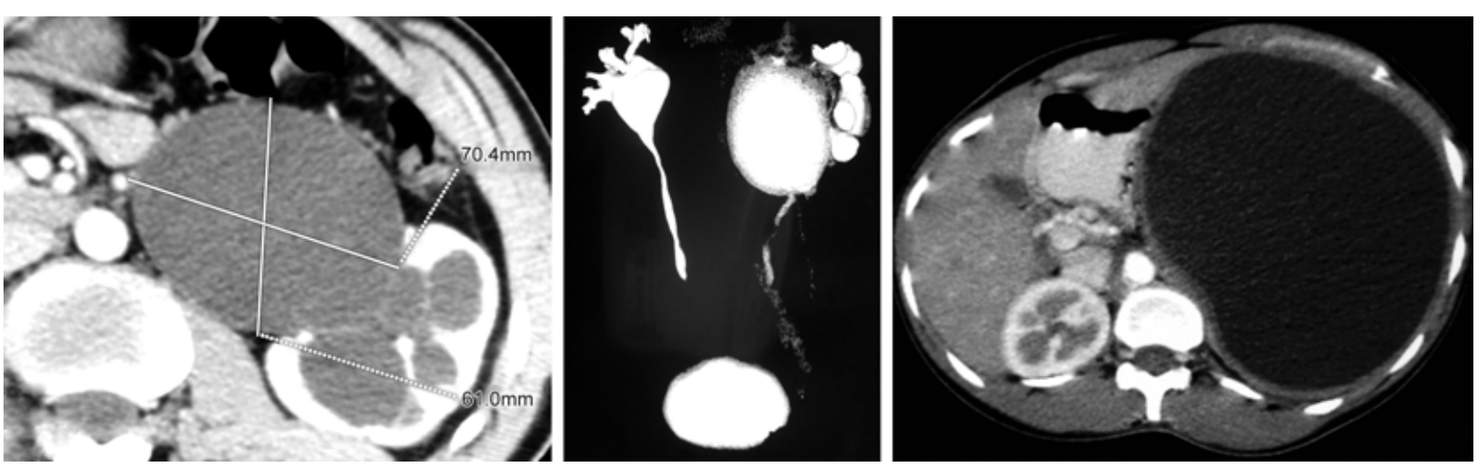


Fig. 27-20: CT scan showing unilateral and bilateral hydronephrosis in differant patients.

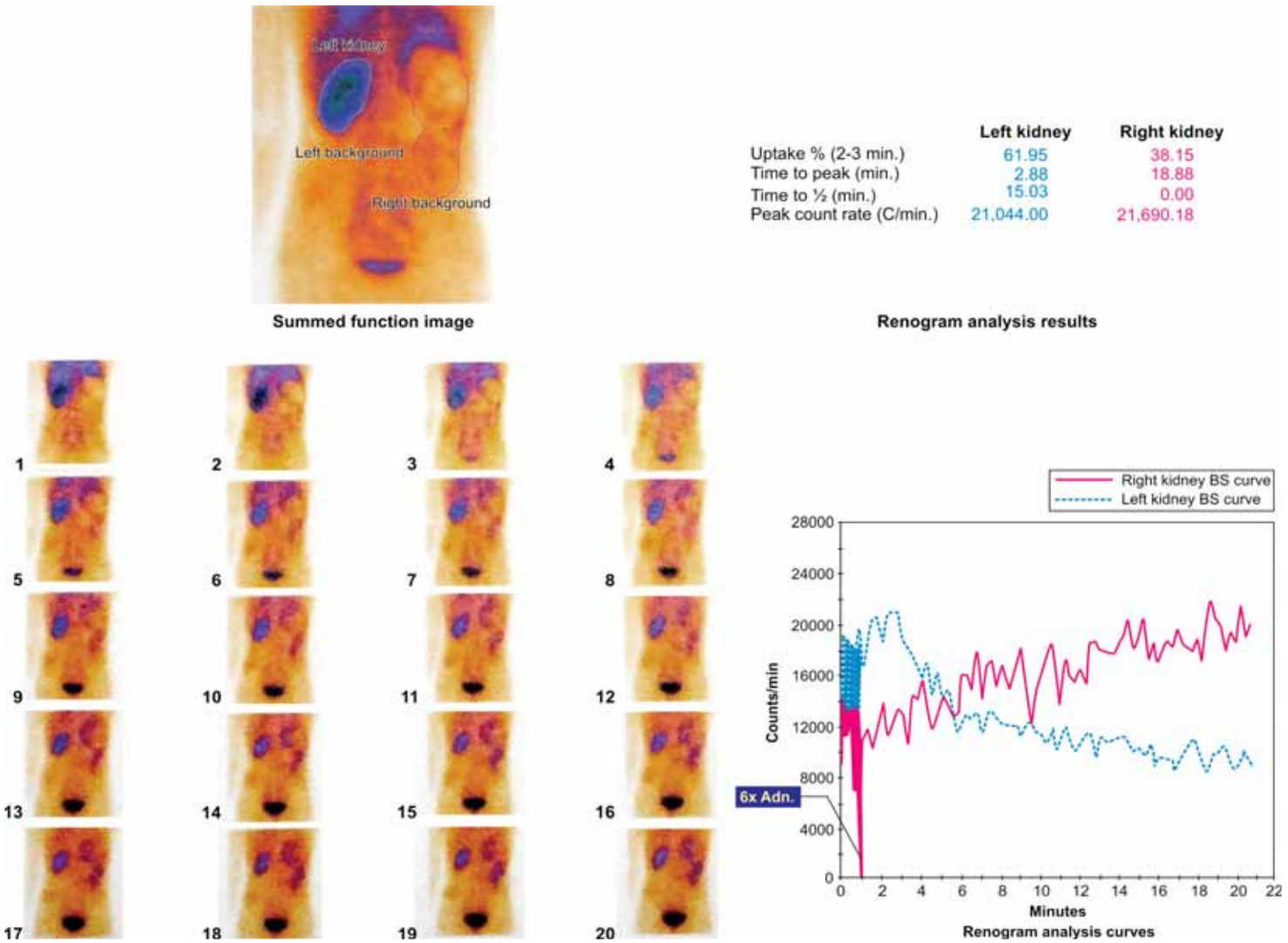


Fig. 27-21: Isotope scan showing hydronephrosis on the right side.

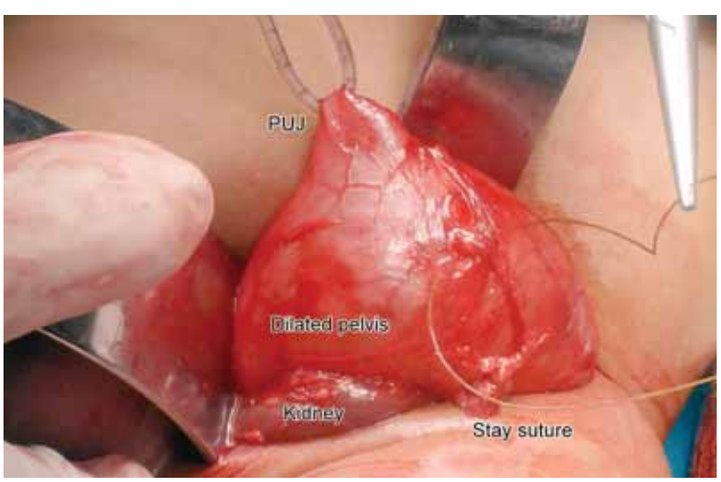


Fig. 27-22: Stay sutures placed for pyeloplasty.

cautery. Stay sutures are placed one at the upper part of the pelvis laterally; another at lateral lower part of the pelvis medially; one more at the upper end of the ureter **(Fig. 27-22)**.

Pelvis which is redundant is excised within the stay suture area including the diseased PUJ. Specimen is sent for histology. Fish mouth

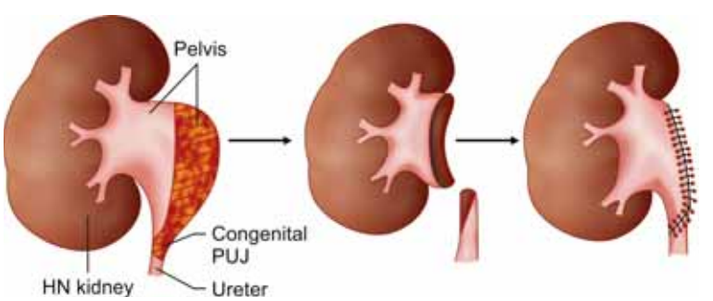
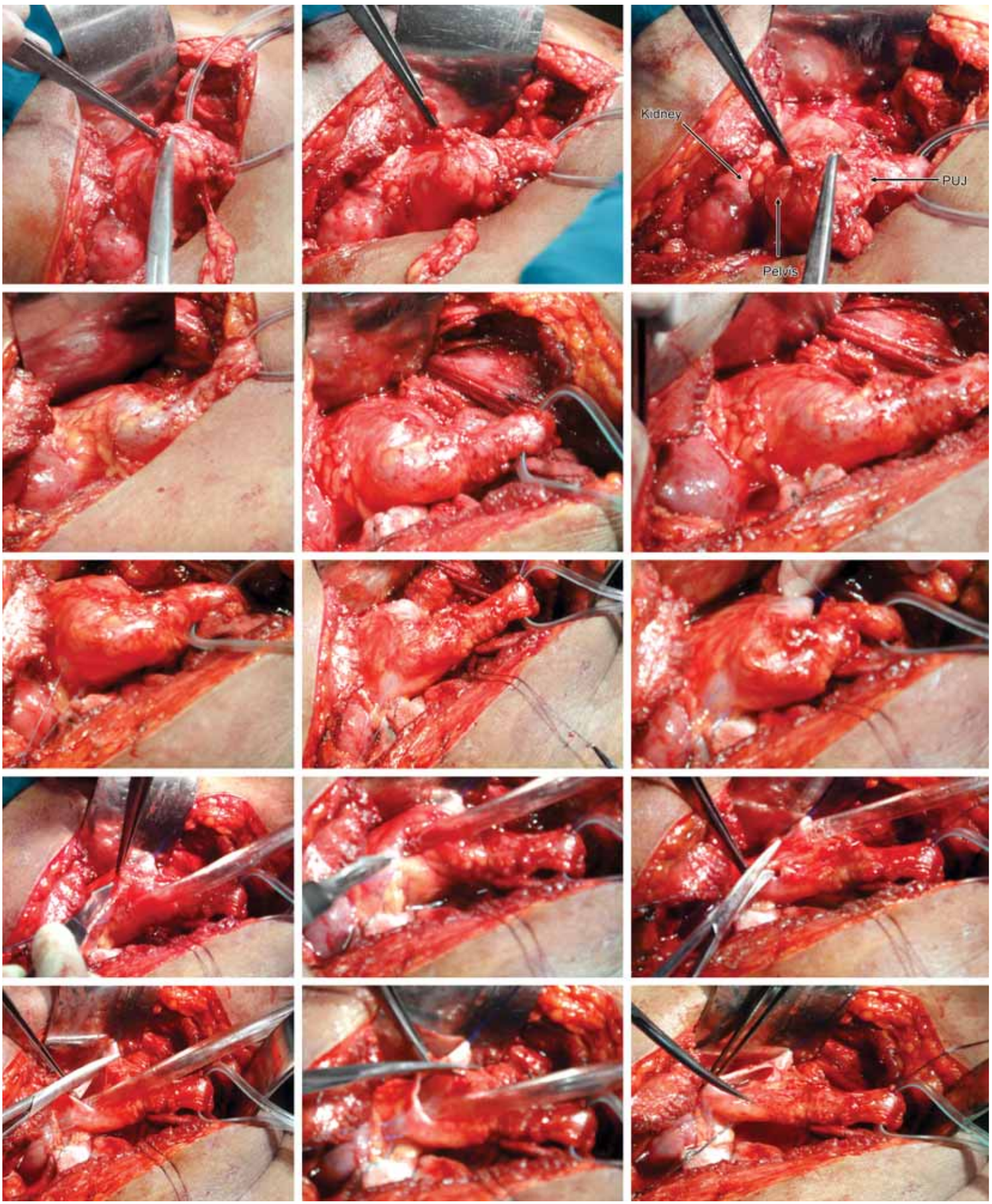
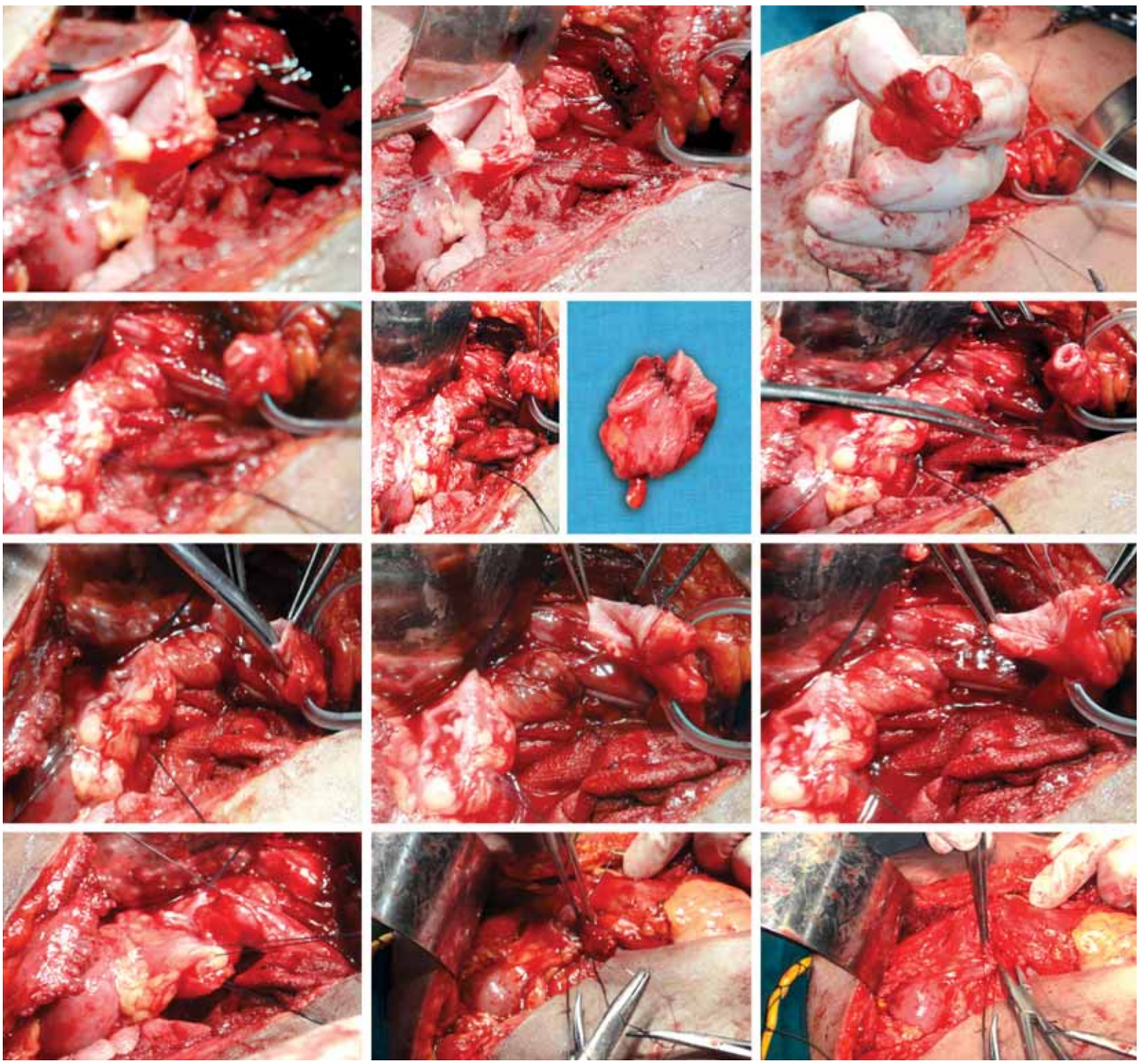


Fig. 27-23: Principles of Anderson-Hyne's operation. Excision of PUJ and redundant pelvis; anastomosis of the ureter with vascularised, tension free, funnel-shaped, dependent stoma.

cut is given to the ureter. Lower angle of the ureter is sutured to the lower angle of the cut end of the pelvis. J stent is passed across the ureter and pelvis. Further sutures are placed either continuous or interrupted using 3 zero vicryl sutures to complete the anastomosis. Further left open cut end of the renal pelvis is sutured. Anastomosis should be tension free, dependent. Adequate mobilisation of the lower ureter is often required. Tube drain is placed; wound is closed in layers. Drain is removed in 7 days; J stent is removed in 3-6 weeks **(Figs 27-23 and 24)**.



Figs 27-24(1)



Figs 27-24(2)

Figs 27-24(1 and 2): Anderson-Hyne's operation—pyeloplasty in an adult.

Complications are – urine leak; infection; inadequate functioning of the kidney; stricture formation at anastomotic site **(Fig. 27-25)**.

Non-dismembered pyeloplasties: Here PUJ is not transected. Reconstruction is done without PUJ transection by different methods, e.g. Foley's Y-V plasty.

Davis T-tube ureterostomy: Placement of T tube in the ureter by making longitudinal incision.

In bilateral HN, without renal failure, *kidney which is functioning better should be operated first.* Three months later, otherside kidney is dealt with. In bilateral HN with renal failure, *bilateral nephrostomy and haemodialysis* support is required initially. After 3-6 weeks IVU is done and the functions of both kidneys are looked for. If they function, then are treated accordingly by Anderson-Hyne's operation. *If kidneys are still not functioning (renal function <20% on isotope study) then nephrectomy and renal transplantation* is the only option left.

Laparoscopic or *retroperitoneoscopic pyeloplasty* is becoming popular but is expensive and time consuming. It gives good result as well **(Fig. 27-26)**.

Endoscopic pyelolysis, even though technically easier results are not assured.

Aberrant renal artery or *vein* in the lower pole of kidney can compress the PUJ causing HN. Renal angiogram confirms the diagnosis. *Treatment of aberrant renal vessels*—If it is a vein it can be ligated safely. But if it is an artery, it exclusively supplies the lower pole

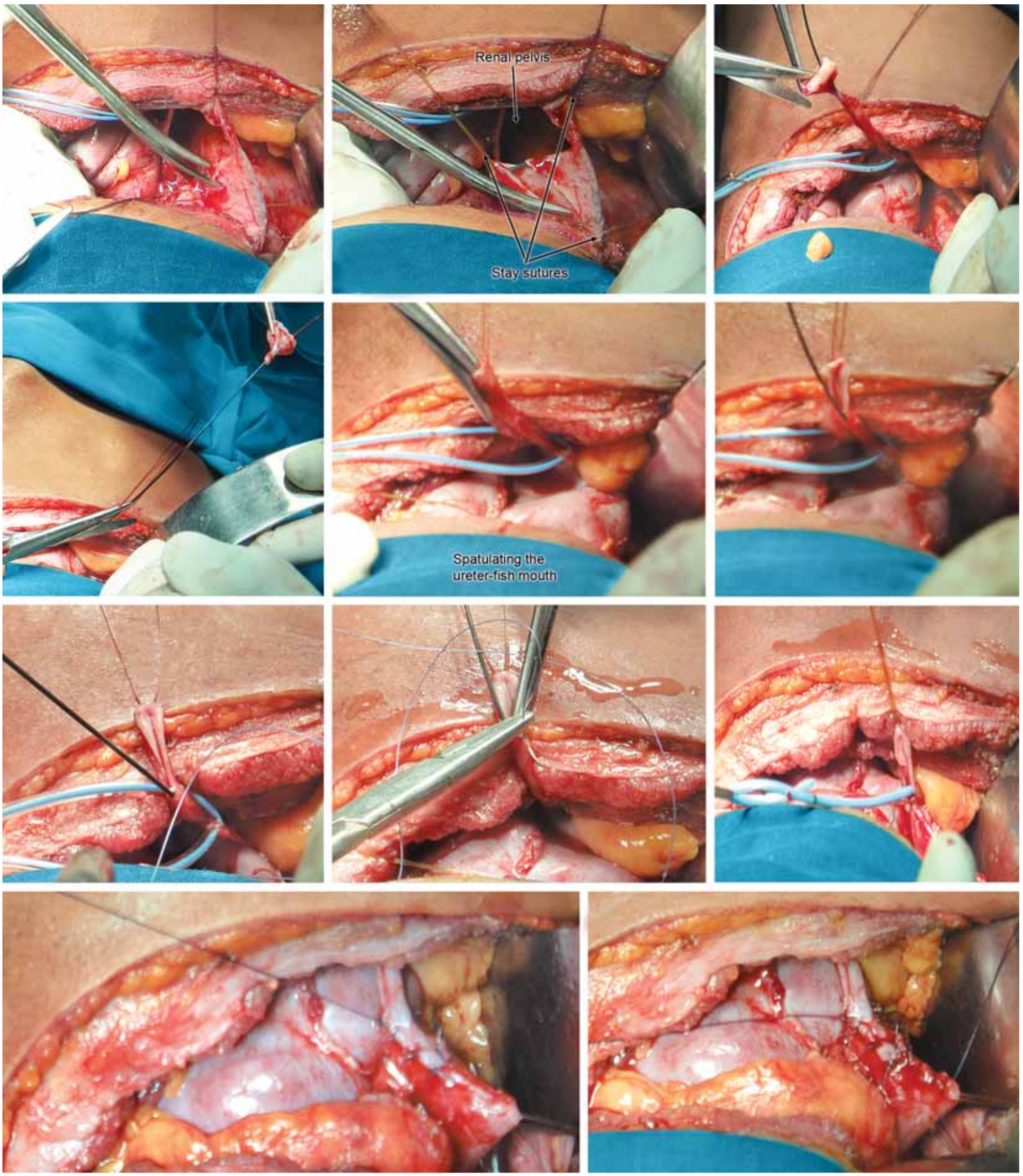
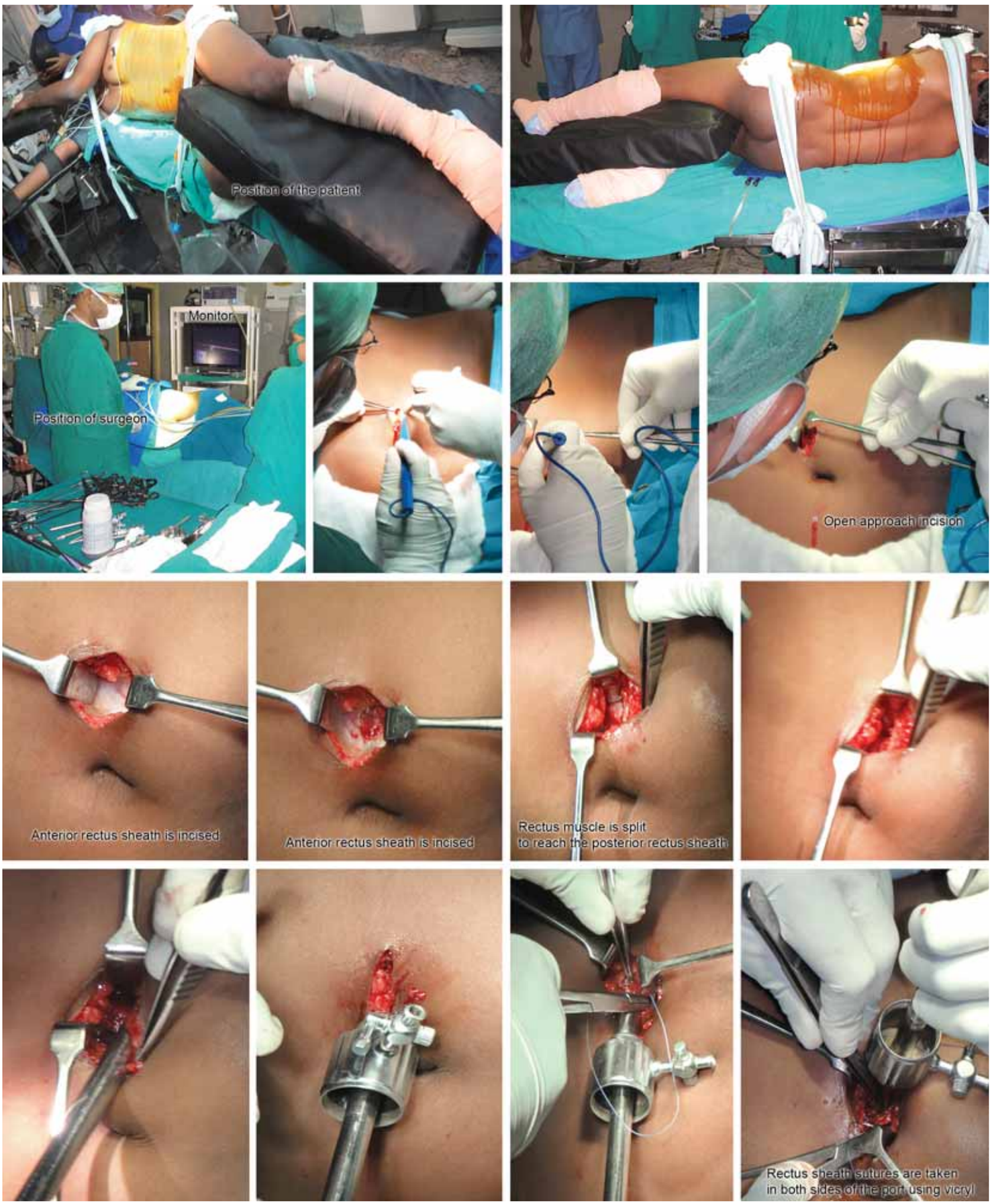
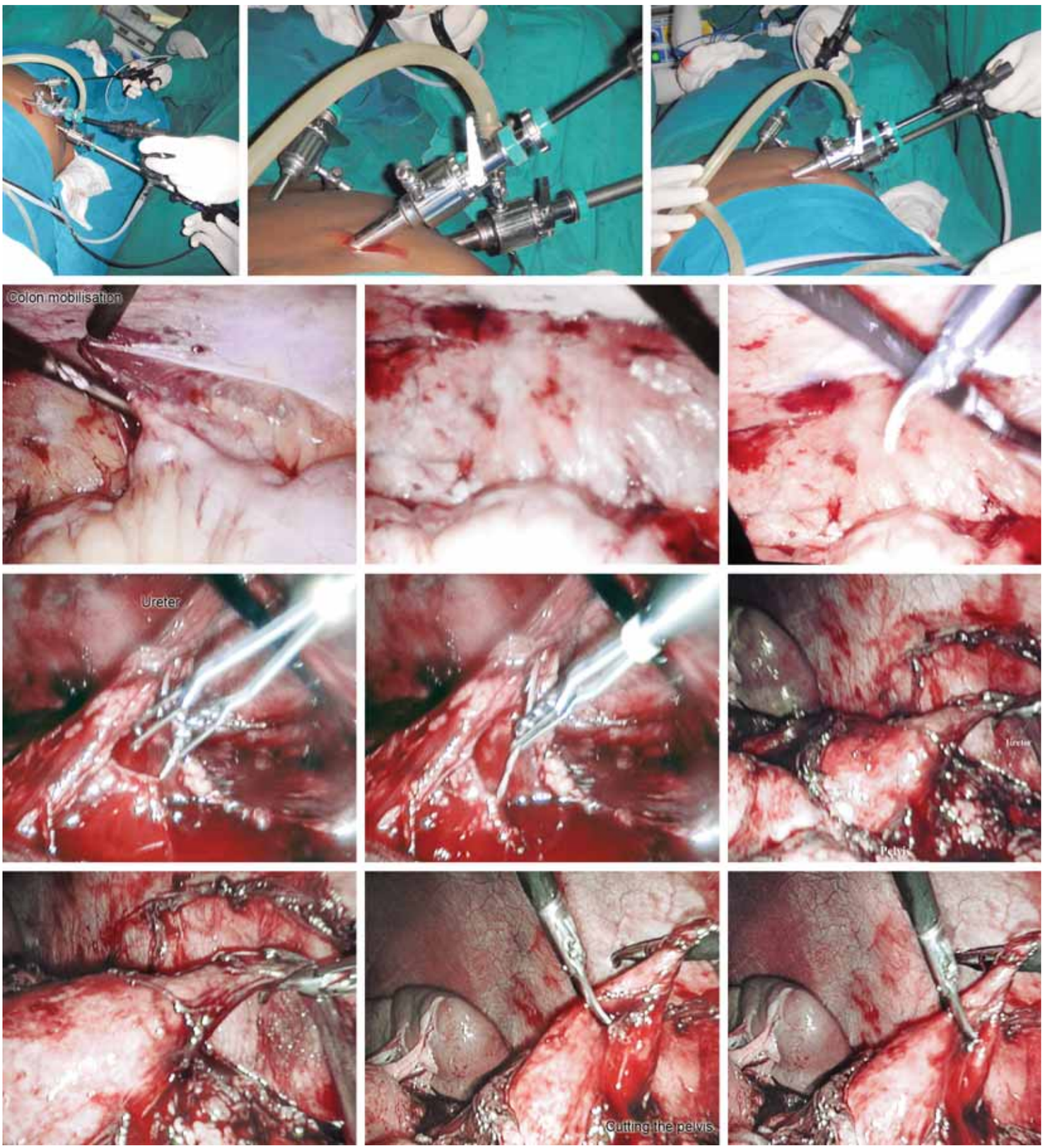


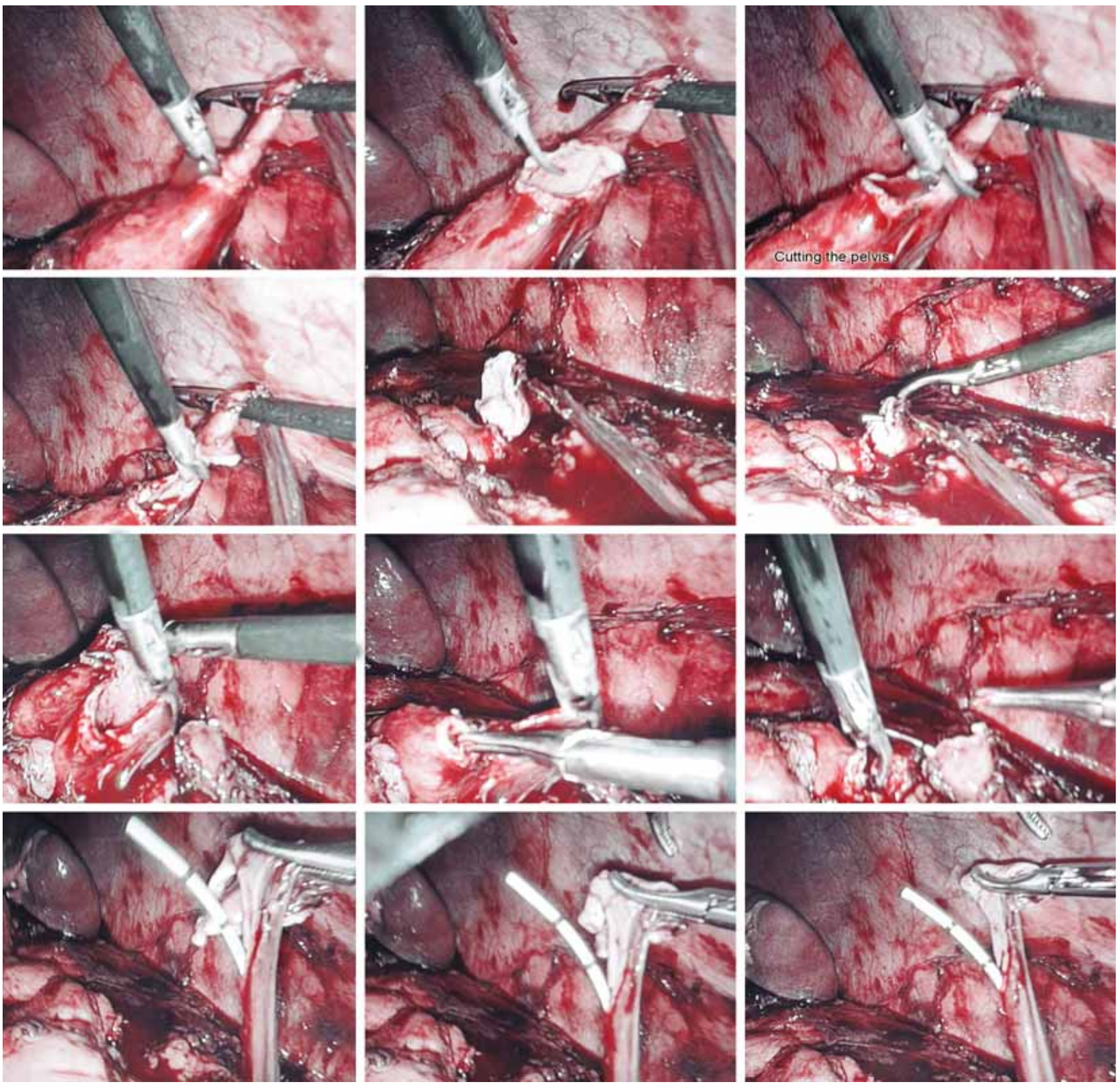
Fig. 27-25: Anderson-Hyne's operation – pyeloplasty in a child.


Position of the patient
Monitor
Position of surgeon
Open approach incision
Anterior rectus sheath is incised
Anterior rectus sheath is incised
Rectus muscle is split
to reach the posterior rectus sheath
Rectus sheath sutures are taken
in both sides of the port using vicryl

Figs 27-26(1)



Figs 27-26(2)



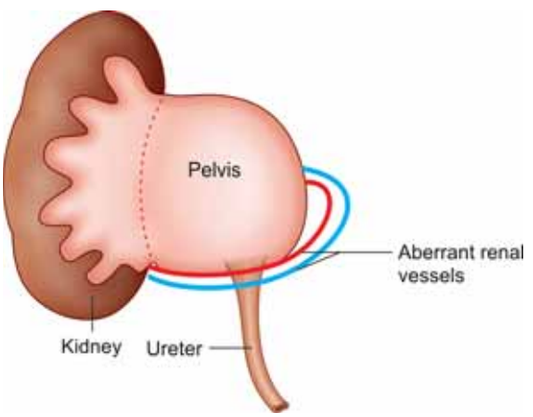
Figs 27-26(2)

Figs 27-26(1 and 2): Laparoscopic pyeloplasty is standard now. Initially cystoscopy is done to pass a ureteric catheter or J stent. Loin position (lateral) is used. Camera port is at the level of the umbilicus through the rectus muscle. Horizontal 1.5 cm incision is made; anterior rectus sheath is incised horizontally; rectus muscle is split; posterior rectus sheath and peritoneum is opened. 10 mm port is passed; two vicryl sutures on two diagonally opposite sides of posterior rectus sheath is taken and kept long for tying at the end of the procedure. Pneumoperitoneum is created. One 10 mm and another 5 mm ports on either side and laterally are passed under vision as working ports. Additional 5 mm working port can be added if need arises. Lateral paracolic gutter is incised along the Toldt's line; colon is mobilised fully medially from the Gerota's fascia; i.e. right side hepatic flexure and left side splenic flexure. Ureter is identified; gonadal vein is crossing the ureter on right side; on left side gonadal vein lies adjacent to ureter on its medial aspects without crossing it. Ureter is identified by its tubular nature, colour, peristalsis, vascular network. IVC is identified on the right side. Ureter is dissected upwards towards the renal pelvis which is mobilised all around. PUJ is identified and dissected. Renal pelvis is incised and cut in V-shaped manner. PUJ is also excised along with that. Spatulation of ureter (fish mouth) is done on its lateral side from its cut end using scissor. J stent is passed if not passed earlier; it is pushed towards the renal pelvis. Bite with 3 zero vicryl is taken from its apex of the spatulation from outside to inside then it is passed to the lower cut end of the pelvis from inside to outside. Knot is placed outside. One should not place knots inside in the urothelium anywhere. Continuous sutures are taken, first posterior layer is done between ureteric cut part and pelvis cut part; Once posterior layer is finished knot is tied. Using new 3 zero vicryl anterior layer sutures are taken similarly. Proximal part of the renal pelvis is again separately sutured and closed. Secure dependent vascular funnel-shaped tension free anastomosis is achieved. Tube drain is placed; port sites are closed.

of the kidney and so cannot be ligated. So kidney is mobilised; upper and lower poles are approximated together so that artery is made to slip away from the site of compression—*Hamilton Stewart operation*. Nowadays this operation is not done. Vessels are dissected carefully and kept aside (preserved) and PUJ is transected and anastomosed in front of the vessels **(Fig. 27-27)**.

TREATMENT OF PYONEPHROSIS

After starting antibiotics, pus is immediately drained from the kidney through a loin incision and *nephrostomy* tube (Cabot's nephrostomy) (Malecot's catheter) is placed. If kidney is totally destroyed, *subcapsular nephrectomy* is done. This also prevents other kidney from getting infected through perirenal lymphatic connections. Approach is though loin. Adhesions are common. It is often difficult to identify the major vessels and renal pedicle. Injury to renal vein, IVC is known to occur. Often mass clamping at the pedicle with transfixation ligatures using polypropylene sutures are better rather than individually identifying and ligation the vessels. If IVC tear is suspected the incision is extended, peritoneum is opened; duodenum and posterior abdominal wall is dissected to identify the IVC completely. Tear is identified with placement of vascular clamps. Tear is sutured. In bilateral pyonephrosis, *bilateral nephrostomy* is the only choice. *'J' stenting* is done often to keep the ureters patent.



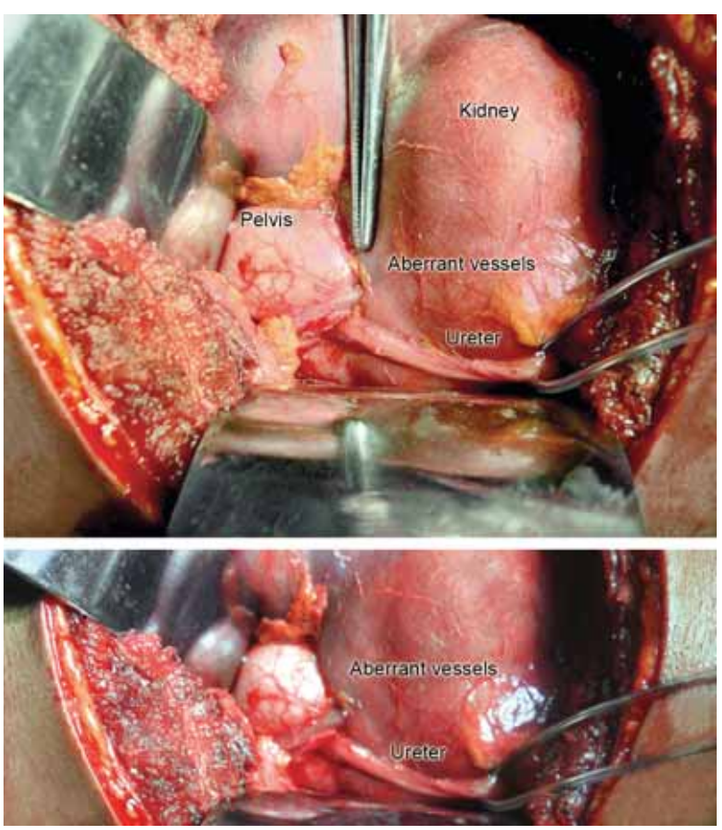


Fig. 27-27: Aberrant renal vessels.

TREATMENT OF RENAL STONES

PCNL (Percutaneous Nephrolithotomy)

Indications are - Stones more than 2.5 cm in size; multiple stones; Stones not responding for ESWL.

Procedure: Initially cystoscopy is done and ureteric stent/catheter is placed and renal pelvicalyceal system is identified under C-arm guidance. Under the guidance of C-arm or U/S, needle puncture is made in the loin percutaneously. Through kidney, calyx and pelvis are approached. Guide wire is passed. Graduated dilators are passed and so track is widened. Then through that, a nephroscope is passed. After fragmentation, stone is removed using different methods [Laser (Holmium), pneumatic, ultrasonic or electrohydraulic] **(Fig. 27-28)**.

Complications of PCNL: Haemorrhage; perforation of collecting duct causing extravasation of irrigation fluid; *injury to colon or pleura* while creating initial track for nephroscope.

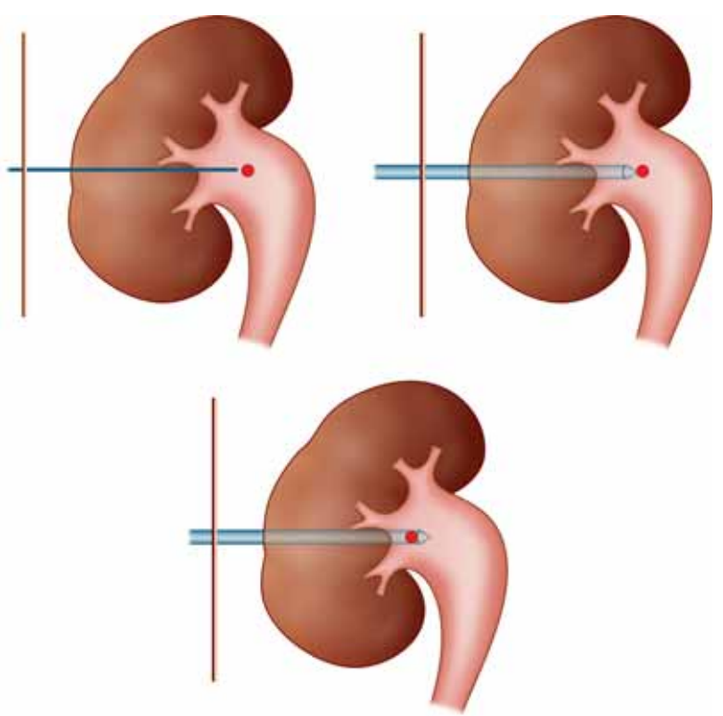


Fig. 27-28: PCNL—technique. It is commonly done procedure now for renal stone.

ESWL (Extracorporeal Shock Wave Lithotripsy) (Fig. 27-29)

Piezo-Ceramic or *Electromagnetic* shock waves are passed to the stone through water bath or water cushion which acts as a media. Shocks are produced at 2/sec. 1000-4000 shocks are required for each stone. *Dornier Lithotripter* is used for fragmenting stones. Stone is located and observed through fluoroscope (C-arm) or ultrasound. Shock waves are triggered to create *compressive waves* over the stone, to fragment it. These fragments are flushed out later.

Advantages—No anaesthesia is required. Can be done as an OP procedure, less than 2.5 cm sized stones are well fragmented, hard stones, oxalate stones are better eliminated by ESWL, ESWL can be done repeatedly in different sittings, if it is not successful one can switch over to PCNL.

Complications—Renal haematoma; Severe haematuria; injury to adjacent structures; fragmented stone retains in the ureter.

Contraindications—Pregnancy; bleeding disorders; patients with abdominal aneurysms; sepsis and renal failure (Serum creatinine more than 3 mg%).

Fig. 27-29: ESWL table and machine used for renal stones. It needs C-arm to guide the exact point of stone to be fragmented.

Surgeries (Fig. 27-30)

Pyelolithotomy: It is suitable for stones in extrarenal pelvis. By loin (posterior subcostal) incision, kidney is approached. Renal pelvis is opened, the stone is removed and the pelvis is closed using 3 zero vicryl. A drain is placed and wound is closed **(Figs 27-31 and 27-32)**.

Extended pyelolithotomy (Gil-Vernet): In case of intrarenal pelvis, incision is done on the hilum between the pelvis and kidney over the renal sinus, dissection is carried out so as to remove the stones from pelvis as well as calyces.

Nephrolithotomy: By placing incision just behind the most convex surface (Brodel's line), stone is removed.

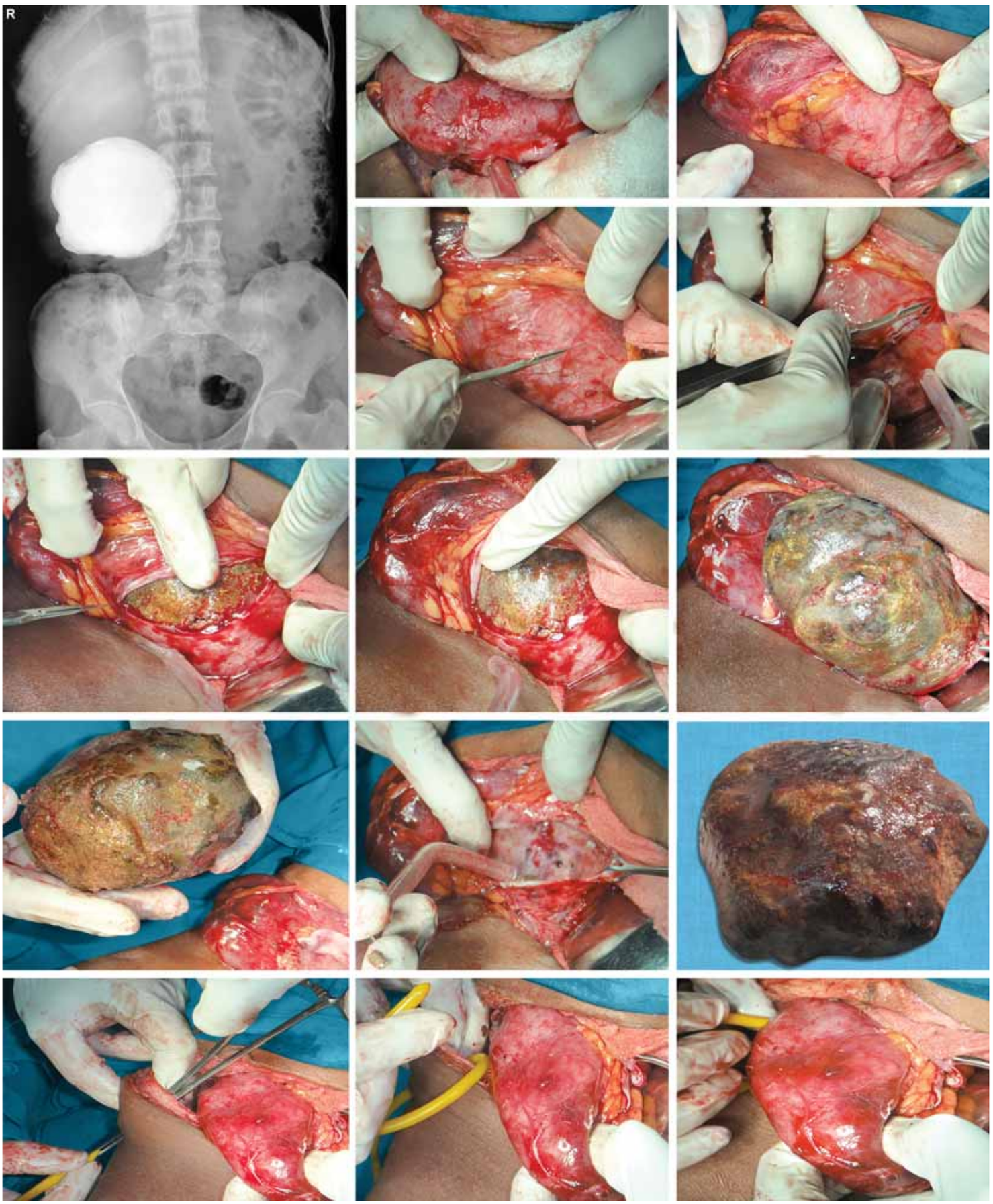
Nephropyelolithotomy: By making incisions both over the kidney and pelvis, stone/stones are removed. It is often done in *staghorn calculus* **(Fig. 27-33)**.

Partial nephrectomy: Done when there are multiple stones occupying a pole, usually lower pole of the kidney or when there is damage to the calyx, if not removed may encourage further stone formation.

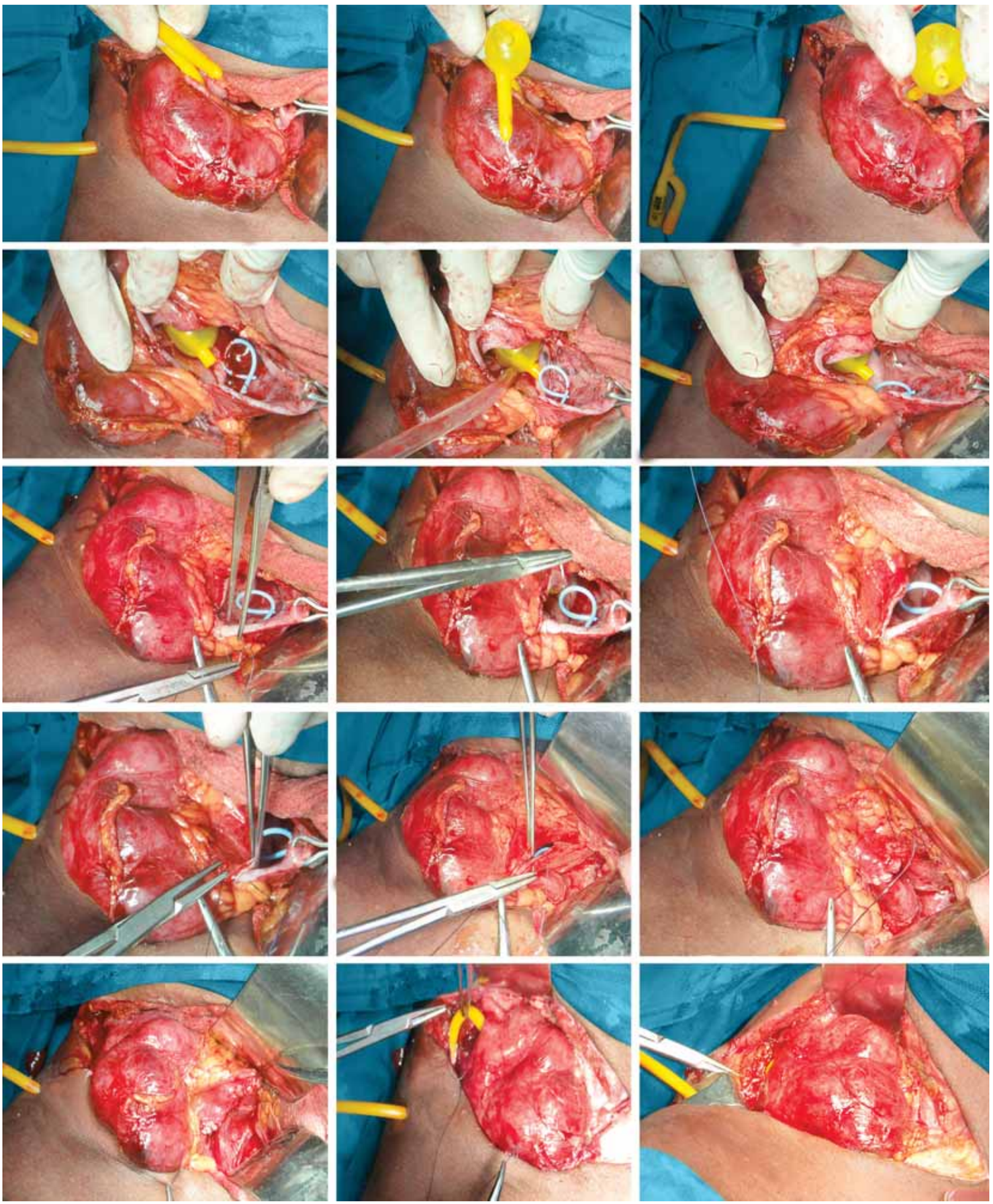
Bench surgery: Kidney is removed out temporarily, cooled by ice packs or inosine or liquid nitrogen. Stones are searched and removed completely. Later kidney is replaced in right iliac fossa.

Coagulum pyelolithotomy: Coagulum solution which contains fibrinogen is poured into the renal pelvis. It is activated so that it solidifies,

Fig. 27-30: Bilateral renal stones (large) with right ureteric stone.



Figs 27-31(1)



Figs 27-31(2)

Figs 27-31(3)

Figs 27-31(1 to 3): Very large renal pelvic stone of more than 8 cm in size weighing 610 grams. It is one of the largest renal stone extracted (*Courtesy:* Dr Ashok Pandit, MCh, Urologist, Mangala hospital, Mangalore).

meanwhile entangling the stones in renal pelvis. This entangled mass is removed en masse.

Anatrophic pyelolithotomy: After exposing the kidney, it is cooled with ice packs for 20 minutes and posterior branch of the renal artery is clamped temporarily using bull-dog clamp. The most avascular plane behind the Brodel's line is thus visualised properly. Kidney is opened through this line and stone/stones are removed (anatrophic means "to prevent atrophy") **(Fig. 27-34)**.

REMOVAL OF URETERIC STONE

Problems with ureteric stones – Obstruction, hydronephrosis; infection, impaction, ureteric stricture **(Fig. 27-35)**.

Surgical Intervention for Ureteric Stones

Indications - Size of the stone more than 5 to 8 mm. IVU showing deterioration of function. Co-existing infection. If stone is impacted in the ureter with persistent symptoms **(Fig. 27-36)**.

Upper third stone: ESWL is used for stone in upper third ureter. The stone is pushed into the renal pelvis and then PCNL is done.

URS—*Ureterorenoscopic stone removal*. Through ureteroscope, stone is visualised and often fragmented using pneumatic bombarder. It is then extracted by ureteroscope. Complications are perforation of ureter and extraperitoneal leakage of urine, bleeding. Open *ureterolithotomy is done* through loin incision **(Fig. 27-37)**.

Stone in middle third ureter: URS; open ureterolithotomy; laparoscopic stone removal.

Stone in lower third ureter: URS; *Dormia basketing* **(Fig. 27-38)**.

Indications for Dormia basketing - Stone in lower third ureter, stone below pelvic brim, stone less than 10 mm size, single stone, basket is passed into the proximal ureter beyond the stone and opened. The stone is then pulled out.

Complications of Dormia basket - Stone dislodgement, urethral injury, avulsion of ureter, stricture ureter, open ureterolithotomy.

Using cystoscope under general anaesthesia, *uretericmeatotomy* is done for stones impacted at the ureteric orifice. It is released by cutting the orifice at upper and lateral aspects.

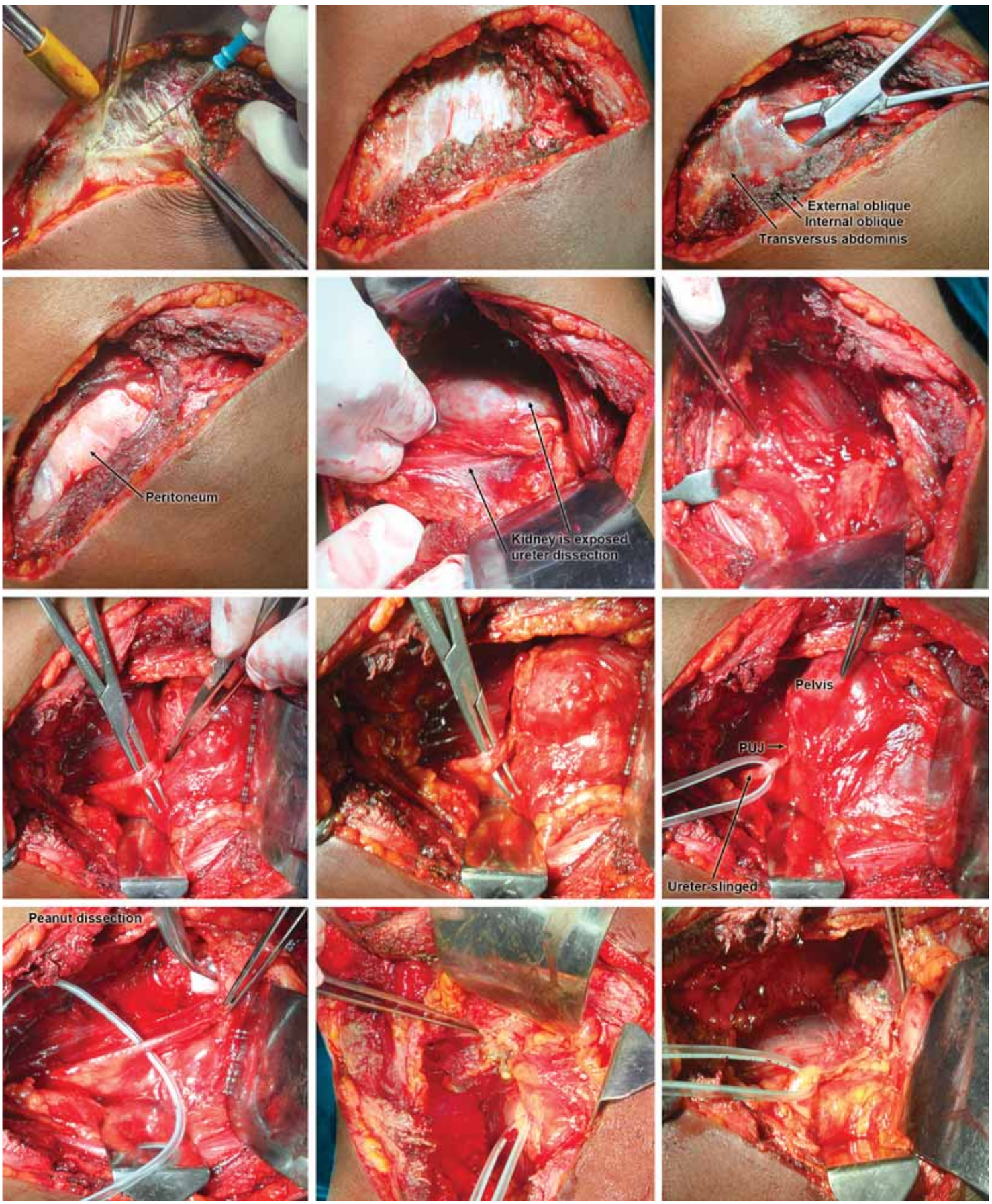
Note: All ureteric stones can also be removed through laparoscopy or retroperitoneoscopy.

Open Ureterolithotomy

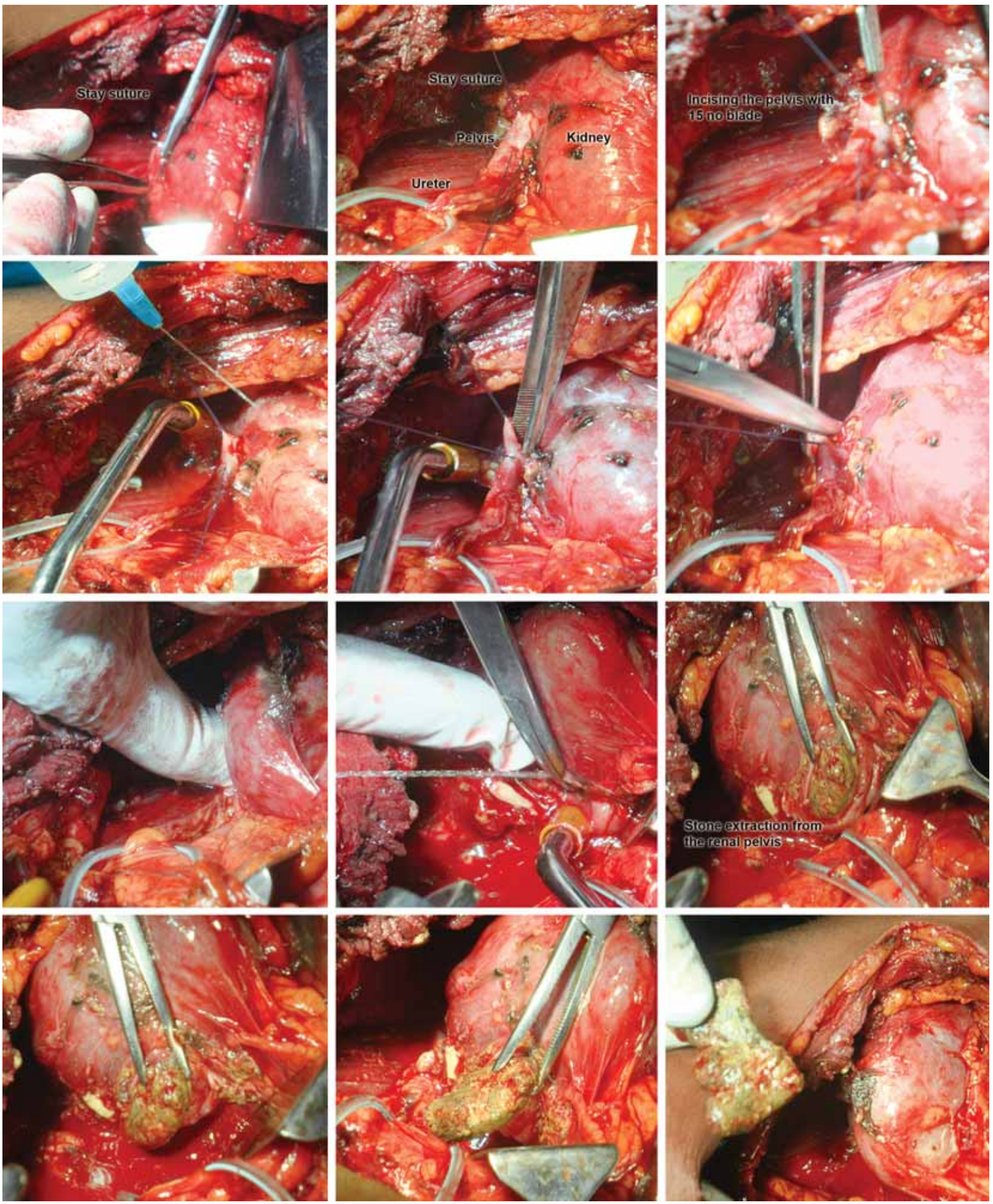
Nowadays open approach is not commonly done; however surgeon should be familiar with the technique. On the day of surgery, plain X-ray KUB should be taken to confirm the location of the stone or ultrasound should be done. Large impacted stone which is not amenable to remove by any endourology technique is removed by open method. Oblique loin incision (*Modified Gibson's*) extending down towards the hypogastric region suprapubically – is used. It is an extraperitoneal approach. Skin, superficial fascia, external oblique, internal oblique are cut in the line of incision; transversus abdominis is split from behind forward as its posterior aspect not adherent to the peritoneum compared to anterior aspect; this avoids inadvertent opening of the peritoneum. Peritoneum is swept forward and medially by blunt finger dissection and this plane is avascular. Care should be taken not to enter behind the psoas major; if it

Mayo's table
Scrub nurse
Assistant
Surgeon
Left sided kidney aproach
Incision
Latissimus dorsi
serratus posterior inferior
12th rib
Cutting the 12th rib

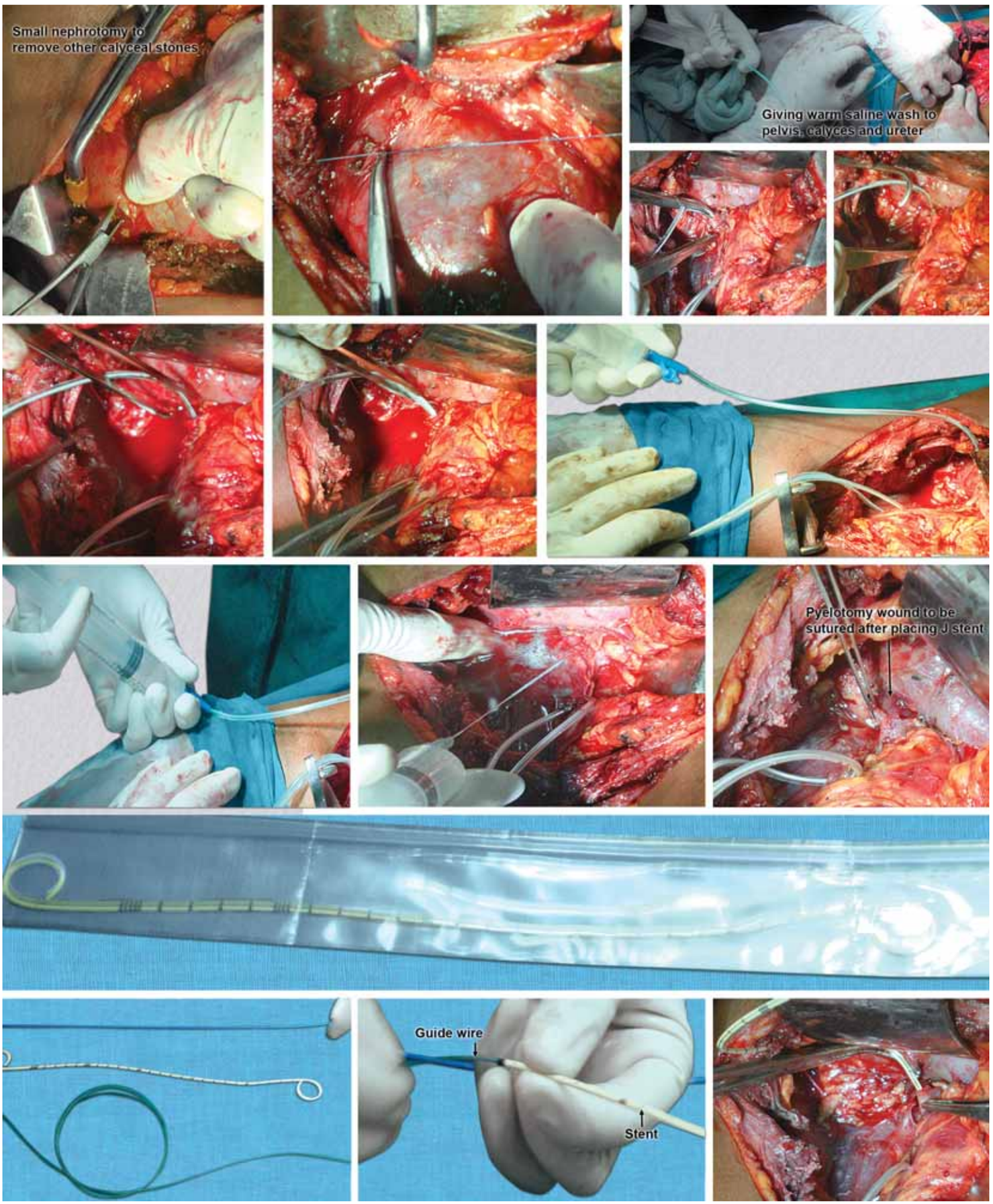
Figs 27-32(1)


External oblique
Internal oblique
Transversus abdominis
Peritoneum
Kidney is exposed
ureter dissection
Pelvis
PUJ
Ureter-slinged
Peanut dissection

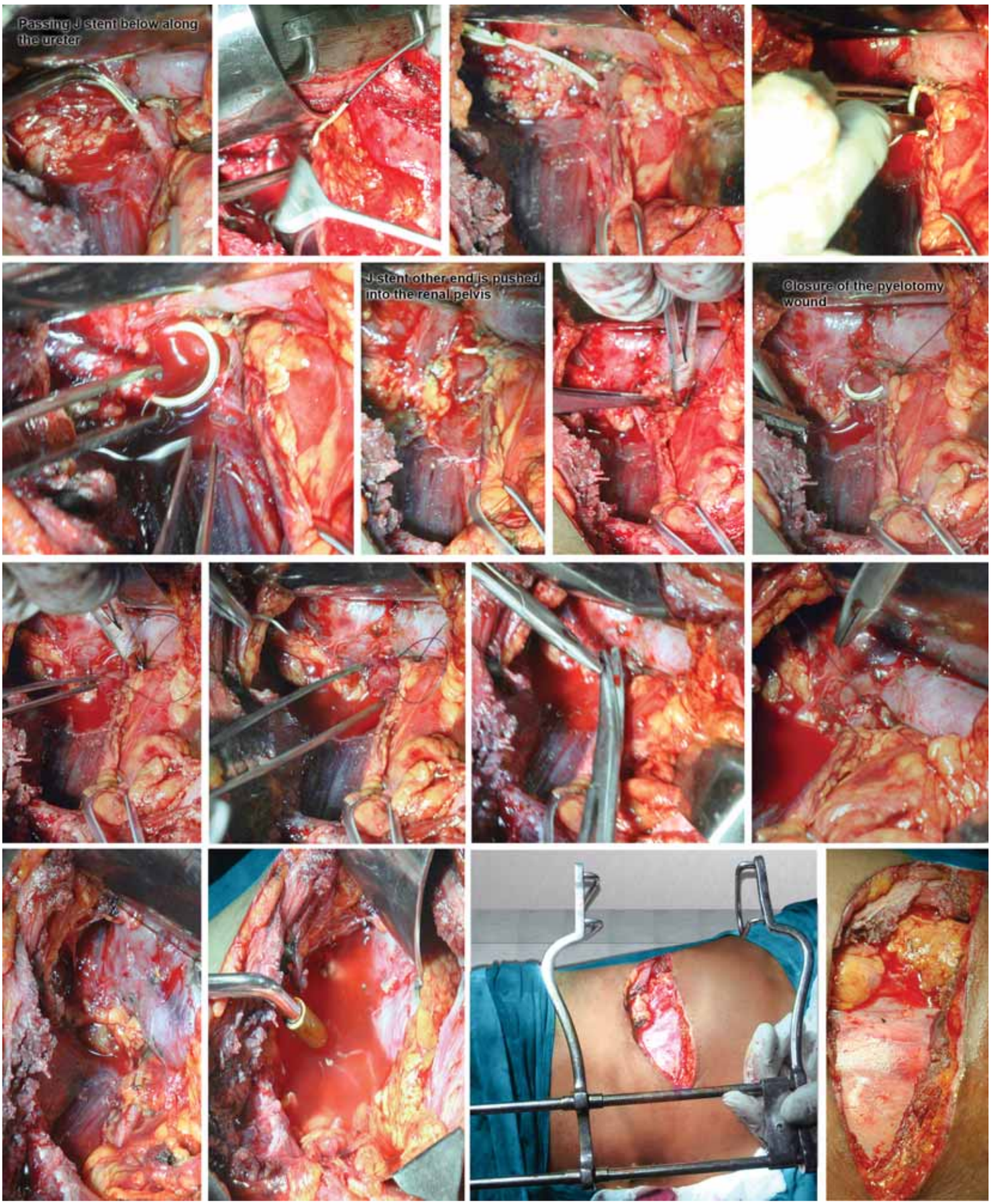
Figs 27-32(2)


Stay suture
Stay suture
Pelvis
Kidney
Ureter
Incising the pelvis with 15 no blade
Stone extraction from the renal pelvis

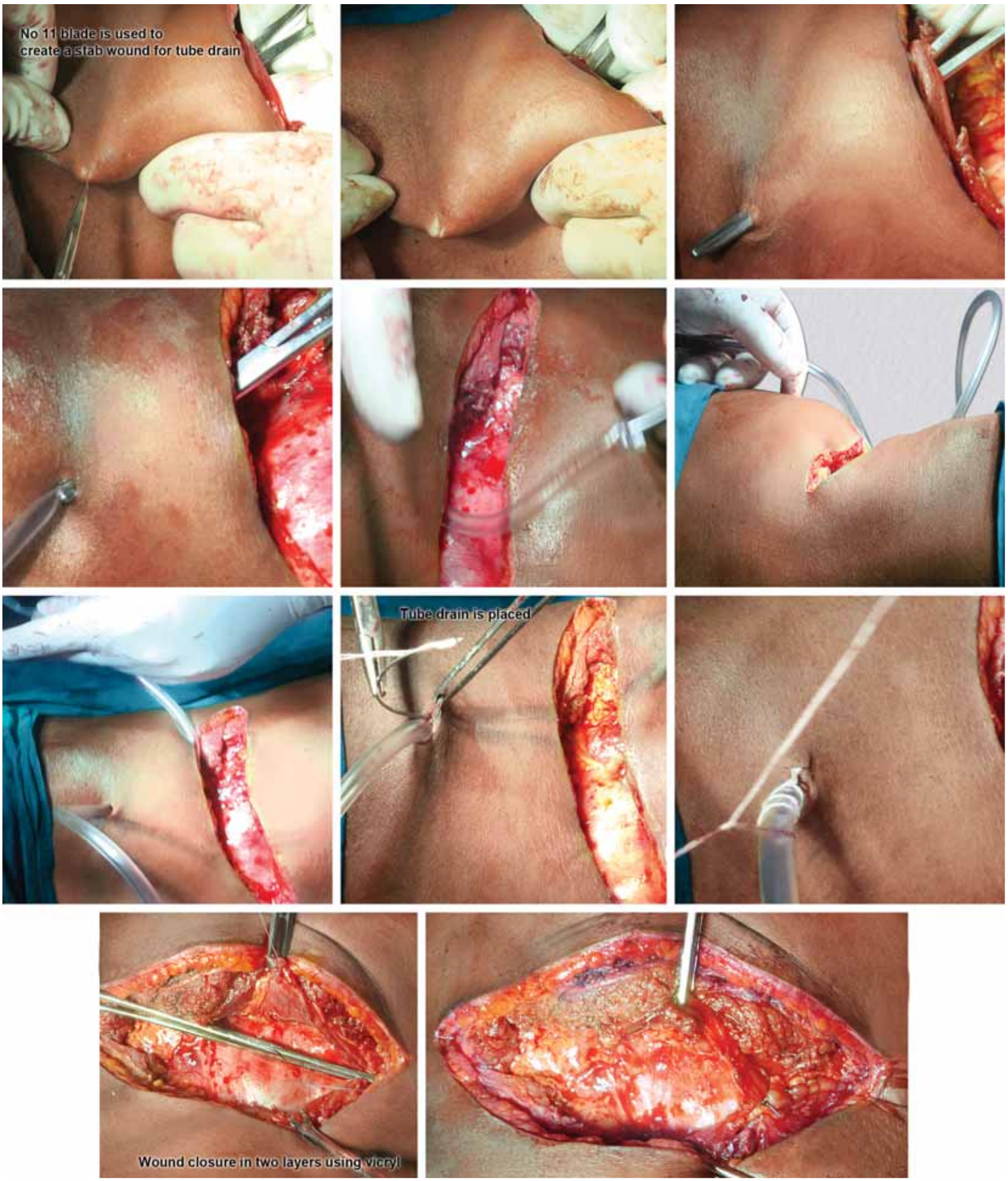
Figs 27-32(3)


Small nephrotomy to remove other calyceal stones
Giving warm saline wash to pelvis, calyces and ureter
Pyelotomy wound to be sutured after placing J stent
Guide wire
Stent

Figs 27-32(4)

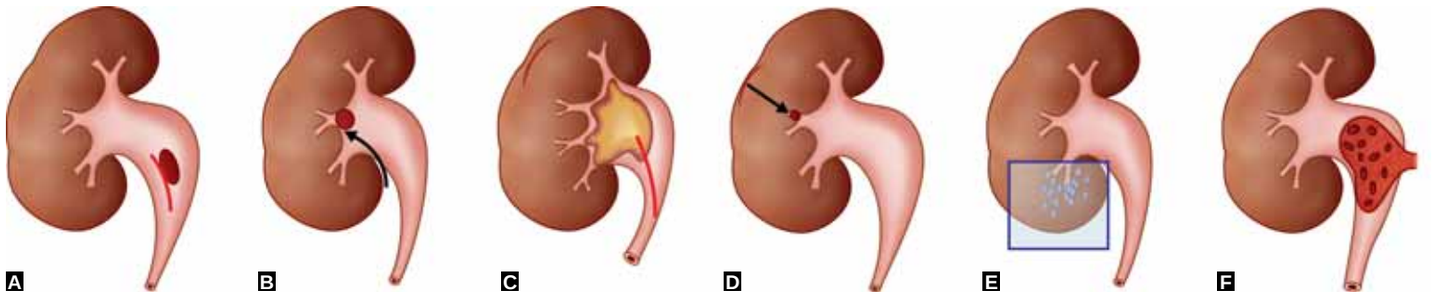

Passing J stent below along the ureter
J stent other end is pushed into the renal pelvis
Closure of the pyelotomy wound

Figs 27-32(5)

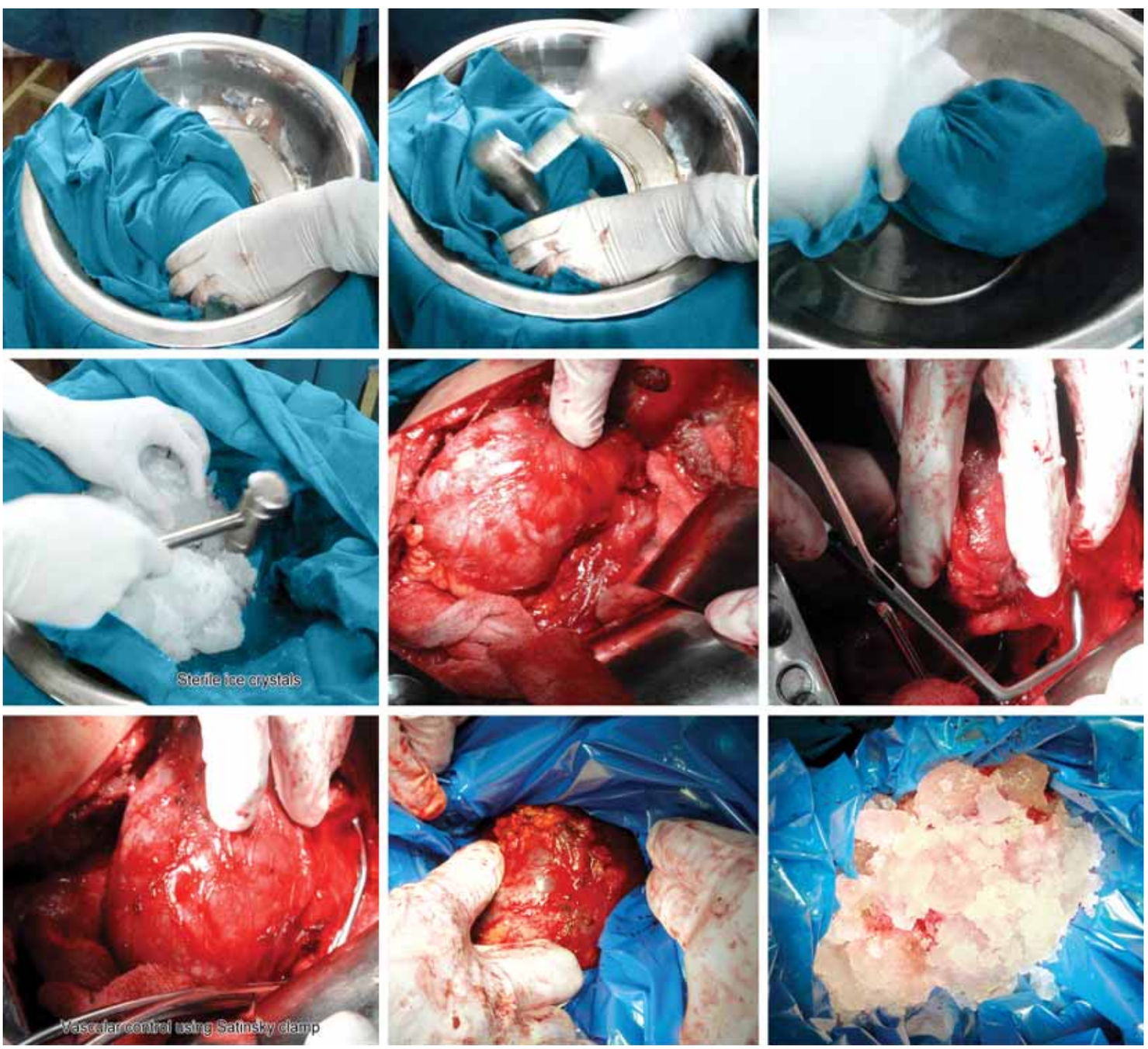


Figs 27-32(6)

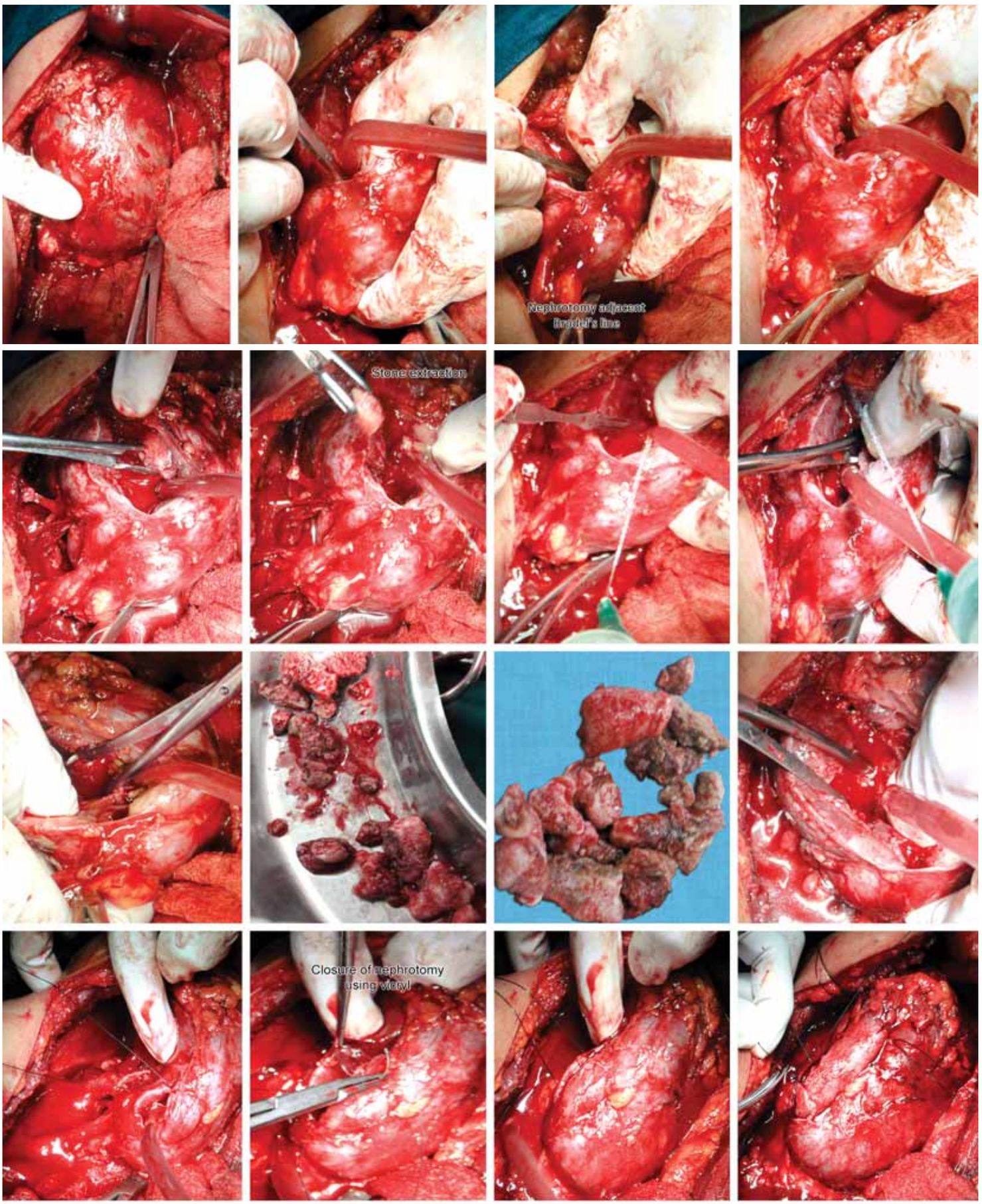
Figs 27-32(1 to 6): Technique pyelolithotomy – open method. Now usually stones are removed through PCNL, ESWL or laparoscopic approach.



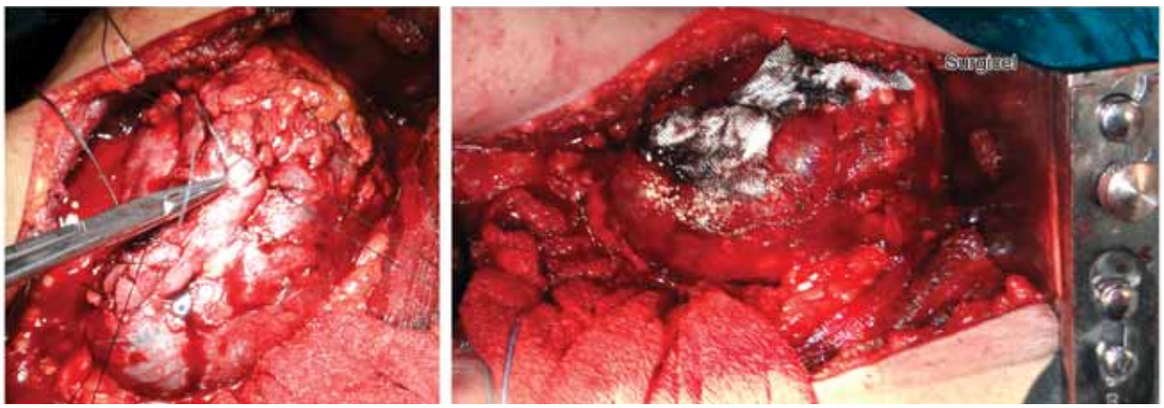
Figs 27-33A to F: Surgeries for renal stones. (A) Pyelolithotomy, (B) Extended pyelolithotomy, (C) Nephropyelolithotomy, (D) Nephrolithotomy, (E) Partial nephrectomy, (F) Coagulum pyelolithotomy.



Figs 27-34(1)


Nephrotomy adjacent
Hyrtel's line
Stone extraction
Closure of nephrotomy
using vicryl

Figs 27-34(2)



Figs 27-34(3)

Figs 27-34(1 to 3): Anatrophic nephropyelolithotomy. Vascular clamp is applied to the pedicle. Ice packs are kept over the kidney for 20 minutes; nephrotomy is done adjacent to Brodel's line to remove all stones. Nephrotomy wound is closed using vicryl. Nephrostomy (optional) and J stent (always) is kept in place. Vascular clamp is removed. Tube drain is placed; wound is closed in layers.

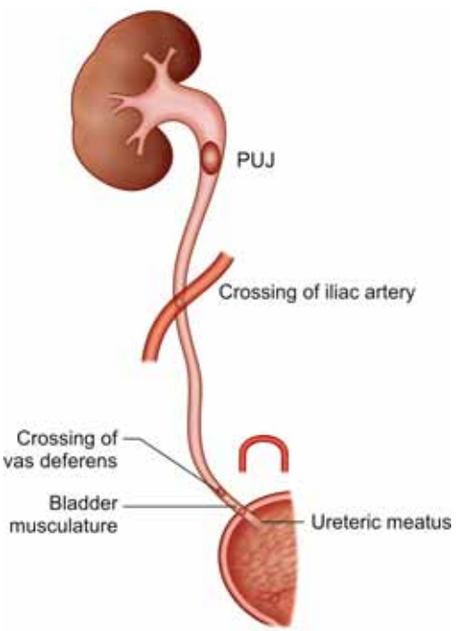


Fig. 27-35: Sites where a stone can get impacted in the ureter—narrow parts of the ureter.

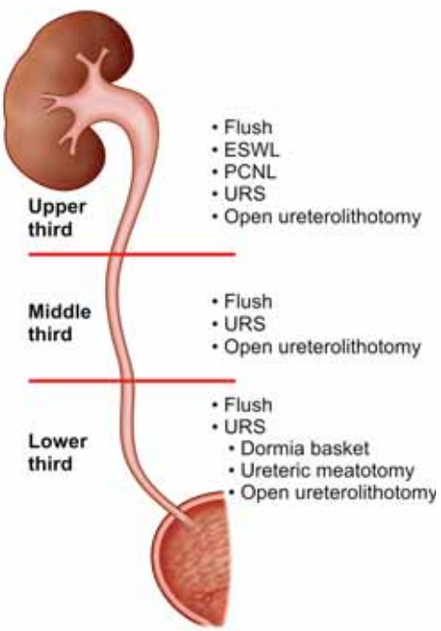


Fig. 27-36: Approaches for ureteric stones at different levels.

Fig. 27-37: J stent is commonly used for all urologic surgeries whether open or laparoscopic.

happens plane will be lost and unnecessary troublesome bleeding can develop. Genitofemoral nerve is identified; ureter is identified by its peristalsis; it is dissected and sling is passed around it. Gently ureter is palpated towards the distal narrower part from proximal dilated part (due to impacted stone). Stone is palpated without giving room for its slippage; carefully ureter distally is also dissected and held with a tape/sling. Both slings held taut to prevent the slippage of the stone in both directions. Two 3 zero vicryl stay sutures are placed; stone is steadied between fingers; longitudinal incision is made directly on the stone from below upwards; grating sensation will be felt while making the incision; stone is retrieved; using fine polythene tube warm saline irrigation is flushed both proximally and distally to clear small particles of the stone. An infant feeding tube is passed distally to confirm that there is no obstruction. J stent is passed across the ureter which is removed after 6 weeks. Ureter incision is closed with 3 zero interrupted vicryl sutures taking bites only from the muscular layer. If wall of the ureter is odematous and friable it is not necessary to suture the ureter; J stent placement is sufficient. Tube drain is placed into the cavity. Wound is closed in layers.

TREATMENT OF STAGHORN CALCULUS

Antibiotic is started. *Unilateral stone* is removed by *nephropyelolithotomy*. Multiple incisions are made over the Brodel's line (avascular plane) and assisted by pelvic incision. Stone is removed. Blood transfusion may be necessary as bleeding can occur. After that, nephrotomy and pyelotomy incisions are sutured with 3 zero vicryl **(Fig. 27-39)**.

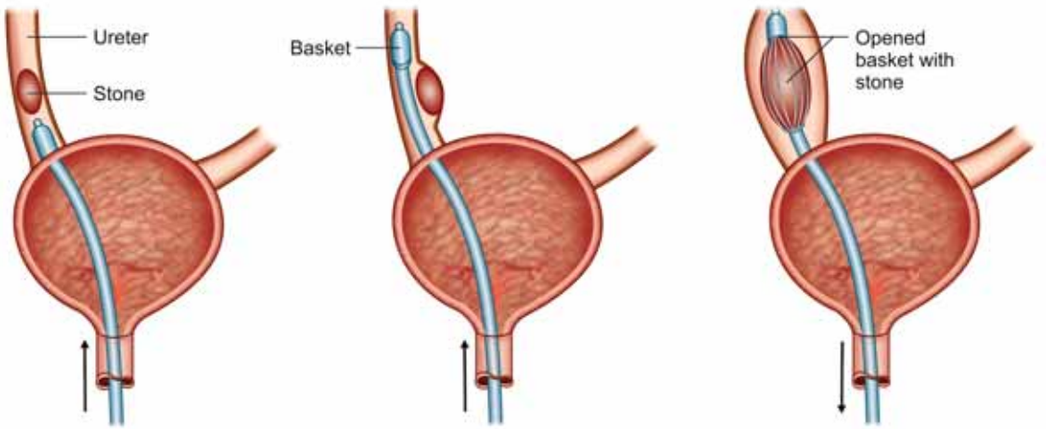


Fig. 27-38: Dormia basket is used to remove the stone in the lower ureter. Single stone less than 1 cm can be removed.

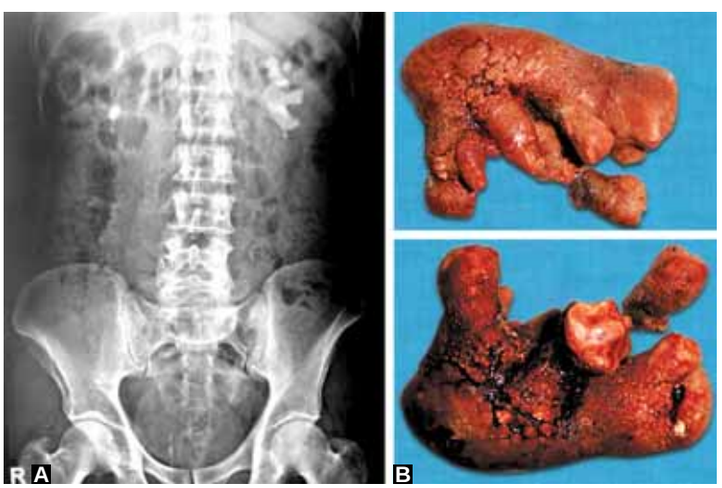


Fig. 27-39: (A) X-ray showing staghorn calculus. (B) Large staghorn calculus removed from another patient.

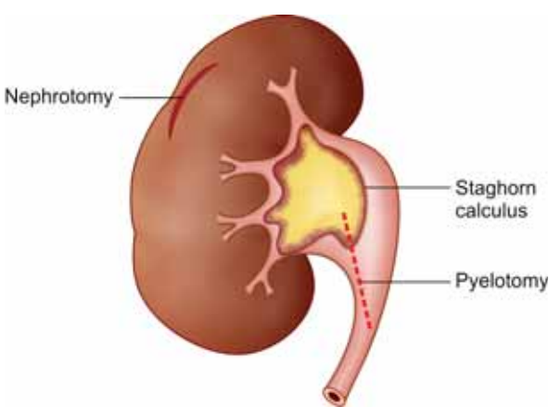


Fig. 27-40: Nephropyelolithotomy. *Note* the incisions placed.

In *bilateral cases* IVU is very essential. The kidney which is functioning better should be treated first. After 3 months, the other side kidney should be operated upon. If there are *bilateral staghorn calculi with pyonephrosis,* then initially bilateral nephrostomy is done using Malecot's catheter *(Cabot's nephrostomy*). IVU is done later to see the renal function. If function is present, then both kidneys are operated one after the other in a gap of 3 months. They often need *haemodialysis.* Sometimes in case of severe infection *nephrectomy* is required. *Presently, PCNL is becoming a popular procedure for unilateral or bilateral staghorn calculi.* But when required, *conversion to open nephropyelolithotomy* should be considered **(Fig. 27-40)**.

Complications of staghorn calculus – Pyelonephritis, pyonephrosis, perinephric abscess, renal failure.

TREATMENT OF RENAL CELL CARCINOMA

Surgery is the treatment of choice. Initial CT imaging and proper evaluation is a must **(Fig. 27-41 and 27-42)**.

Radical nephroureterectomy: *Structures removed are* entire kidney along with tumour; perinephric tissue; ipsilateral adrenal gland (adrenal gland can be spared); proximal 2/3rd ureter/as low as possible; lymph nodes from crus of diaphragm to aorta bifurcation with renal

Fig. 27-41: CT scan of renal cell carcinoma.

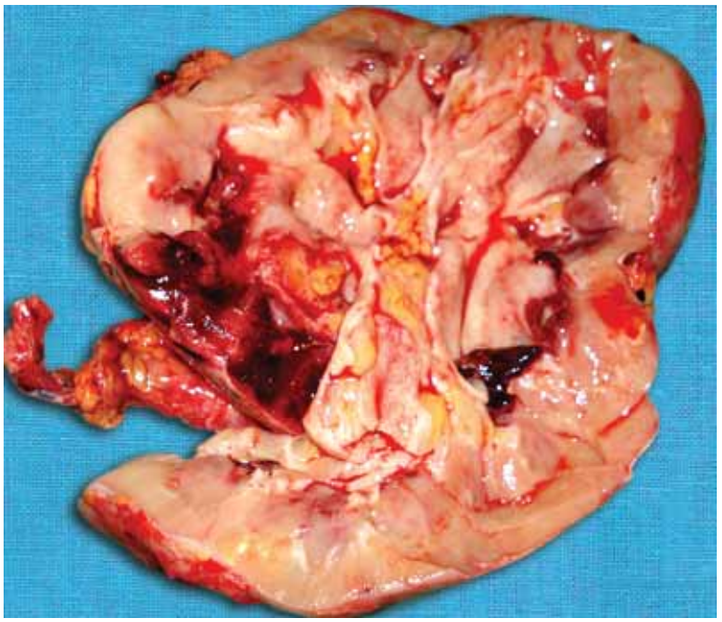


Fig. 27-42: Large upper pole renal cell carcinoma.

hilar nodes. Transperitoneal approach is often used. Retroperitoneal/Nagamatsu (resection of 11th ribs) approach/thoracoabdominal approach/posterior vertical are other approaches used. Patient will be in lateral position. After laparotomy, colon is mobilised medially. Vessels are identified and dissected and ligated securely (transfixation and three ligatures proximally using nonabsorbable silk/polypropylene sutures). Preoperative renal artery embolisation can be done to decrease vascularity and to facilitate the removal of entire tumour. Always renal vein is ligated early so as to prevent tumour dislodgement (But early ligation of renal vein may cause congestion and torrential bleeding and so renal artery is ligated first commonly in practice). But usually renal artery which is posterior is dissected and clamped or ligated in continuity; then renal vein is ligated and divided; later ligated renal artery is divided. In case of IVC extension of tumour thrombus (8%), after applying an oblique vascular clamp, IVC is opened, tumour thrombus is removed and IVC is sutured. In supradiaphragmatic vena caval extension of thrombus, cardiopulmonary bypass is necessary. First renal vessels (artery and vein) should be ligated to prevent tumour dissemination and bleeding. Lymphadenectomy is not necessarily undertaken routinely; it is only done when imaging shows significant nodal enlargement or on table enlarged nodes are seen.

Even in large fixed tumour, palliative nephrectomy or debulking is advised as it may cause regression of secondaries.

Nephron sparing surgeries are done in bilateral RCC (bilateral partial nephrectomy). Renal artery is temporarily occluded using vascular clamps and kidney is cooled to have proper control of bleeding and adequate visualisation of the line of resection. Partially resected specimen is assessed by frozen section biopsy. Retained partial capsule is sutured after haemostasis. Renal arterial clamp is released. It is presently done for unilateral localized tumours also. After isolation of the renal artery with placing icepacks to control the ischaemic time, artery or its branch is clamped using vascular clamp. Icepacks are already in place. Tumour with clearance margin of 5 mm to 10 mm is excised; sent for immediate frozen section biopsy. Bleeding is controlled using continuous 3 zero vicryl sutures. Methylene blue is injected from below across the ureteric catheter; if renal excised wound stains blue that means there is disruption of the calyces and it should be sutured. Arterial clamp is released. Any bleeding points if present are sutured. Surgicel is placed on the raw area. Drain is placed. Loin wound is closed. Warm ischaemic time for kidney is 30 minutes; cold ischaemic time is up to 4 hours **(Fig. 27-43 to 27-44)**.

Partial nephrectomy (Carl Boye Semb, university of Oslo)– It is done when disease is limited to one of the poles usually lower (T1a, T1b). Polar vessels are ligated and polar segment of the kidney is resected. Cut raw area is sutured with continuous 3 zero vicryl sutures. Tube drain is placed. Procedure is done through loin incision **(Fig. 27-45)**.

Complications

Intraoperative

Bleeding can occur from IVC, renal vein or branches. Vascular clamps should be used to control the bleeding. Vessel wall is sutured using continuous polypropylene 4 zero or 3 zero sutures.

Bowel injuries can occur especially to colon which is close to Gerota's fascia. If injury occurs then temporary colostomy or ileostomy is needed for 3 months after which it is closed. Sharp dissection injuries or cautery injuries can occur.

Injuries to liver, gall bladder, spleen (on left side) can occur during dissection due to avulsion. Pancreatic injury on left side can also occur. Injury to pleura, diaphragm are not uncommon **(Fig. 27-46)**.

Postoperative

Delayed bleeding, pseudoaneurysm formation, arteriovenous fistula can occur in nephron sparing nephrectomy. It is usually treated by therapeutic angioembolisation.

Infection, abscess formation, septicaemia can occur after any type of nephrectomy. Lymphocele can develop after lymphadenectomy.

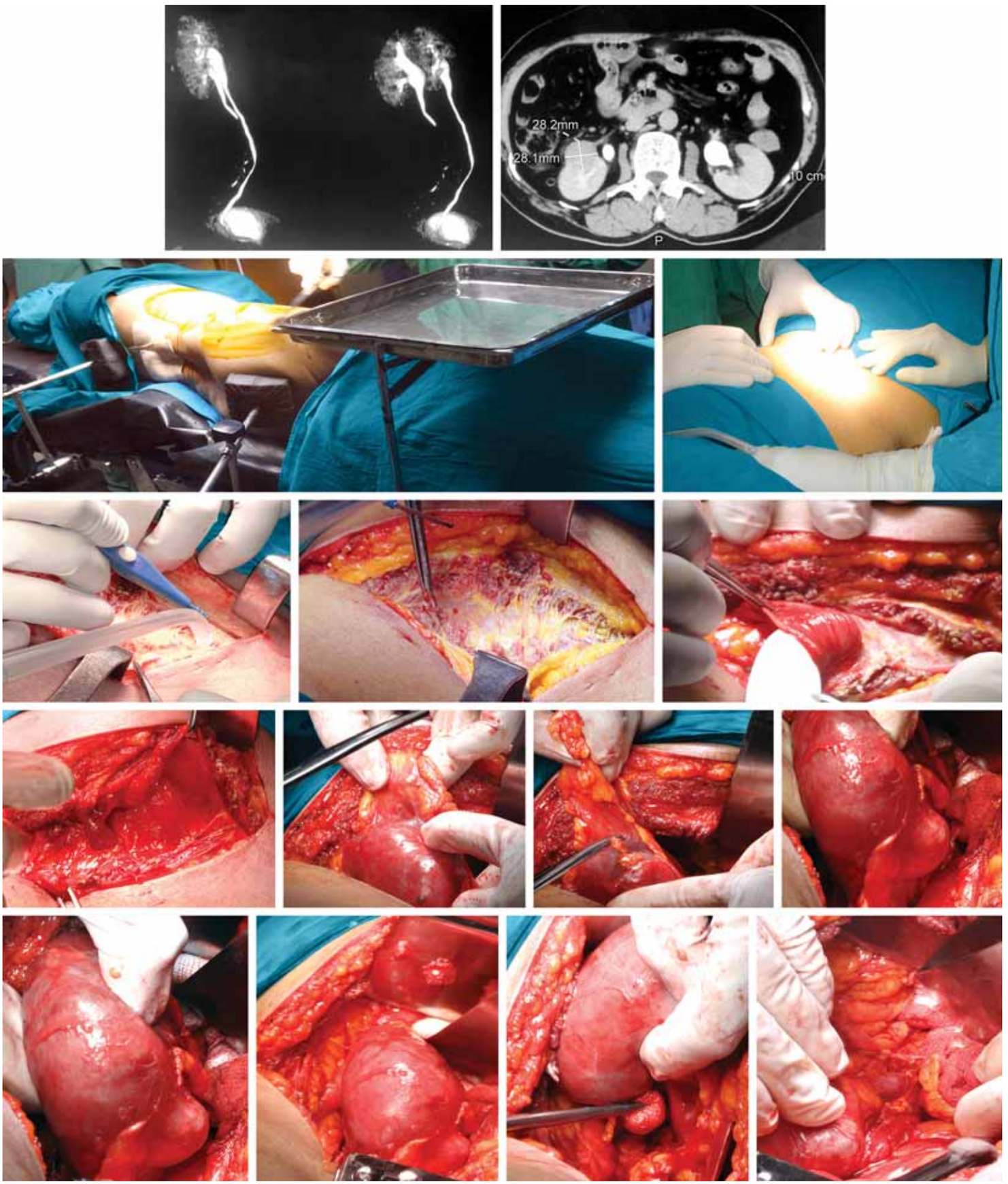
Raised creatinine level in postoperative period in many nephrectomies.

TREATMENT OF POLYCYSTIC DISEASE OF KIDNEY

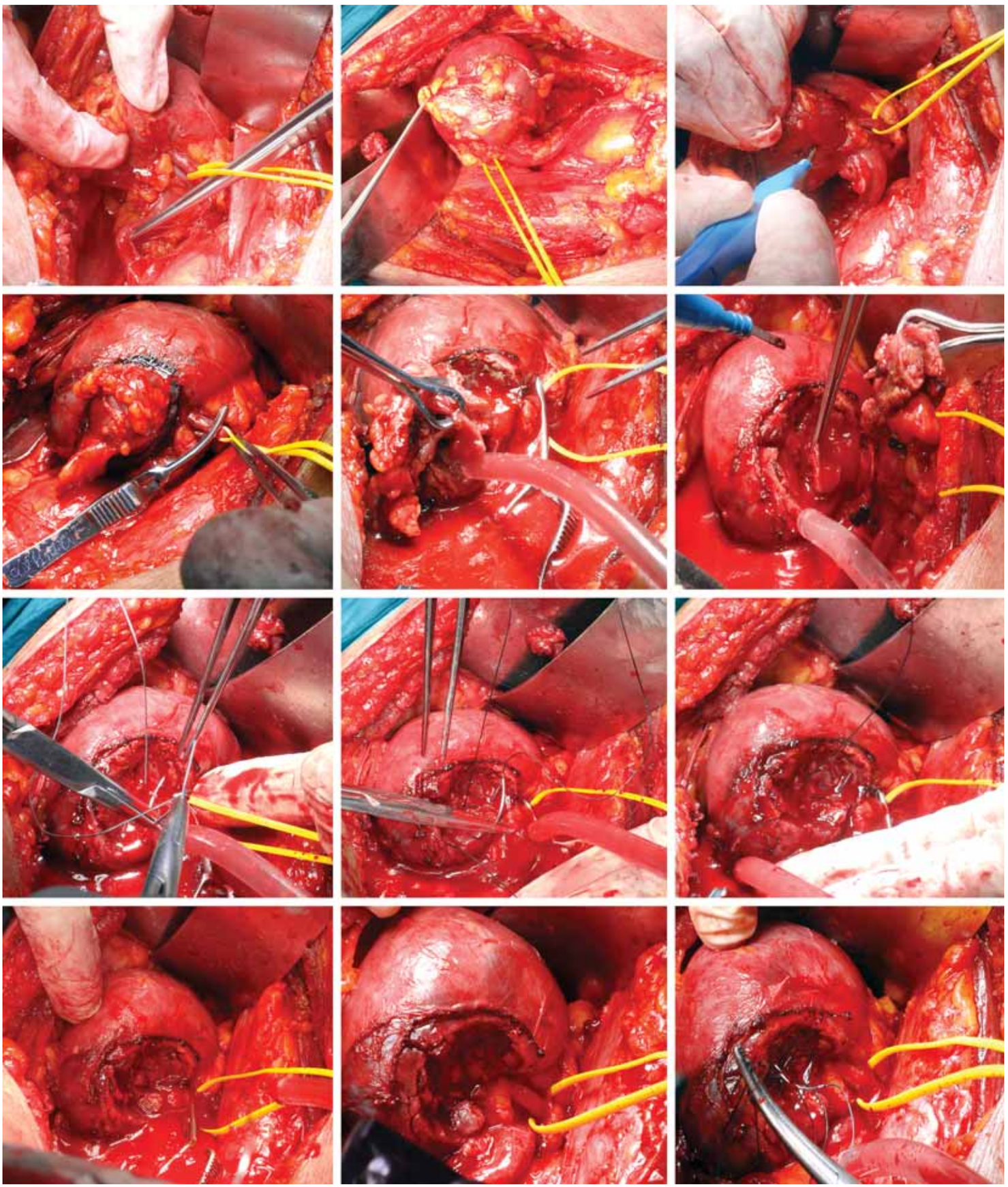
Initially wait and watch policy. If one of the cysts overdistends causing pain, haemorrhage, infection, then surgical intervention is required. *Rovsing operation*: The kidney is exposed. The cyst is opened. The fluid is evacuated. The cut edge is marsupialised. Presently U/S guided aspiration is done as a simpler approach. Laparoscopic/retroperitoneoscopic aspiration/de-roofing of the renal cyst is also commonly done. Once renal failure sets in, then initial haemodialysis followed by bilateral nephrectomy, is done and later renal transplantation should be planned for.

TREATMENT OF SOLITARY RENAL CYST

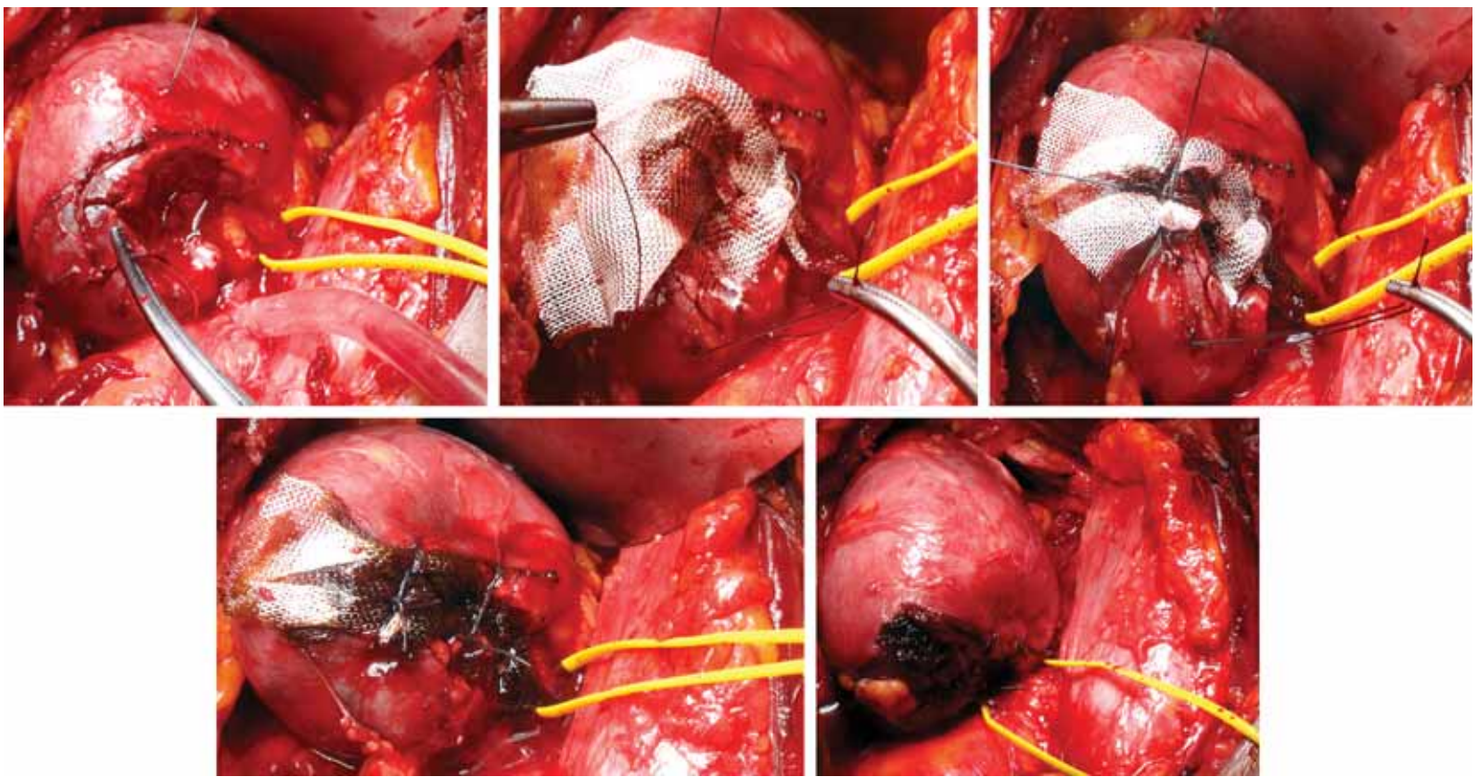
Kidney is exposed. The cyst is aspirated and a portion of the cyst wall is removed (*Kirwin's operation*) and cavity is filled with perinephric fat. Occasionally if the cyst is in one of the pole, partial nephrectomy is done. Laparoscopic approach is ideal.



Figs 27-43(1)



Figs 25-43(2)



Figs 27-43(3)

Figs 27-43(1 to 3): Nephron sparing nephrectomy.

TREATMENT OF BLADDER STONE (FIG. 25-47)

Cystoscopic litholapaxy - Under general anaesthesia, cystoscope is passed and the stone is visualised. It is fragmented by pneumatic, laser, electromagnetic waves or mechanohydraulic lithotripsy. The bladder is flushed using an irrigator (Freyer's evacuator or irrigator or Ellik's evacuator).

Contraindications are - Too large stone; too small stone, too soft stone, too many stones, stone in bladder diverticula, bladder tumour, contracted bladder, patient's age below 10 years. When patients general condition is poor, as the procedure takes a longer duration it is avoided and open removal is advised. However presently most of the stones can be removed through cystoscopy except very large and hard stone **(Fig. 27-48)**.

Suprapubic open cystolithotomy - Through Pfannenstiel incision, bladder is approached extraperitoneally. Bladder is identified by its detrusor muscle pattern, which has criss-cross pattern and also its venous pattern. Bladder is opened near the fundus vertically between stay sutures; incision should avoid venous plexus and stone is removed. Bladder is closed with 2 zero vicryl continuous single layer or two layers sutures. Often SPC is added using Malecot's/Foley's catheter but is not mandatory. Foley's catheter is passed per urethera which is removed after 3 weeks. Wound is closed in layers with a drain in retropubic space **(Figs 27-49 and 27-50)**.

Suprapubic percutaneous litholapaxy - This procedure is becoming popular. When cystoscope cannot be passed per urethra, bladder is approached suprapubically. Through a needle, guide wire and dilators, a track is created through which a nephroscope is passed to remove the stone after fragmenting. The cause is treated **(Fig. 27-51)**.

TREATMENT OF BLADDER TUMOURS

Noninvasive Tumour

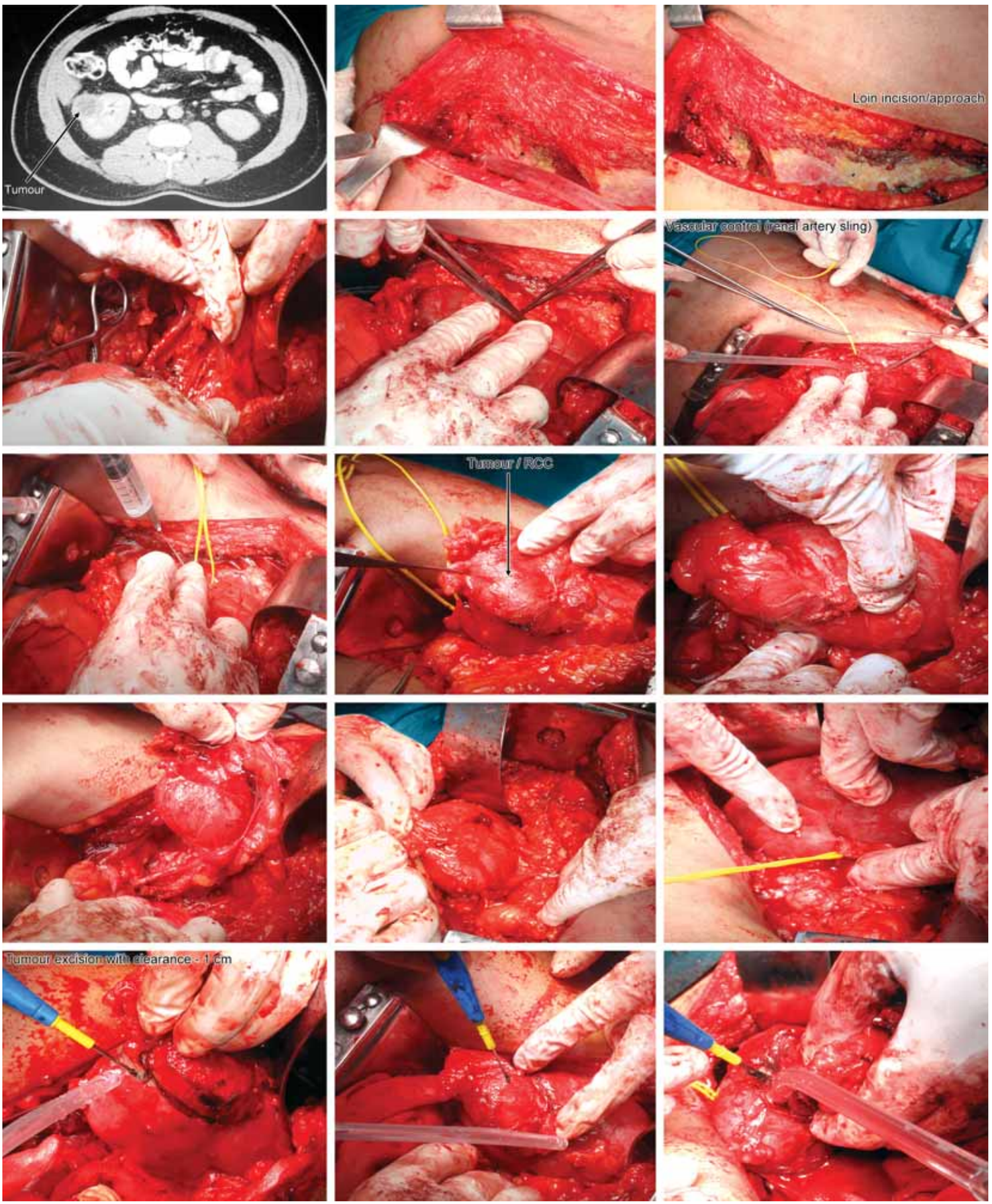
Endoscopic resection of tumour is ideal. *Intravesical chemotherapy* using BCG (Dose: 120 mg in 150 ml of normal saline weekly for six weeks), mitomycin C, epirubicin, adriamycin, thiotepa, methotrexate can be given especially for carcinoma *in situ*. BCG is very useful. Very rarely *BCG provocation* can occur. Fever, joint pain, granulomatous prostatitis, sinus formation, disseminated tuberculosis are the features. Dysuria, frequency and urinary irritation can occur. BCG is *live attenuated vaccine*; its advertent IV entry can be *life threatening* and so if there is haematuria its infusion should be postponed. Mitomycin C causes skin desquamation and rash. *Systemic chemotherapy*: Using cisplatin, 5-FU, adriamycin, mitomycin.

Helmstein balloon degeneration for large papillary tumour. Balloon is passed into the bladder and inflated so as to cause pressure necrosis of the summit of the tumour. Later remaining part of the tumour can be resected easily through cystoscopy.

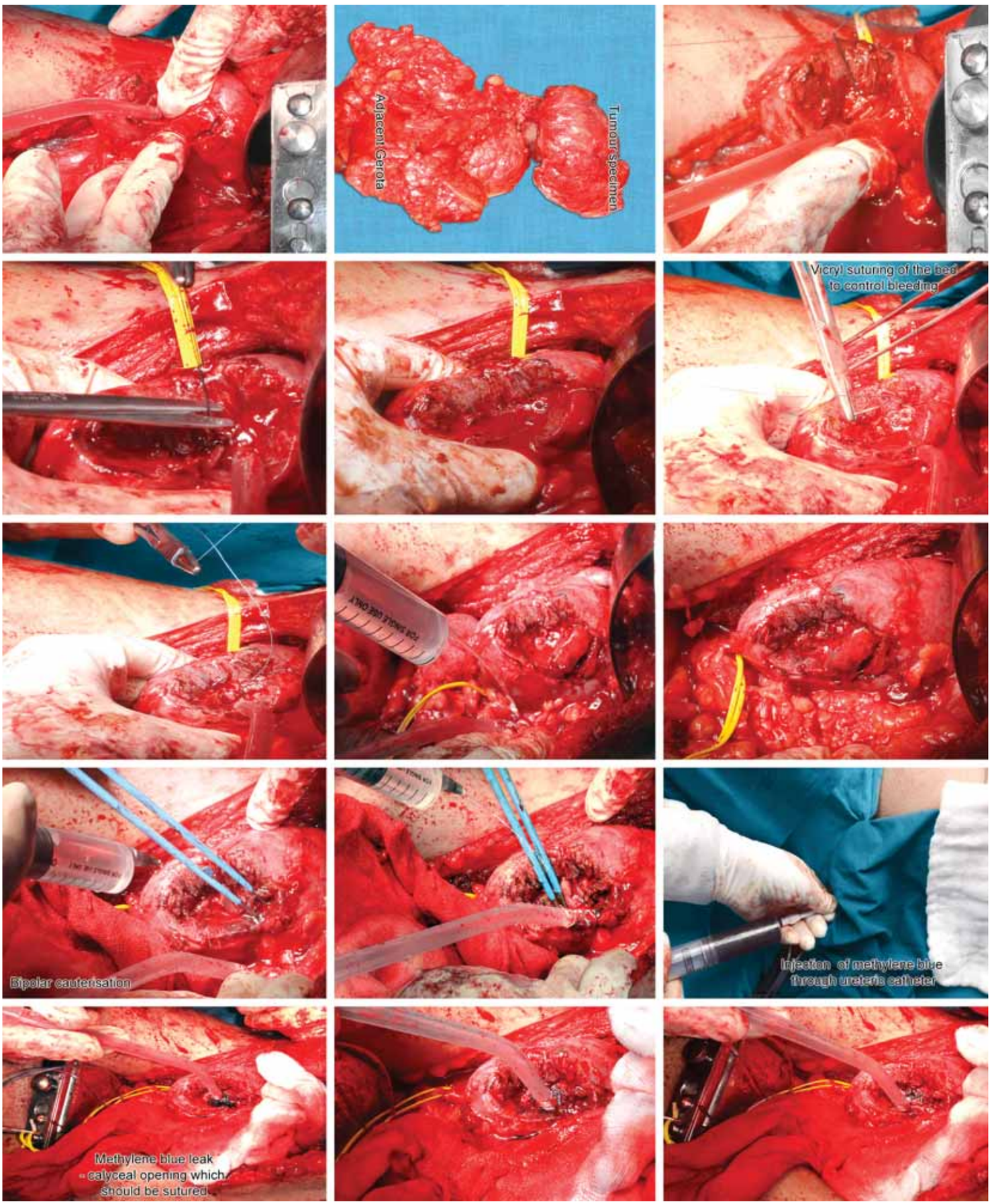
Invasive Bladder Tumour

Curative interstitial radiotherapy using implantation of radioactive gold grains (Au 198) (half life is two and half days), or radioactive tantalum wires (Ta 182) (half life is 4 months).

Radical deep external beam radiotherapy (45 Gy) using cobalt 60 is useful, as bladder is retained normal act of micturition and potency can be maintained. Complication is that it may eventually lead to formation of thimble bladder **(Fig. 27-52)**.


Tumour
Loin incision/approach
Vascular control (renal artery sling)
Tumour / RCC
Tumour excision with clearance - 1 cm

Figs 27-44(1)


Adjacent Gerota
Tumour specimen
Vicryl suturing of the bed to control bleeding
Bipolar cauterisation
Injection of methylene blue through ureteric catheter
Methylene blue leak - calyceal opening which should be sutured

Figs 27-44(2)

Figs 27-44(3)

Figs 27-44(1 to 3): Nephron sparing nephrectomy in a different patient with vascular control using a bull dog clamp.

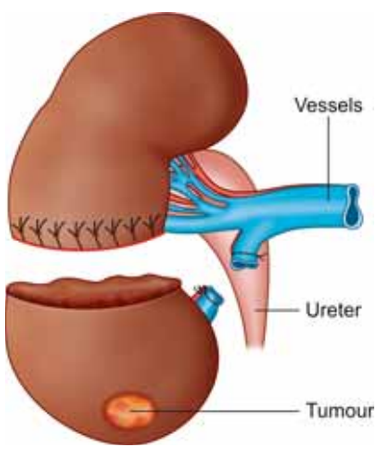


Fig. 27-45: Partial nephrectomy. Procedure is done through loin posterior approach. It is done for lower pole tumour. Segmental/polar vessels are ligated and kidney is divided; surface is sutured; surgicel is placed; J stent should be placed; wound is closed with a tube drain.

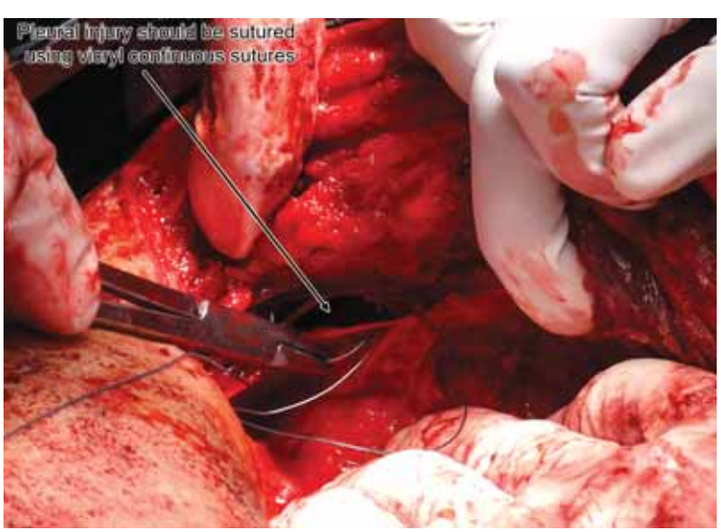


Fig. 27-46: Pleural injury can occur while approaching kidney. It should be sutured with vicryl continuous sutures. Anaesthetist should inflate the lung fully while taking the last bite from the pleura to inflate the lung properly.

Fig. 27-47: X-ray showing bladder stone.

Surgery

Indications for surgery - Multiple bladder tumours, sessile tumours, recurrent tumours, poorly differentiated tumours, *in situ* carcinomas, squamous cell carcinoma, adenocarcinomas.

Partial cystectomy done when tumour is confined to fundus of the bladder and is single, with a margin of clearance of 2.5 cm. External beam RT and chemotherapy should be given. Partial cystectomy can be done through laparoscopy easily. Through cystoscopic guidance

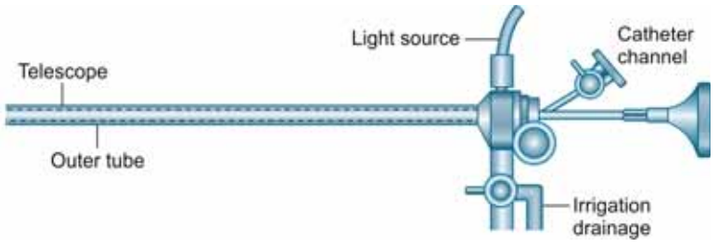


Fig. 27-48: Doing cystoscope as diagnosis and to remove bladder stone by fragmentation.

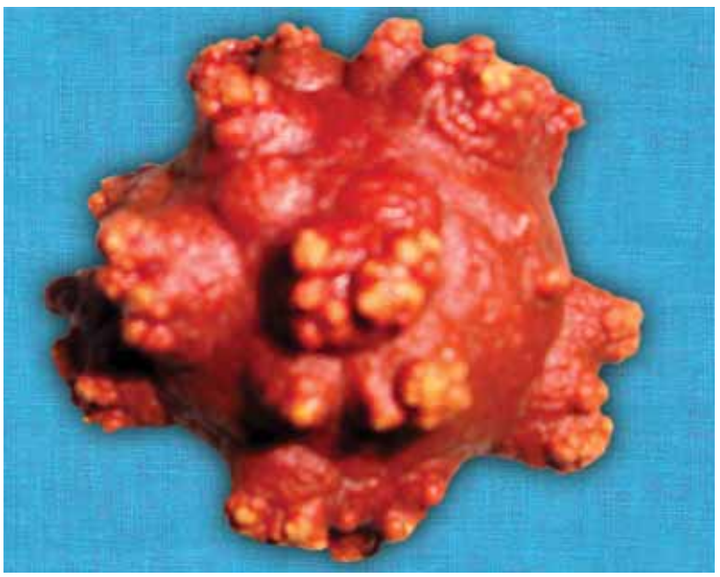


Fig. 27-49: Large oxalate stone removed from the urinary bladder.

Fig. 27-50: X-ray showing SPC with Malecot catheter.

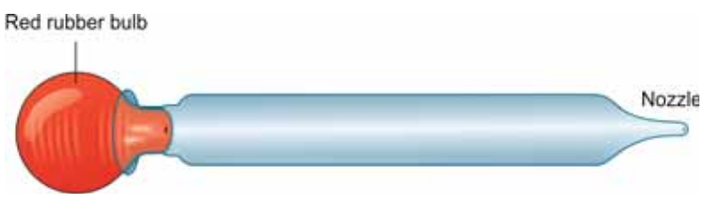


Fig. 27-51: Asepto syringe used for bladder wash in patients with urinary catheter which has been blocked; or when haematuria is noticed in the catheter. It is also used to fill the bladder with saline.

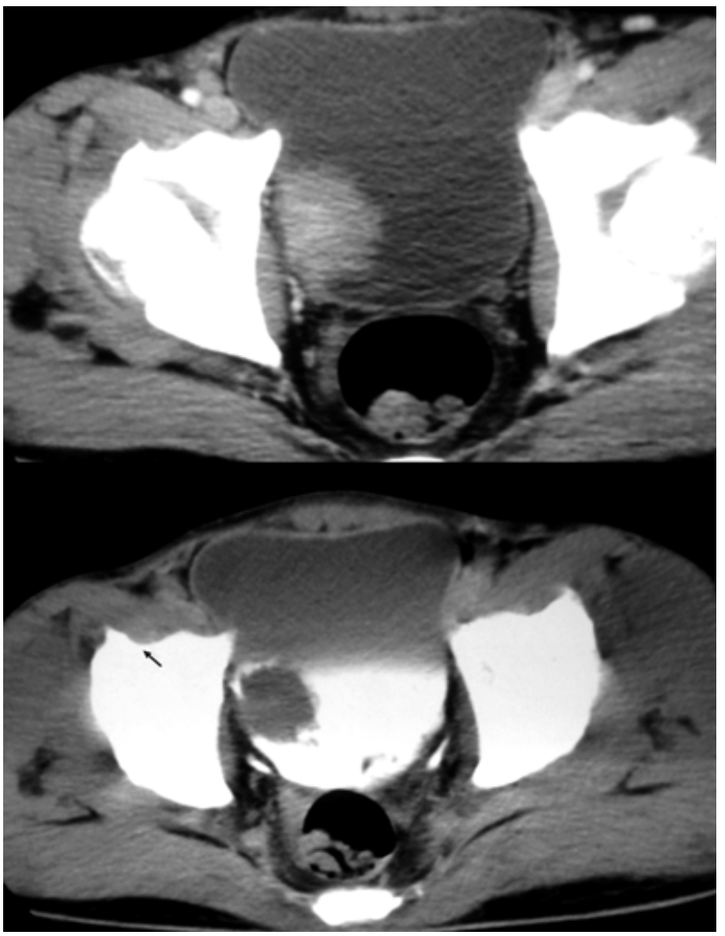


Fig. 27-52: CT picture showing bladder tumour. Specimen showing transitional cell carcinoma of bladder.

and laparoscopy tumour margin is marked on the bladder surface; resection is done through the laparoscopy; bladder wall is sutured by intracorporeal continuous vicryl sutures. Position and port sites are almost similar to laparoscopic hysterectomy. Partial cystectomy is also done often along with sigmoid resection, ileal resection or with hysterectomy whenever disease processes like diverticulitis, Crohn's

disease or malignancy invades the bladder partially. Along with the resection of the primary tumour and organ, disc of urinary bladder attached to the colon or ileum is removed; primary suturing of the bladder wall is done using 2 zero vicryl sutures.

Radical cystectomy: CT scan is a must before doing radical cystectomy to see the pelvis and lymph node status. Here urinary bladder, urethra, paravesical tissues, lymph nodes (pelvic) are removed. In females hysterectomy with removal of part of the vagina is done. After surgery urinary diversion is done either by doing continent ileal conduit, or ureterosigmoidostomy or by creating rectal urinary pouch.

Intravesical chemotherapy by BCG, mitomycin C, adriamycin and interferons are used later.

Systemic chemotherapy by cisplatin, adriamycin, mitomycin, vinblastine—adjuvant therapy. Neoadjuvant cisplatin based chemotherapy is beneficial improving survival by 7%. MVAC regime is methotrexate; vinblastine; adriamycin and cisplatin.

Prognosis

Depends on type, differentiation, location, stage, invasion, number, lymph node status, pelvis involvement and response to treatment. TCC alone—85%; TCC with SCC or adenocarcinoma—6%; SCC/adenocarcinoma alone—3%; spindle cell carcinoma— 2%.

RADICAL CYSTECTOMY

It is done as a curative surgery for bladder carcinoma. Staging, cystoscopic biopsy, preliminary preparation for anaesthesia should be done.

Procedure is done under general anaesthesia in supine head down position. Head down (reverse Trendelenburg) position helps in keeping the bowel in the proximal abdomen away from the surgical field.

Technique

Lengthy midline incision is placed to open the abdomen. Incision extended above the umbilicus should be towards left side of the umbilicus. Abdomen is explored for liver, nodes and metastases in other areas. Median umbilical ligament is divided at umbilical level; it is dissected towards the dome of the urinary bladder. Lateral bladder dissection is done; vas deferens is identified, dissected, ligated and divided. Medial umbilical ligament is similarly dissected and divided between ligatures. Superior vesical artery (vessels) is ligated and divided. Posterior dissection is done in rectovesical plane after opening the peritoneum in rectovesical pouch. Fascia of Denonvillier's is dissected downwards. Dissection is done between rectum and urinary system. Neurological bundle of Walsh can be scarified in radical surgeries. Seminal vesicles, prostate is identified; dissection is reached towards the apex of the prostate identifying the membranous urethra. With bipolar cautery harmonic scalpel ligation, vessels are dealt. Venous plexus in the lateral aspect is divided between secure ligatures. Dissection in the retropubic area in the space of Retzius is undertaken by blunt finger and sharp scissor dissection. Many vessels in this area should be ligated otherwise troublesome bleeding can occur. Dissection is done beyond the prostate. Both ureters are divided close to the trigone; cut end pieces of ureters are sent for frozen section biopsy. Lymph nodes are cleared from common iliac artery downwards along the iliac vessels up to Cloquet (Rosenmuller) lymph node which is cleared; posteriorly nodes are cleared up to obturator nerve. Lymph nodes on both sides are cleared according to template. Iliac and obturator lymph nodes are cleared completely.

Urethra distal to prostate is transected. 24 no. French sized Foley's catheter is passed per urethra from below and is inflated, pulled with traction; it gives compression to prostatic bed to prevent bleeding and also acts as drainage.

Reconstruction is planned. It is creation of neobladder and achieve drainage either by suturing the neobladder pouch to the cut end of urethra as orthotopic drainage; or neobladder is exteriorized after ureteral reimplantation into the created pouch.

Creation of Pouch

Two types of pouches is used. One pouch is ileal W pouch with creation of continent at its summit; summit is brought out with valve mechanism created in it through the right iliac fossa. Other pouch is caecal and ascending colon pouch with terminal ileum as a passage with intussuscepted ileum towards the caecum as valve mechanism. Here 15 cm of terminal ileum is selected; additional further proximal 5 cm is also taken to create intussusception. Right colon is mobilized from right paracolic gutter, hepatic flexure, and right half of the transverse colon. Colonic mesentery is not ligated; right branch of the middle colic artery is ligated; left colic artery should be retained and also arcade of the terminal ileum. Ileum is transected either by stapler or with knife and cautery; right half of the transverse colon is transected; ileo transverse colon anastomosis is done. Mesenteric defect is closed. Harvested ileocolic segment is mobilised carefully towards right side without interrupting its blood supply; it is achieved by mobilising the mesentery up to the 3rd part of the duodenum. Ascending colon, part of the transverse colon in the harvested part is opened using scissor or cautery along the taenia. Ileocaecal valve is identified. Distal part of the harvested ileum is skeletonised for 5 cm which is intussuscepted towards ileocaecal valve; it is achieved by passing a long Babcock's clamp through the lumen and holding the ileal wall from inside at 5 cm from the ileocaecal junction and pulling it distally towards the caecum. Once it is intussuscepted its terminal mucosa is denuded for 2-3 cm and sutured again to prevent it retracting backwards; it functions like a valve. Foley's catheter 20 sized is passed from the cut end of the harvested ileum to confirm the patency and is placed in the caecum with inflation. Two ureteric catheters are passed through it towards caecum and kept. One of which is labeled or marked with tie to identify the side. Right side ureter is mobilized proximally for adequate length. Left side ureter is also mobilised adequately and is passed behind the mesentery from left towards right. Both ureters are reimplanted into posterior part of the caecum/ascending colon at around 1-2 cm gap. Small stab incision of 8-10 mm length is made in the right half of the caecum or proximal ascending colon; ureter is transected near its cut margin obliquely (fish mouth). Stent marked right is passed through right ureter into the pelvis. It is anastomosed to the caecal wall using interrupted 3 zero vicryl sutures with knots outside. Similarly left ureter is implanted into the caecum posteriorly on its left side. Opened ascending colon is closed horizontally to create a colonic pouch. An independent Foley's catheter is passed through the separate wound in front of the caecum to bring it as ostomy from the pouch to drain it. Length of the ileum is assessed to have adequate shortest distance from the pouch to reach right iliac fossa, the site of ostomy (stoma) which is permanent. Circular piece of the skin is excised in the spinoumbilical line in front of the rectus muscle. Either

cruciate incision is made in the anterior rectus sheath or similar disc of the sheath is removed. Rectus muscle is split; peritoneum is opened; assistant will give counter pressure through a mop covered finger from inside while creating stomal opening. Care should be taken not to injure the inferior epigastric vessels. Cut ileal end of the harvested segment is brought out using a Babcock's clamp. 2 cm proximal from the cut end of the ileum seromuscular interrupted sutures are placed between the bowel and anterior rectus sheath using 3 zero vicryl. Even though it is not mandatory it is often practiced to fix the bowel to the peritoneum by interrupted vicryl sutured adjacent to stomal opening. Skin is sutured to the cut edge of the ileum; while initially taking seromuscular bites away from the cut edge then from the mucosa at the edge, then from the full thickness skin it is taken so as to create protrusion of the mucosa of stoma outwards – *Brooke's method of maturation of the urinary conduit.*

Gastrostomy may be done for feeding and aspiration purpose. Suction tube drains are placed one in the pelvis another in the right side abdomen. Abdomen is closed in layers.

***Note*:** There are many methods of creating pouches – Mainz pouch (Ileo colic); Indiana pouch; orthotopic pouches like studer neobladder of ileum; Hautmann neobladder of ileum; Monti and spiral Monti types.)

URETEROSIGMOIDOSTOMY (Henri Chaput, 1894, French Surgeon)

It is a procedure done for urinary diversion after radical cystectomy or as a permanent diversion for many other causes, e.g. bladder dystrophy. Left ureter is implanted to the sigmoid colon, right one to the upper rectum or rectosigmoid junction. Collecting system is not necessary here; but exposure of urinary tract to faecal infection is the real problem.

Different types of ureterocolic anastomosis are present. Fish like incision on the sigmoid by incising the seromuscular layer lengthier and mucosa is opened on the end of this incision to anastomose cut end of ureter on it. Coffey, Grey Turner, Nesbit, Cohen's, Cordonnier type; Leadbetter are different types. In Leadbetter (Boston, USA) type submucosal tunneling is done to prevent reflux.

Complications

Because the pressure in sigmoid colon is more, it causes *pyelonephritis* and recurrent upper urinary tract infection. Due to diarrhoea *hypokalaemia occurs.* Because of reabsorption of chloride, *hyperchloraemic acidosis* occurs. *Treatment of complications* - IV sodium bicarbonate (8.4%) with slow IV potassium; IV antibiotics; Patient is advised to take potassium citrate and sodium bicarbonate and to avoid salt; in many cases conversion to *ileal conduit* may be required.

Stricture formation is common in ureterosigmoidostomy. Mucosa to mucosa anastomosis may prevent this **(Fig. 27-53)**

URINARY DIVERSION

It is diversion of urine temporarily or permanently, proximal to the site of obstruction. Temporary type is done in benign conditions and distal obstructions, to promote healing. Permanent type is done in advanced malignancies which block the urine flow distally, after radical cystectomy, after radiotherapy with frozen pelvis, etc **(Fig. 27-54 and 27-55)**.

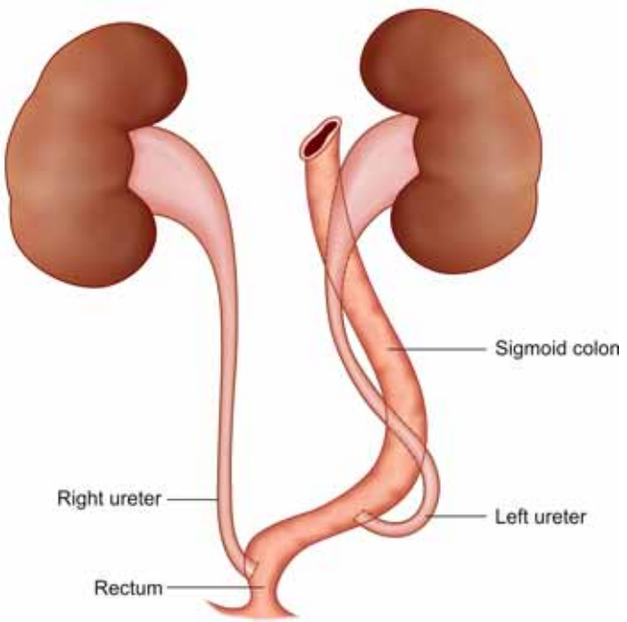


Fig. 27-53: Ureterosigmoidostomy.

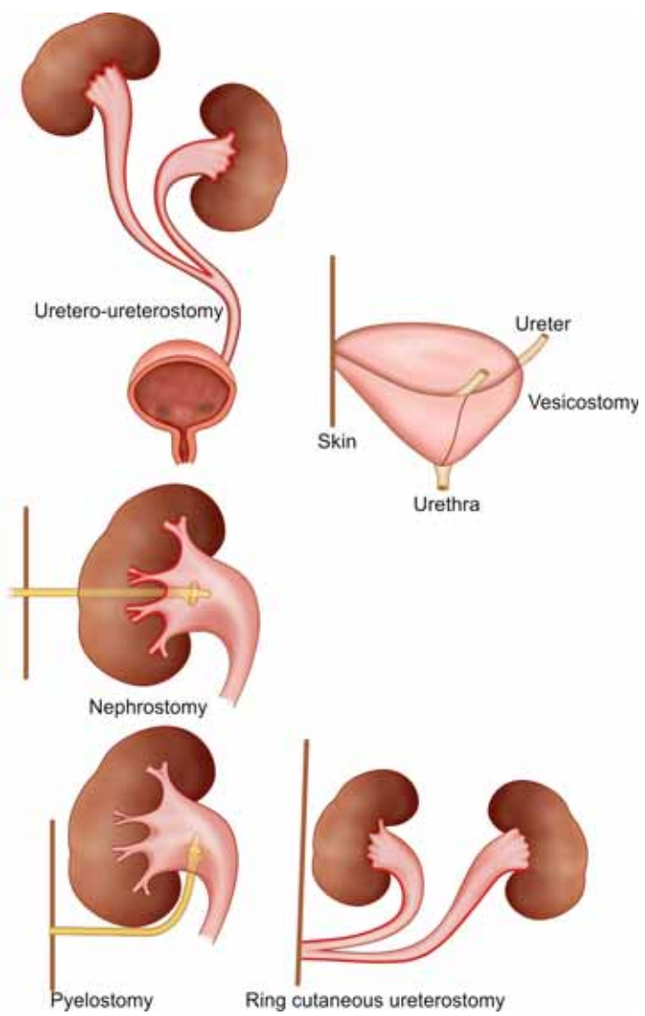


Fig. 27-54: Types of urinary diversions.

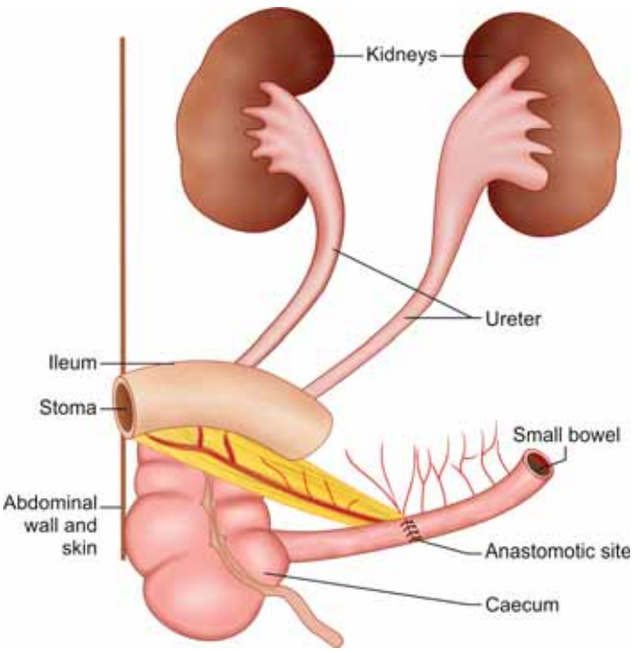


Fig. 27-55: Ileal conduit as urinary diversion.

Temporary Diversions

Suprapubic cystostomy (SPC); vesicostomy in children in ectopiae vesicae, epispadias, urethral anomalies; urethrostomies; nephrostomies in pyonephrosis and high obstructive uropathies; pyelostomies are other procedures; ureteral J stent is a method of internal temporary diversion which is kept maximum for 3 months.

Permanent Diversions

External Diversions

Noncontinent ileal conduit

Here 20 cm of vascularised distal ileum (30 cm from IC valve) is prepared. Ureters are re-implanted over the ileum. Other end of ileum is brought out as a 3 cm stoma in right iliac fossa. Patient has to wear a bag over it. Ileal pouch can be created as a reservoir – J, S, W, etc.

Continent ileal conduit

It is similar conduit with creation of specialised valve (Koch's continent) within, using ileal mucosa or appendix. Patient has to empty the conduit by passing self catheters once in 6 hours. Instead of appendix, intussusception of distal 5 cm ileum into the caecum across the ileocaecal valve and denudation and suturing of the mucosa can create a continent conduit.

Mitrofanoff continent stoma of appendix

It is done in children with spina bifida with neurogenic bladder. Mesentery of appendix is retained (undisturbed). It is dissected at its base from caecum which closed with 2 zero vicryl. Base is mobilised without disturbing its blood supply and implanted into the bladder using 3 zero vicryl sutures. Tip is transected to get the needed lumen; warm saline wash is given into the lumen gently. Transected opened lumen is brought out through a stab incision into the skin in right iliac fossa and its mucosa (full thickness appendix wall) is sutured to skin to create a stoma; often local skin flaps are used to support the appendix and to achieve continence. Urine is drained from the urinary bladder by catheterisation across the appendix stoma. It is a continent cystostomy using pedicled appendix.

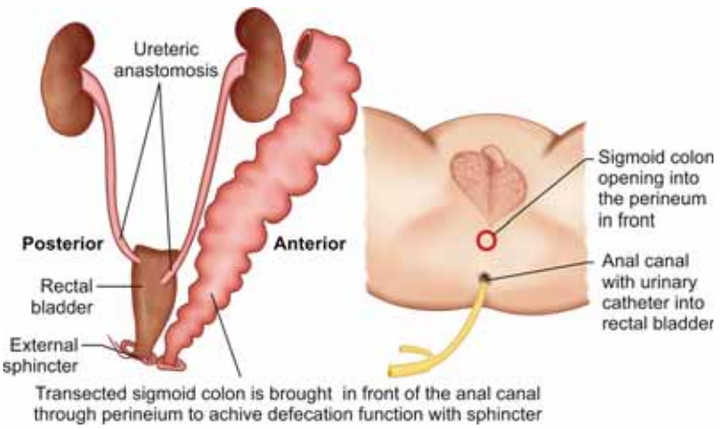

Ureteric anastomosis
Posterior
Anterior
Rectal bladder
External sphincter
Sigmoid colon opening into the perineum in front
Anal canal with urinary catheter into rectal bladder
Transected sigmoid colon is brought in front of the anal canal through perineum to achive defecation function with sphincter

Fig. 27-56: Lowsley's rectal bladder.

Lowsley's (urologist, New York) rectal bladder

Left side colon is mobilsed fully; rectosigmoid junction is transected; rectal stump is closed either hand sewn or stapler. Distal cut end of the sigmoid is brought down through the perineum in front of the rectum and anal canal to anastomose to incised skin in front of the original anal canal. This new anal canal created acts as defecating organ. Rectal bladder behind acts as urinary reservoir and normal anal canal acts as urination device. It is kept catheterised for few weeks **(Fig. 27-56)**.

Cutaneous ureterostomy/cutaneous ring ureterostomy are other options.

Internal Diversions

Ureterosigmoidostomy (Leadbetter-Palitano); rectal bladder creation; ileocystoplasty; caecocystoplasty/sigmoidocystoplasty; creation of neobladder (orthotopic) using ileum/caecum/sigmoid colon which is sutured to urethra.

Types of Urinary Diversions

Nephrostomy; pyelostomy; cutaneous ureterostomy; cutaneous ring ureterostomy; suprapubic cystostomy; vesicostomy in children; urethrostomy; ureterosigmoidostomy; rectal bladder; urinary ileal conduit (Koch's conduit).

Complications of Diversions

Urine leak, faecal leak, intestinal obstruction, sepsis; Hyperchloraemic hypokalaemic metabolic acidosis; pyelonephritis; Osteomalacia, growth retardation; Calculi formation—4%; Continent failure, blockage of diversion stoma (stenosis); Reflux of urine; Vitamin B_{12} and folate deficiency due to absence of ileum; Complications of stoma; Renal failure; Metaplasia and adenocarcinoma especially at uretero sigmoidostomy junction.

URETERIC REIMPLANTATION

Ureter may often need to be reimplanted into the urinary bladder. In stricture distal ureter, ureteral tuberculosis, trauma to ureter may be iatrogenic reimplantation is needed.

Usually oblique Gibson's loin incision extending to suprapubic area is ideal; Pfannenstiel incision is also can be used.

Ureter is fully mobilised keeping its blood supply intact. Diseased part is excised. Urinary bladder is mobilised fully both in front, behind, and on opposite side to get adequate tension free length for anastomosis. Cut distal end is reimplanted into the urinary bladder. Ureter can be reimplanted directly or through tunneling depending on need and surgeons' choice. Mucosa to mucosal anastomosis is better.

Psoas hitch - Mobilised urinary bladder is fixed to psoas major muscle on its medial side adjacent to genitofemoral nerve without injuring it; 2 zero interrupted vicryl sutures are placed between muscular layer of bladder and psoas major muscle. Usually three sutures are placed; this psoas hitch prevents urinary bladder getting retracted back into the pelvis and so keeps ureteric anastomosis tension free.

Boari flap - If psoas hitch seems inadequate to achieve tension free anastomosis, then superolateral part of the urinary bladder is elevated after incision as flap; it is tubularised to achieve extra needed length. Cut end of the ureter is sutured into that. This procedure is usually sufficient.

Isolated segmental ileal interposition is done whenever entire length of the ureter is lost. Isolated pedicled 30 cm ileum is harvested; bowel continuity is maintained by doing bowel anastomosis. Ileal harvested segment is washed thoroughly using warm normal saline. Proximal end is closed; just distal to this closed proximal end over the antimesenteric border 8-10 mm sized opening is made in the bowel; renal pelvis or proximal ureter is anastomosed to this ileal segment using 4-6 interrupted 3 zero vicryl sutures with knots placed on outside. Distal part of the isolated segment is sutured to the bladder using 2 zero vicryl as interrupted end to end anastomosis. Knots should be outside the lumen. Nephrostomy, J stent, cystostomy, nasogastric tube, peritoneal cavity tube drain and urinary catheterisation are also needed while finishing the surgery.

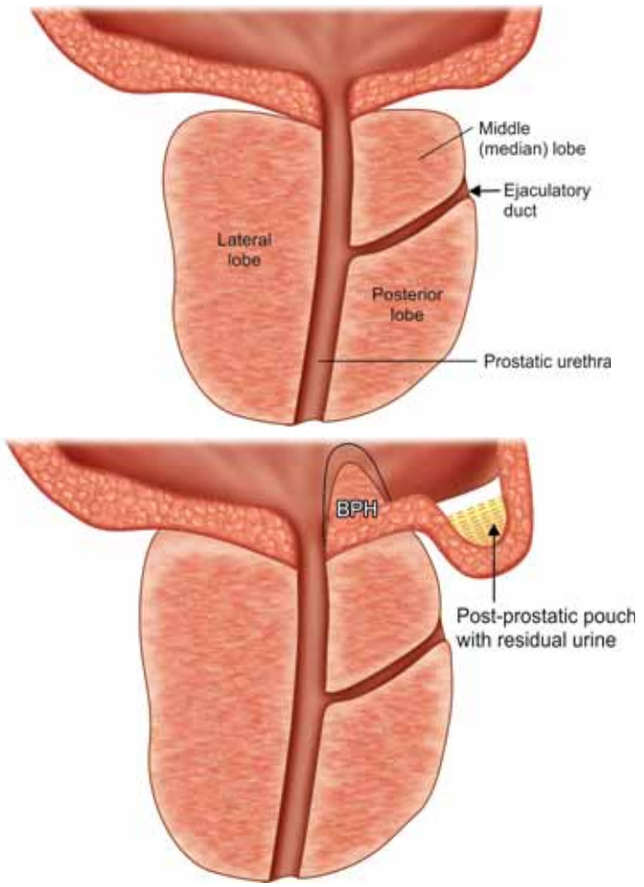


Fig. 25-57: Diagram showing normal prostate pattern and post prostatic pouch with residual urine.

MANAGEMENT OF BENIGN PROSTATIC HYPERPLASIA (BPH)

Patient with *acute retention* of urine requires *urethralcatheterisation*. If urethral catheterisation fails, then *suprapubic cystostomy (SPC)* is done. Trocar SPC is available which is technically easier to do and minimally invasive; but bladder should be full and is confirmed clinically by dullness in suprapubic region and by ultrasound. If bladder is not full chances of intraabdominal injury is high. If patient presents with *uraemia*, then urethral catheterisation is a must. That allows the kidney to function adequately and further obstructive damage is prevented. Serum electrolytes should be corrected properly in these patients **(Fig. 27-57)**.

Indications for Surgery

Prostatism (frequency, dysuria, urgency); acute retention of urine; chronic retention of urine with residual urine more than 200 ml; complications like hydroureter, hydronephrosis, stone formation, recurrent infection, bladder changes; haematuria.

Surgeries

Transurethral Resection of Prostate (TURP)

Using cystoscope with fluid like glycine irrigating continuously, enlarged prostate is identified and resected using a loop with a hand control. Resection is done using high frequency diathermy current, above the level of verumontanum. After surgery, continuous bladder irrigation using normal saline is done using three way Foley's catheter. Antibiotics should be given. Catheter is removed in 72 hours. ***Postoperative complications are:*** Water intoxication with congestive cardiac failure—TURP syndrome; hyponatraemia; haemorrhage; infection; incontinence; perforation of the bladder or prostatic capsule; stricture urethra; retrograde ejaculation and impotence; recurrence **(Figs 27-58 and 27-59)**.

TURP

- No suprapubic incision
- Most common and popular method
- Done using resectoscope
- Recurrence may occur in large prostate
- TURP syndrome can develop
- Continuous postoperative irrigation using glycine solution is needed for 72 hours
- Faster recovery and early discharge is possible.

Freyer's Suprapubic Transvesical Prostatectomy

Before TURP, it was a popular and was the procedure of choice for enlarged prostate. Under spinal anaesthesia, through Pfannenstiel incision, rectus sheath is opened horizontally; recti are split; peritoneum is not opened; it is pushed upwards beyond the dome of the bladder. Urinary bladder is identified by its muscle pattern and lateral vesical

Fig. 27-58: TURP is done using cystoscope and resectoscope.

Fig. 27-59: Asepto syringe for bladder irrigation.

venous plexus. Bladder is confirmed by aspirating urine. Stay sutures are placed one at the dome another at the lower part of the bladder. Urinary bladder is opened vertically; urine is sucked out. Deaver retractor is placed on the dome of the bladder. Prostate is felt by index finger. With finger dissection anterior plane is created by opening the prostatic urethra anteriorly. Lateral lobes and median lobe are removed by finger dissection. Posterior lobe is not removed. Warm pack is kept on the prostate bed to control bleeding. Vicryl sutures are placed on either sides of the raw area to control bleeding. Often anterior and posterior wedge at the vesicourethral junction need to be excised to prevent later urinary obstruction. 24-30 F 3 way Foley's catheter is passed from urethra into the bladder; balloon is inflated adequately; traction is given to the catheter so that balloon creates tamponade and control of the haemorrhage. Malecot's catheter is placed through the bladder at a separate stab incision which is brought out through a separate stab wound at the abdominal wall. Bladder wall is closed using 2 zero vicryl sutures. Another tube drain is placed in the Retzius space. Recti are sutured; rectus sheath is closed; skin is closed. Complications are haemorrhage, infection, stricture urethra, incontinence, impotence, bladder neck contracture.

Millin's Retropubic Prostatectomy

Here urinary bladder is not opened; retropubic space is dissected to identify the prostate which is enucleated. Urethra is sutured; drain is placed and wound is closed. 3 way Foley's catheter should be placed in the bladder across the urethra. It is done without opening the bladder. Cystoscopy should be done before doing retropubic prostatectomy as bladder is not opened during surgery. Pfannenstiel extraperitoneal approach is used under spinal anaesthesia. Self retaining retractor is placed. Supine head down position is used. Fat on the surface of prostate behind the pubis is gently cleared off. Bipolar or unipolar diathermy should be used area is vascular. Puboprostatic ligament is ligated and divided. Prostatic capsule is incised 1 cm below the bladder neck transversely. Stay sutures using 2 zero vicryl should be placed on both sides. Once prostate with adenoma is exposed, anterior commissure of the prostatic lobes are opened to enter the prostatic urethra. With finger dissection prostate is separated from the capsule entirely first on one side then on opposite side. Mop is placed over the area to control bleeding. Middle lobe is again excised using finger. Prostatic urethra may need to be divided above the level of verumontanum. 24 F Foley's 3 way catheter is passed per urethrally into the bladder; traction to that will control the bleeding. Capsule is sutured using 2 zero vicryl. Drain is placed in the retropubic space. Wound is closed in layers. Complications are – haemorrhage, infection, extravasation, urethral stricture, incontinence.

Young's perineal prostatectomy through perineal approach.

Other Methods

Microwave hyperthermia treatment with temperature of 45–50 degree; laser treatment is becoming popular, using holmium laser; high energy electromagnetic treatment; placement of intraurethral stents at prostatic urethra; placement of extrauretheral stents which are inert; transurethral balloon dilatation of the prostate; if patient presents with acute retention of urine, initial urethral catheterisation is done. If not possible then *suprapubic trocal cystostomy* ideally or formal open SPC is done. Once patient's obstructive uropathy is under control, TURP is done after 7-14 days after evaluation.

Specific Problems after Surgical Intervention of Prostate

Retrograde ejaculation—65%; Erectile dysfunction—5%; Failure, recurrence of symptoms and enlargement—10%; Need for re TURP/surgery in 10 years—15%; Severe sepsis—6%; Recurrent late urinary infection—20%; Postoperative haematuria—3% needs transfusion; Mortality in TURP is 0.5%.

Other methods used for BPH

- Transurethral incision of prostate—TUIP
- Laser ablation
- Transurethral microwave therapy—TUMT
- Transurethral needle ablation using high frequency radiowaves—TUNA
- High intensity US energy
- Water induced thermotherapy—through a balloon placed in prostatic urethra
- Prosthetic stents
- Balloon dilatation

PROSTATIC ABSCESS

It is infection, suppuration and pus formation in the prostate gland. Presentation is fever, rigors, perineal pain, urinary disturbances, and tender soft fluctuant swelling in the prostate on rectal examination. Often presentation may be retention of urine. Total count will be increased. Urine microscopic examination will show pus cells. US is diagnostic. Ultrasound is often done over perineum also. Treatment is antibiotics; US guided aspiration transperineally in lithotomy position or transperineal incision and drainage. Suprapubic cystostomy is better in case of retention of urine. After drainage antibiotics are needed for longer period of weeks to prevent recurrent infection.

RADICAL PROSTATECTOMY

Radical retropubic prostatectomy is the treatment of choice in early carcinoma of prostate. Procedure can be done through laparoscopy or robotic assisted. Adenocarcinoma occurs in peripheral zone; not in central zone. Urethra passes through central zone.

Technique

Under spinal or general anaesthesia and patient is placed in supine with head down position. 30 F Foley's catheter is passed per urethrally and inflated with 30 cc distilled water. Lower midline incision is made. Anterior rectus sheath is incised; recti are retracted; space of Retizus is reached. Peritoneum is not opened. Blunt dissection is used to reflect the peritoneum above both sides to expose iliac vessels, obturator fossae and ductus deferens. Obturator and iliac lymph nodes are cleared from the bifurcation of the common iliac vessels above up to obturator nerve behind; below up to the pubic bone and along the obturator fossae on both sides. Bladder is retracted above with a retractor and by pulling up of the balloon of the Foley's catheter passed; endopelvic fascia is incised and puboprostatic ligament is divided. Superficial dorsal vein is divided. Bipolar cautery is used carefully. Deep dorsal vein is identified and securely ligated using no 1 vicryl by transfixation at two places to avoid injuring neurovascular bundle of Walsh (when nerve sparing dissection is planned). It is divided in between. Dorsal venous complex may extend posteriorly which is tackled better using harmonic scalpel. But care should be taken not to injure the nerve bundles and urethral sphincters by these energy sources. Judicious use of these instruments is needed. Ligation even though technically difficult and time consuming if often seems better. Once these veins are divided apex of the prostate and membranous urethra are exposed. Urethral wall is divided after placing four stay sutures at four angles (anchor sutures) on its wall which facilitates anastomosis later between bladder and urethra. Foley's catheter is divided after applying clamp on its balloon end side which prevents balloon getting deflated which is used for bladder traction later. Posterior wall is divided and rectourethralis. Denonvillier's fascia is identified which is divided in midline distal to apex of the prostate. In nerve sparing radical prostatectomy, dissection should be careful to preserve neurovascular bundle. Retrograde dissection once completed, ureteric orifices are identified by injecting the indigocarmine intravenously. Bladder neck posteriorly is dissected from the seminal vesicles to reach the isolated bladder neck which is transected. Bladder neck preservation by preserving the circular muscles will compromise the clearance of the tumour. Vas deferens, seminal vesicles are removed enbloc with the prostate.

Haemostasis is achieved by underruning the prostate bed using 3 zero vicryl sutures. Vesicourethral anastomosis is done using 3 zero vicryl or monocryl as water tight around 22 F Foley's catheter. Suction drain in the retropubic space is needed. Wound is closed in layers.

Complications

Bleeding, infection, septiacaemia, pelvic abscess formation, stricture or incontinence are complications.

TREATMENT OF STRICTURE URETHRA (FIG. 27-60)

Intermittent Dilatation

Gradual dilatation, initially with thin dilators, later with thicker dilators of increasing size. Dilatation should be done in operation theatre under aseptic precaution. One should avoid forcible dilatation or over dilatation. Dilatation is done "*Once a week for one month, once a month for one year, and later once a year.*

Fig. 27-60: Ascending urethrograms showing single and multiple strictures in two patients.

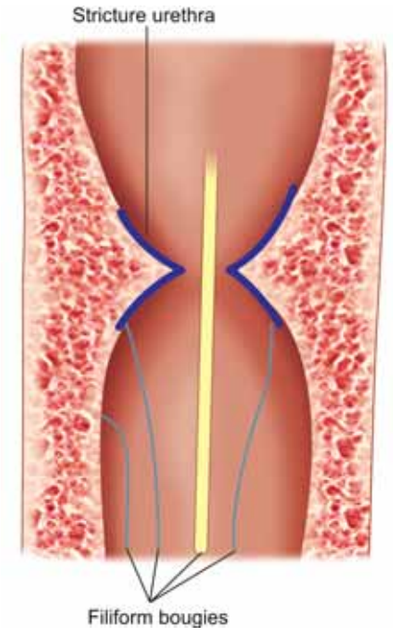


Fig. 27-61: Filiform bougies are used to dilate narrow stricture urethra. One of the bougies will be passed into the urethra (Faggot).

Dilators used: Lister's dilator [has got olive tip (blister)]; Clutton's dilator; Filiform bougies **(Fig. 27-61)**.

Complications of dilatation are - Infection and bleeding due to trauma; false passage; fistula formation.

Visual Internal Cystoscopic Urethrotomy or Stricturotomy

Here using cystoscope, stricture is visualised and is cut at 12 o'clock position, until it bleeds (fibrous tissue is cut completely). After that Foley's catheter is passed and kept in position for 48 hours **(Fig. 27-62)**.

External Urethrotomy

It is done by open method. Presently it is not commonly done as cystoscopic urethrotomy is more popular. It is presently done as an initial stage surgery for urethroplasty *(Wheelhouse's operation*).

Urethroplasty

Stricture is excised and urethra is reconstructed using *prepuceal skin* or scrotal skin *(Johanson's urethroplasty).*

Problems in urethroplasty are - Staged procedure and so prolonged hospitalisation; infection; necrosis of skin flap; leak and fistula formation; restenosis.

Complications of stricture urethra

- Retention of urine
- Urethral fistula
- Infection—urethritis, cystitis, pyelonephritis
- Urethral diverticula
- Periurethral abscess
- Bilateral hydronephrosis
- Stone formation
- Renal failure
- Due to straining—hernia, haemorrhoids, rectal prolapse

TREATMENT OF HYPOSPADIAS

Staged Procedure (Fig. 25-63)

I. At the age of one and half years, surgical correction of the chordee is done.
II. At the age of 5-7 years, reconstruction of urethra is done using *prepucial skin* (ideal) or scrotal skin if the patient has been circumcised. Best is prepucial skin. *Perineal urethrostomy is done for diversion*. Perineal urethrostomy should be there until reconstruction of urethra takes up well *(Denis-Browne procedure).*

Fig. 27-62: Cystoscopic view of the stricture urethra which needs internal urethrotomy.

Fig. 27-63: Hypospadias which needs staged repair.

Magpi repair: Meatal advancement glandular repair—for glandular hypospadias.

*In hypospadias, circumcision is contraindicated as prepucial skin is required for future urethroplasty***.**

TREATMENT OF POSTERIOR URETHRAL VALVE

Micturating cystourethrography (MCU) is diagnostic. It shows dilated proximal urethra. U/S abdomen shows cricket ball bladder. Blood urea and serum creatinine should be done. IVU may be needed. Antenatal US shows fetal urinary tract dilatation.

Differential diagnosis - *Marion's disease:* Bladder neck obstruction due to hypertrophied interureteric bar. MCU differentiates it from posterior urethral valve. Treatment is Y-V plasty *(Bonin's Y-V Plasty)*. Neurogenic bladder also mimics same.

Treatment

Initial SPC and later cystoscopic resection of the posterior urethral valve is done usually after several weeks.

TREATMENT URETHRAL STONES

If it is impacted in the external meatus or fossa navicularis, meatotomy and extraction of the stone is done (Meatotomy is cutting and widening of external meatus so as to have an easy stone extraction). If it is impacted in other parts of the urethra, urethroscopy and removal of stone from urethra is done or through a cystoscope the stone is pushed into the bladder and then extracted. In case of retention of urine, initial suprapubic cystostomy is required before removal of the stone. Diverticulum and stricture urethra should be treated accordingly.

Complications of urethral stones: Bleeding, stricture urethra and infection.

Chapter

28

Obesity and Morbid Obesity

OBESITY AND MORBID OBESITY

Obesity is weight more than 20% above the normal. Body mass index (BMI) is weight in kilogram divided by height in meters squared [wt in kg/(Ht in meters)^2].

Morbid obesity is a condition wherein BMI is more than 40 kg/m^2. It is often also defined as weight 100 lbs or more; or 100% over ideal body weight.

Weight more than double the expected weight to that age and height of the individual is also often called as *morbid obesity*. If body weight exceeding BMI 50 kg/m^2 is called as *superobesity*.

Causes of Obesity

- Familial, hyperinsulinism, hyperadrenocorticism, hyogonadism.
- Abnormal eating behaviour—Hormones which control eating are– ghrelin from stomach; insulin from pancreas; leptin from fat; PYY 3-36 from colon. Hypothalamus is the center in CNS which controls eating.

Nutritional status	*BMI (kg/m^2)*
• Underweight	• < 18.5
• Normal	• 18.5-24.9
• Overweight (Preobesity)	• 25.0-29.9
• Obesity	• > 30
– Class I	– 30.0-34.9
– Class II (Moderate)	– 35.0-39.9
– Class III (Severe/Morbid)	– 40.0
• Superobesity	• > 50
• Super superobesity	• > 60

Complications of obesity	*Obesity and surgery*	*Treatment for obesity*
General: Difficulty in work, fatigue, depression, back pain, arthritis and gout *Cardiovascular*: Hypertension, stroke, thrombophlebitis, pulmonary embolism	• Hernia and gall stones are more common in obese individual. • Burst abdomen, incisional hernia are more common in obesity	*General*: Dieting, exercise *Drugs*: Orlistat, Sibutramine *Surgeries*: • *Restrictive* – Vertical banded gastroplasty

Contd...

Contd...

Complications of obesity	*Obesity and surgery*	*Treatment for obesity*
Pulmonary: Hypoventilation, poor respiratory effort *GIT*: Hiatus hernia with reflux, changes in liver, pancreatitis, gall stones *Endocrine*: Diabetes mellitus	• Delay in recovering from anaesthesia • Infertility is more common	– Laparoscopic adjustable gastric banding (LAGB) – Jaw wiring • *Malabsorptive* – Biliopancreatic diversion (BPD) – Biliopancreatic diversion with duodenal switch (BPD – DS) – Jejunoileal bypass • *Combined* • Roux-en-Y gastric bypass (RYGB) open or laparoscopic

Obesity is more common in young women. Child of a normal weight parents has 10% chance of become obese. If both parents are obese then child has got 80% chances to develop obesity.

Problems with Morbid Obesity

Obstructive sleep apnoea, degenerative joint disease, back pain, hypertension, GERD, gall stones, type II diabetes, hyperlipidaemia, arrhythmias, venous diseases, DVT, skin diseases, urine incontinence, infertility, ventral hernias, obesity hypoventilation syndrome, polycystic ovarian disease, hirsutism, gynaecomastia, steatohepatosis, malignancies—are common problems. All these conditions are called as *comorbidities*.

Infertility is common in married morbid obese women due to improper ovulation, polycystic ovary disease. Urinary incontinence is common in morbid obese women (stress incontinence and detrusor instability). Pregnancy in morbid obese patient is considered as high risk pregnancy. Gestational diabetes, hypertension, are common. It is better these women to undergo bariatric surgery prior to pregnancy which definitely reduces the complications during pregnancy. Such individual after bariatric surgery needs more iron and vitamin supplements.

Evaluation of the patient – cardiac, respiratory assessment, lipid profile, blood glucose, renal and liver status assessment, anaesthesia risk assessment.

Medical Management

- *General:* Diet, life style changes, exercise.
- *Drugs*: (1) Orlistat is a selective inhibitor of gastric and pancreatic lipases that reduces the absorption of lipids from intestine. (2) Sibutramine is a noradrenaline and 5 HT reuptake inhibitor which act as appetite suppressor.

Surgical Treatment (Bariatric Surgery)

Bariatric surgery causes long term durable weight loss. Patient's eating behaviour is reduced to slow ingestion of small boluses of food and or also reducing the absorptive surfaces.

Types of Bariatric Surgery

1. *Restrictive* wherein caloric intake is reduced. Purely gastric restrictive procedures are vertical banded gastroplasty (VBG) and laparoscopic adjustable gastric banding (LAGB).
2. *Malabsorptive* wherein absorption of calories and nutrients from food is reduced. Biliopancreatic diversion (BPD) and biliopancreatic diversion with duodenal switch (BPD–DS) are malabsorptive procedures.
3. *Combined* wherein both methods are used. Roux-en-Y gastric bypass (RYGB) is both restrictive and malabsorptive types. Gastric bypass reduces GI polypeptide ghrelin level secreted from fundus of stomach and duodenum. Ghrelin acts on specific receptor in CNS – hypothalamus to initiate appetite. This stimulation is reduced to decrease appetite. In restrictive only procedure ghrelin level raises and so appetite stimulation is not controlled.

Indications for Bariatric Surgery

BMI more than 40 kg/m^2 or BMI more than 35 kg/m^2 with comorbidity is indication for bariatric surgery. American Association of Bariatric Surgery (ASBS) published indications and approved surgeries.

Contraindications

Patients who are unfit for general anaesthesia (cardiac/renal/respiratory/hepatic) or who are unable to adjust postoperative life styles or psychiatric patients are contraindications for bariatric surgery.

Preoperative preparations and evaluations are:

- Complete cardiac, respiratory/renal/hepatic evaluation.
- Lipid profile and blood glucose assessment.
- Obstructive sleep apnoea in obese patient should be assessed using polysomnography and be treated.
- Risk assessment for DVT should be done.
- If GERD symptoms are present gastroscopy should be done.
- USG abdomen to identify gallstones should be done; if gallstones are present it is of usual practice to do cholecystectomy along with bariatric procedure.
- Nutritional evaluation and dietician advice for preoperative and postoperative diet management.
- Psychological screening is needed to all patients to counsel their postoperative care and diet.
- Separate theatre table is needed for morbid obese patient. Equipments should be long and flexible. In laparoscopic surgery, special ports and instruments are needed.

DIFFERENT SURGERIES

Vertical Banded Gastroplasty (VBG); Mason (1982)

It is a purely restrictive type with creation of a calibrated stoma in the lesser curvature which is reinforced by an encircled mesh with a proximal gastric pouch. After laparotomy Ewald's stomach tube is passed per orally to place against lesser curve. A 2.5 cm circular window is created in the body of stomach near lesser curvature 8 cm below the *angle of His*. After this, four lines of linear vertical stapling are done from circular opening towards angle of His. This staple line ideally should be divided using another cutting linear stapler to reduce chances of dehiscence. This creates a 50 ml proximal gastric pouch. A 1.5 × 7 cm polypropylene mesh is placed around the lesser curve through circular opening and sutured to create a 5 cm collar stoma **(Fig. 28-1)**.

VBG causes only medium term weight loss; its efficacy is less compared to other procedures. *Complications of VBG are* – stricture at stoma (20%), vomiting (30%), reflux (20%), staple line dehiscence (40%), conversion into other procedures. Mortality is 0.3%.

VBG is technically easier to do; it has got very less chances of long term metabolic and nutritional deficiencies.

Laparoscopic Adjustable Gastric Banding (LAGB)

It is also a restrictive type (1992, Guy Bernard) to create a narrow stoma just below the OG junction. It is used in adolescents and elderly. It is contraindicated in hiatal and paraoesophageal hernias. It is done using *laparoscopy*.

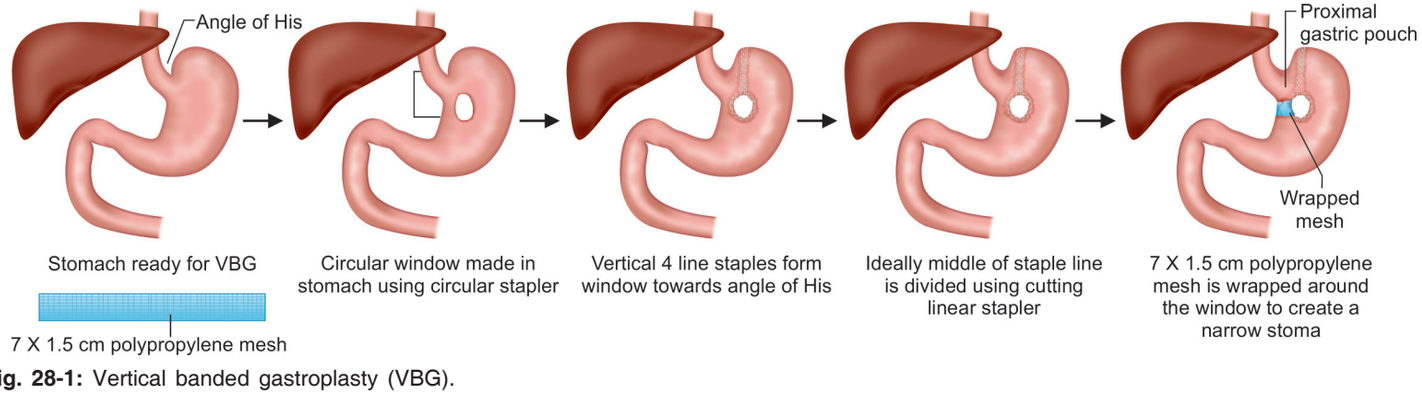

Angle of His
Proximal gastric pouch
Wrapped mesh
Stomach ready for VBG
7 X 1.5 cm polypropylene mesh
Circular window made in stomach using circular stapler
Vertical 4 line staples form window towards angle of His
Ideally middle of staple line is divided using cutting linear stapler
7 X 1.5 cm polypropylene mesh is wrapped around the window to create a narrow stoma

Fig. 28-1: Vertical banded gastroplasty (VBG).

Under general anaesthesia, with patient in reverse trendelenburg position six laparoscopic ports are placed. Using pars flaccida method, retrogastric tunnel is created; a silicone band is passed through the tunnel to encircle the cardia just below the OG junction; tail of the band is buckled and locked. Stoma diameter is determined by inserting a calibration tube. Stomach over the band is imbricated using interrupted sutures except the buckle area. Silicone tube end is brought out through the abdominal wall to connect access port. It is used for band volume adjustment by injecting or withdrawing the saline.

Gastrograffin study is done on 1st postoperative day to assess band position and lumen patency. Patient is advised to have liquid diet for one month. Band adjustment is done under fluoroscopic guidance in 2 months. Adjustment is done to achieve weight loss at a rate of 2 kg/week. Efficacy of LABG is 55% **(Fig. 28-2)**.

Complications of LABG are – spleen/stomach injury; bleeding; band slippage (10%); band erosion (7.5%); tube related complications; vomiting; pouch dilatation; reflux. Conversion rate is 3%; mortality is less than 0.5%.

Jejunoileal Bypass

It was the first malabsorptive procedure done for obesity. Now this technique is not done due to high incidences of complications.

Proximal jejunum is divided and proximal cut end is anastomosed to distal ileum just proximal to ileocaecal valve to reduce the absorptive surface area of small bowel **(Fig. 28-3)**.

Complication rates were higher and so procedure is not practiced. Colon in these patients absorbs high level of oxalate causing nephrocalcinosis. Bypassed bowel promotes bacterial growth causing endotoxin induced liver injury, cirrhosis, liver failure. Complications like protein, vtamin K, vitamin B_{12} deficiencies; gallstone formation; enteritis and diarrhea; arthritis, osteoporosis are common.

Roux-en-Y Gastric Bypass

It is commonly done combined procedure. It can be done by open or laparoscopic method. Proximal stomach is dissected between 1st and 2nd branches of left gastric artery. Vagii nerves and *nerves of Latarjet* are retained carefully. Stomach is transected at this proximal site to create a proximal gastric pouch (15 ml if BMI is > 50; 30 ml if BMI is 40-50). It is usually carried out through linear stapler. Jejunum is transected 45 cm from *ligament of Treitz*. A side to side jejunojejunal anastomosis is done using stapler 75 cm distal to the distal cut end. Proximal Roux part of the distal jejunal cut part (75-150 cm, based on patient's preoperative weight) is brought out through the transverse mesocolon towards the created proximal gastric pouch and gastrojejunostomy is done to this proximal gastric pouch. Mesenteric defect is closed. Stomal integrity is checked on table by air distension and methylene blue infusion. Gastrograffin study is done in 24 hours to assess pouch size, stomal patency and distal obstruction. Oral food is started in 24 hours and patient is discharged in 4 days **(Fig. 28-4)**.

RYBG is more useful in weight loss compared to purely restrictive types. 5 year weight loss is 60-75%. It also prevents progression of non insulin dependent diabetes mellitus, controls hypertension, sleep apnoea, hyperlipidaemia, asthma, arthritis, GERD.

Complications are – Roux obstruction, anastomotic leak, acute distal gastric dilatation, stomal stenosis, marginal ulcer, dumping syndrome, internal hernias, vitamin B_{12} deficiency, iron deficiency anaemia. Distal gastric dilatation needs emergency intervention which is usually due to jejunojejunal obstruction.

Laparoscopic RYGB (1994, Wittgrove, Clark, Trembly)

Technique is similar to open RYGB. Anastomoses are done using endoscopic stapler. GJ between gastric pouch and Roux jejunum is done either using linear stapler through laparoscopic port after making a gastrotomy in the pouch which is later sutured after staple firing; or by using circular stapler anastomosis is done wherein anvil is initially passed transorally often under endoscopic guidance across the pouch into the Roux jejunum; or by using hand sewing with absorbable sutures. Omentum is released from the colon and is covered over the GJ. Mesenteric defect and *Patterson Brown defect* are closed. A *Brolin antiobstructive stitch* is placed between Roux and biliopancreatic limbs. Integrity of anastomosis is checked using insufflation of air, methylene blue. *Complications ar*e similar to open RYBG. Conversion rate is 9%. *Advantages* of LRYBG to open RYBG are—faster recovery, less postoperative pain, less wound related complications, less morbid one. *Disadvantage* of LRYBG is availability of facility, technical expertise, and steep learning curve.

Now technique is modified to antegastric, antecolic one which has become popular (Gagner).

Biliopancreatic diversion (BPD) (Nicola Scopinaro, Italy)

It is done in patients who had failed restrictive procedure or who are superobese.

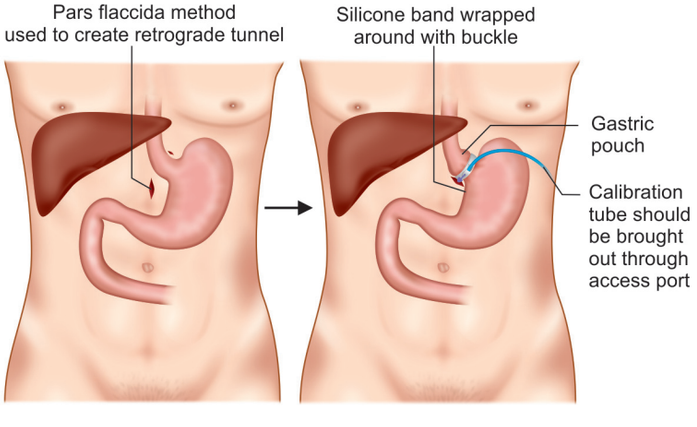

Pars flaccida method used to create retrograde tunnel
Silicone band wrapped around with buckle
Gastric pouch
Calibration tube should be brought out through access port

Fig. 28-2: Laparoscopic adjustable gastric banding (LAGB).

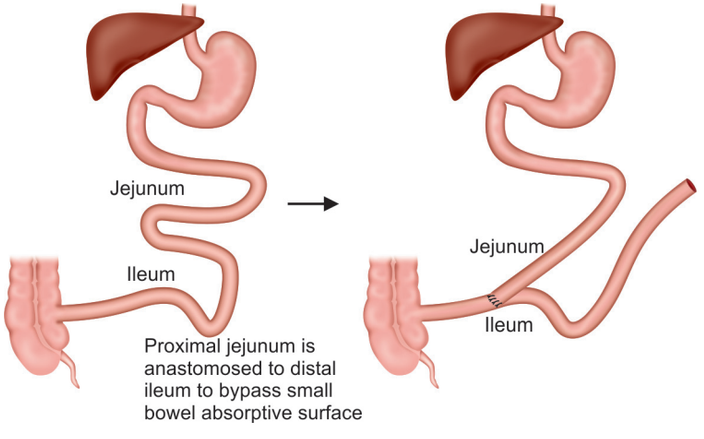


Fig. 28-3: Jejunoileal bypass procedure (JIB).

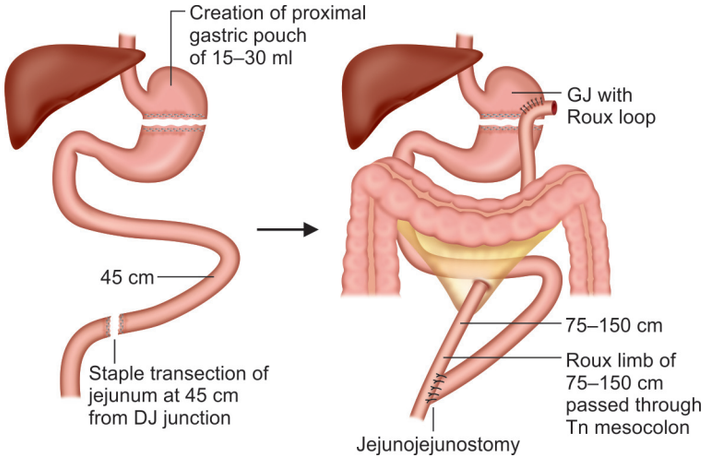

Creation of proximal gastric pouch of 15–30 ml
GJ with Roux loop
45 cm
75–150 cm
Roux limb of 75–150 cm passed through Tn mesocolon
Staple transection of jejunum at 45 cm from DJ junction
Jejunojejunostomy

Fig. 28-4: Roux-en-Y Gastric bypass procedure (RYBG).

Distal subtotal gastrectomy is done with formation of proximal gastric pouch (of 400 ml in BMI 40-50; 200 ml in BMI >50). Ileum is transected 250 cm proximal to ileocaecal valve; distal ileal segment is brought up to anastomose into the proximal gastric pouch. Proximal biliopancreatic jejunoileal limb is anastomosed into distal ileal segment 50 cm proximal to ileocaecal valve as end to side stoma. Additionally cholecystectomy should be done **(Fig. 28-5)**.

Modification of BPD with duodenal switch (BPD–DS) has become more popular. Here sleeve gastrectomy along the greater curvature is done to create gastric reservoir (200 ml) along lesser curve. Duodenum just distal to first part is divided using stapler; proximal cut end is sutured to proximal upward pulled end of the distal ileal segment of earlier transected ileum, 250 cm from ileocaecal valve. Biliopancreatico duodenal with proximal jejunoileal segment is later stapled to distal ileum 50 cm proximal to ileocaecal valve. Duodenal switch reduces the marginal ulcer rate and dumping syndrome.

Results of BPD/BPD-DS are excellent for weight reduction compared to restrictive procedures. But they need lifelong supplement of vitamins, fat soluble vitamins, calcium, and iron. Technically BPD is easier to do when compared to BPD–DS **(Fig. 28-6)**.

Complications of BPD/BPD-DS are—anemia (30%); protein deficiency (20%); dumping syndrome; marginal ulcer (in BPD 10%; in BPD-DS it is 1%); osteoporosis; night blindness; biliopancreatic limb obstruction; staple line leak; staple line bleed; DVT; subphrenic abscess. Vitamin B_{12} deficiency is specific.

Cholecystolithiasis after Bariatric Surgery

Gall stone formation is common after bariatric surgery (50%). It is due to rapid weight loss. If gall stones are present at the time of bariatric surgery it is essential to do laparoscopic cholecystectomy during bariatric procedure. It is controversial about doing prophylactic cholecystectomy during bariatric surgery even though it is practiced in many places. Advantages are – it prevents future gall stone formation after bariatric surgery (loss of access); it prevents difficulties in approaching CBD in case needed endoscopically due to surgery. Disadvantage is cholecystectomy adds additional 1 hour time for bariatric surgery increasing the risk of immediate complications. Patients who are not having gall stones after bariatric surgery should

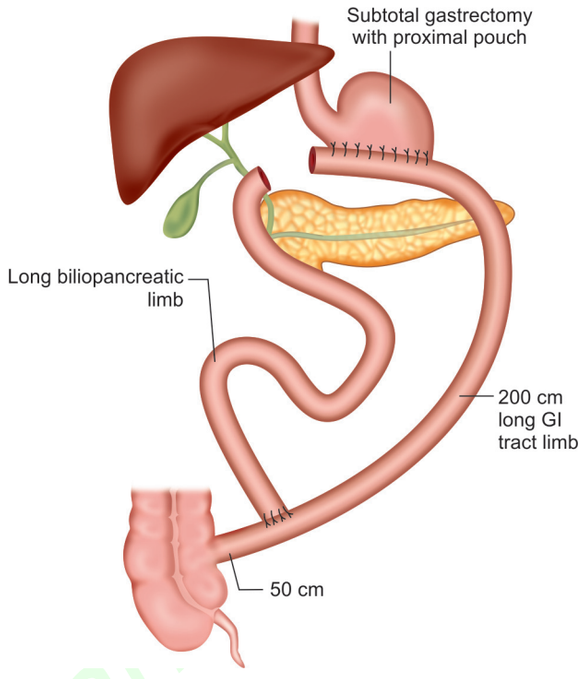


Fig. 28-5: Biliopancreatic diversion procedure (BPD).

receive ursodeoxycholic acid 300 mg twice daily for 6-12 months post bariatric surgery period. Often stomach is anchored to abdominal wall as access part to biliary system for future need.

Note: Many of these patients require abdominal contour plastic surgery (panniculectomy, abdominoplasty) after weight reduction due to bariatric surgery.

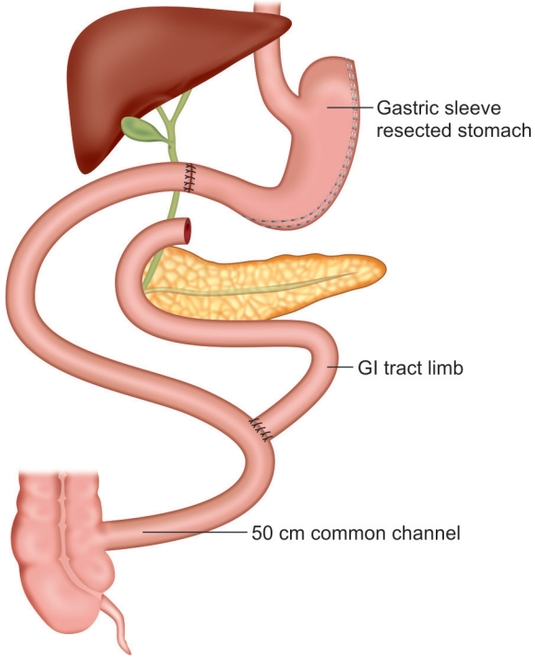


Fig. 28-6: Biliopancreatic diversion with duodenal switch procedure (BPD–DS).

Bariatric Surgery

Only effective therapy for severe obesity is bariatric surgery.
80% of bariatric surgeries are gastric bypasses specifically laparoscopic approach.
Original gastric pouch was of 150 ml volume with loop gastrojejunostomy which is later changed to a pouch of < 20 ml volume with Roux-en-Y gastrojejunostomy.
Indications are – BMI more than 40 Kg/m^2 or BMI more than 35 Kg/m^2 with comorbidity (diabetes, hypertension), sleep apnoea, obesity hypoventilation syndrome.
Management needs – bariatric surgeon, nutritionist, physician, pulmonologist, cardiologist, endocrinologist, psychiatrist, psychologist and anaesthesiologist.
Principle – bypassing the gastroduodenum blocking the neurohumoral effect; rapid delivery of food to hindgut; early satiety; malabsorption. Usually 75 cm Roux limb is used; longer limb of 150 cm Roux limb is used for BMI more than 50 Kg/m^2.

Technique –
Access - Supine position; operating surgeon stands on the right side; 5 mm optical viewing trocar; left upper quadrant Veress needle and trocar; 5 mm liver retractor, is placed and anchored to the bed with a self-retaining device; wider trocar for endostapler (12 mm).
The Roux limb creation - The transverse colon and omentum are placed towards the upper abdomen; ligament of Treitz is identified; proximal jejunum is oriented as proximal and distal parts by C configuration; jejunum is divided 50 cm distal to the ligament of Treitz using linear cutting stapler; the mesentery of the jejunum divided using two stapler firings; sufficient length of mesentery is created to achieve adequate tension-free passage Roux limb; the Roux limb is marked. Roux limb is measured distally for 75 cm from the marker; bowel should be straightened (not stretched) while marking; side to side jejunojejunostomy anastomosis is done after doing jejunotomies using harmonic scalpel between the biliopancreatic and the Roux limb using linear stapler; jejunotomy ends are closed using another lineal stapler firing. Reinforcing sutures may be placed using 3-0 silk. One reinforcing stitch is placed between the stapled end of the biliopancreatic and the Roux limb - *Brolin stitch*. One more is placed proximally at the crotch between the biliopancreatic and Roux limb. The mesenteric defect (*Patterson Brown defect*) between the biliopancreatic and Roux limb is then closed with a continuous vicryl or silk 3 zero suture.
Greater omentum is divided at the level of the midtransverse colon using the harmonic scalpel. The Roux limb is passed upward between the leaves of the divided omentum to the gastric pouch in the *antecolic* and *antegastric* approach.
Creation of gastric pouch - The patient is placed in the steep reverse Trendelenburg position; window is created in the gastrohepatic ligament with the harmonic scalpel. Linear stapler is fired toward the gastric lesser curvature to divide the lesser omentum and descending branch of the left gastric artery but the main left gastric arterial trunk should be preserved which is the main blood supply of the gastric pouch. Gastric pouch of 15-20 ml is created by sequential firing using lineal staplers from lesser curve towards the angle of His. Gastric pouch is dissected off from left crus to achieve pouch mobility and to reduce tension while creating GJ; pouch is also properly separated from gastric remnant below to avoid gastrogastric fistula.
Creation of GJ – Linear: posterior suture line between gastric pouch and Roux limb → gastrotomy and jejunotomy creation using harmonic scalpel → GJ is done using lineal stapler → stapler entry common opening is sutured using 3 zero silk with endoscope in place → GJ is checked for leak and bleeding (*bleed and leak test* by insufflation using endoscope). *Transoral circular stapler method* - Gastroscope is passed into the pouch → snare is pushed through a small gastrotomy → guidewire is passed through a laparoscopic port which is grasped by the snare to pull out through the mouth → anvil of the stapler is attached to the guidewire and pulled antegrade into the gastric pouch → the circular stapler is passed in the open end of the Roux limb → the stapler and anvil are connected → the stapler is fired to create a circular stapled GJ anastomosis → the open Roux limb is closed with a linear stapler. *Circular transabdominal and hand sewn* are other methods. Jackson Pratt *drain* is placed behind the pouch; omentum is placed and sutured on the GJ as Schauer cap. Roux limb may be stitched (one stitch) to the gastric remnant to avoid its twist.
Leak test – It is done by initially occluding the Roux distal limb with a clamp and by submerging the GJ with warm normal saline and pouch is insufflated with air through endoscope.
At the end *cholecystectomy* is done; if not patient is put on ursodeoxycholic acid for 6-12 months. Additional core needle biopsy performance is a controversial.
Postoperative management - Pain control; antiemetics; essential preoperative medications are continued as IV until the patient is started on liquids; incentive spirometry use; nil orally on the night of surgery; Gastrografin swallow study on 1st postoperative day (must); if the swallow study does not show any leak or obstruction, then oral clear fluid is started; monitoring; cardiac evaluation; psychiatrist counseling; drain removal on 7th day.
Complications – gastric leak (1-5%), sepsis, pulmonary embolism (1%) are major complications. Fever, tachycardia, tachypnea are probable features of leak. Acute dilation of the gastric remnant is less than 1% in incidence but life threatening; it is due to obstruction of the biliopancreatic limb; presents as severe epigastric pain with gastric distension; plain X-ray is useful; CT scan is diagnostic; it is treated with emergency decompression by percutaneous gastrostomy; the biliopancreatic limb obstruction is managed surgically only once the patient has stabilised. Wound infection rate is 10%. Infections of laparoscopic trocar sites can occur.
Late complications are - Marginal ulceration at GJ site (10%) is due to ischemia, smoking, gastrogastric fistula, large pouch size, retained anastomotic suture, NSAID; *Helicobacter pylori* infection. Late bowel obstruction can occur which is due to an internal hernia 1-10%; if episodic abdominal pain or recurrent partial small bowel obstruction, laparoscopic exploration is performed; often obstruction is due to intermittent bowel herniation through a mesenteric defect. Anastomotic stricture at GJ can occur due to tension on the Roux limb or pouch ischaemia or chronic marginal ulcer, usage of circular stapler; strictures occur 1 to 3 months after surgery; Present with dysphagia, vomiting; treated with endoscopic balloon dilations in 2-3 times. Nutritional deficiencies like deficiency of iron (30%); folate (35%); vitamin B_{12} (25%); anemia (up to 54%) can occur. Very late long term complications like severe protein calorie malnutrition requires revision surgery to lengthen the common channel.

Chapter

29

Adrenal Gland Surgeries

ADRENAL GLAND SURGERIES

Adrenalectomy is the standard treatment for adrenal tumours, bilateral adrenal diseases like primary adrenal hyperplasia, incidentalomas more than 5 cm in size, and often metastases in adrenal gland.

Surgical Anatomy of Adrenal Glands

The adrenal glands are named in relation to the kidneys. The term "adrenal" comes from Latin – *ad* means "near"; and *renes* means "kidney". Suprarenal is derived from Latin – *supra* means "above" and *renes* means "kidney". Adrenal glands are essential endocrine glands.

Two suprarenal endocrine adrenal glands are located in the retroperitoneum along the upper pole and medial part of the kidneys in front of the crus of diaphragm opposite 12th rib and vertebral end of 11th intercostal space. Each adrenal gland is 5 × 3 × 1 cm in dimensions weighing 5 grams. Adrenal gland is within renal fascia but separated by a fascial septum from kidney. Right gland is *triangular* in shape (top hat); left one is *semilunar* (cocked hat). Gland is yellow or mahogany (reddish-brown) or *golden-orange* in colour. Right adrenal is relatively higher than left adrenal (right kidney is lower level than left kidney). Between two adrenal glands structures present are – crura, the aorta and coeliac arteries, coeliac plexus and inferior vena cava. Kidney may be ectopic or ptotic but adrenal will be in the original position. But fusion of kidney like horse shoe kidney may have fusion of adrenal glands also **(Figs 29-1 and 29-2)**.

Right Adrenal Gland

It has got a base, an apex, anterior and posterior surfaces, anterior, medial and lateral borders. Anterior surface is related to inferior vena cava medially, bare area of the liver laterally, duodenum below. It is devoid of peritoneum. Posterior surface is related to right crus of diaphragm above and right kidney below. Hilum of right adrenal is near upper end. Apex is related to bare area; base is related to upper pole of right kidney. Three arteries supplying the right adrenal gland course behind the IVC. Right adrenal vein arises near upper part of the hilum. Right adrenal gland is not very close to right kidney (unlike left adrenal gland which is very closely attached to left kidney).

Left Adrenal Gland

It has got narrow upper end and round lower end. Upper end is related to posterior end of spleen; hilum of left adrenal gland is near lower end through which left adrenal vein exits. Anterior surface is related to cardiac end of stomach, splenic artery and pancreas. Gastric related part only is covered with peritoneum/omental bursa. Posterior surface is related to left kidney laterally, left crus of diaphragm medially. Medial convex border is related to left celiac ganglion, left inferior phrenic artery, left gastric artery. Lateral concave border is related to the stomach.

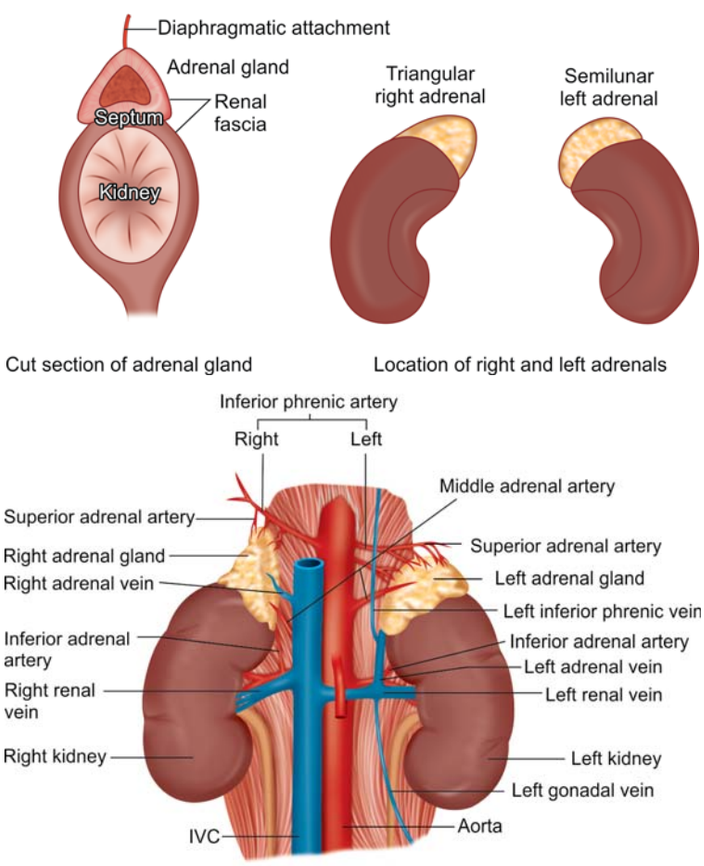


Fig. 29-1: (1)

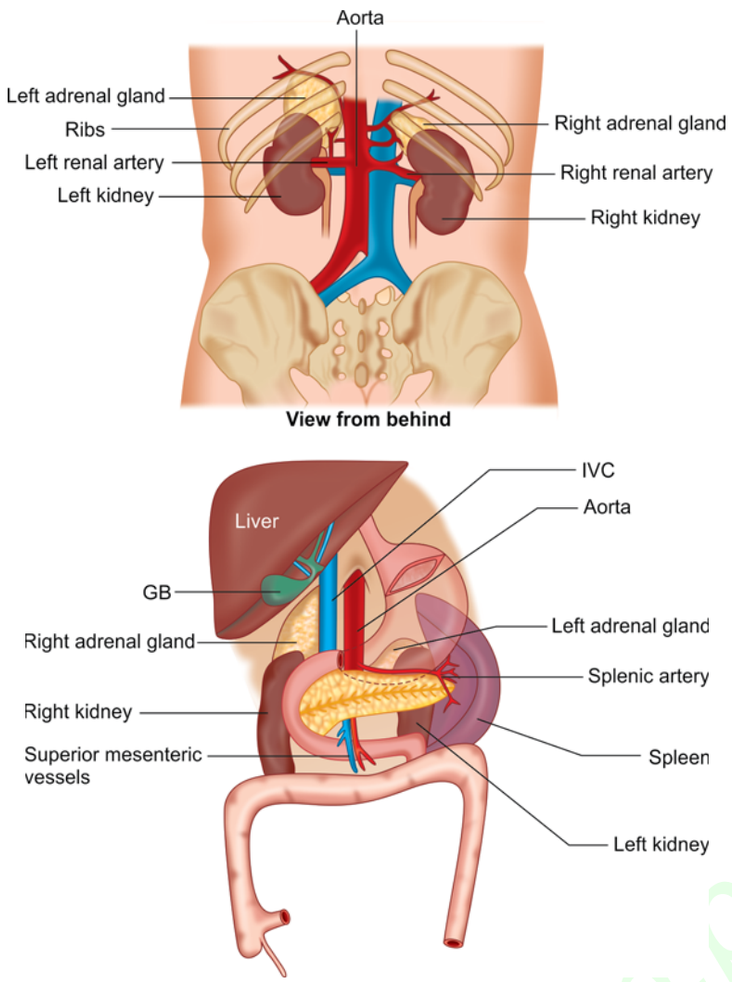


Fig. 29-1: Surgical anatomy of adrenal gland.

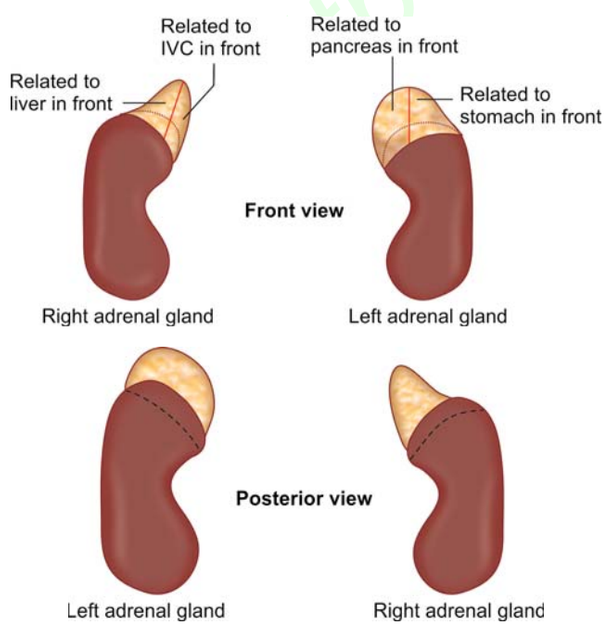


Fig. 29-2: Anterior and posterior views of adrenal glands.

Arterial Supply

Adrenal gland is one of the most vascular organ (gram of tissue) like thyroid (so metastases are common). It is supplied by – superior adrenal artery, a branch of inferior phrenic artery; middle adrenal artery, a branch of aorta; and inferior adrenal artery, a branch of renal artery. Main supply to right gland is superior adrenal artery; to left gland is middle adrenal artery. Inferior phrenic artery often gives group of 6-8 arteries separately instead of one superior adrenal artery. Middle adrenal artery arises from aorta at the level of origin of superior mesenteric artery; it may be single/multiple/often absent or supply perirenal fat. Left side it is more commonly constant and predominant. Inferior adrenal artery is usually single but can be multiple arises from renal artery or from accessory renal artery or superior polar artery of kidney.

Venous Drainage

Venous drainage is not accompanied by adrenal arteries. Adrenal gland is drained by one single vein which begins at the adrenal hilum. *Right adrenal vein* is short < 1 cm and stout drains from the anteromedial part of the gland from upper part of its hilum into inferior vena cava on its posterolateral aspect directed above downwards obliquely. Occasionally an *accessory right adrenal vein* may be present draining into IVC or hepatic veins above the level of right adrenal vein. Right adrenal vein may drain into right hepatic vein or right renal artery instead of IVC. *Left adrenal vein* is long and is directed downwards perpendicular to the renal vein and medially to drain into left renal vein after crossing the left renal artery in front. It is on the anterior surface of the gland. Left inferior phrenic vein joins left adrenal vein on its medial aspect at a point 1.5 cm above the junction of left renal vein and left adrenal vein. Variations like double adrenal veins may be present. Tearing or avulsion of adrenal vein from IVC or left renal vein can occur during dissection causing torrential haemorrhage.

Lymphatics

Adrenal gland is drained into lumbar and lateral aortic nodes. Lymphatic plexus are present under the capsule and in medulla. Subcapsular plexus drains with the arteries; medullary plexus drains with the veins. Right adrenal drains into paraaortic nodes, right renal nodes and nodes at right crus of diaphragm. Left drains into nodes adjacent to left renal artery and paraaortic nodes. Lymph may also drain into the posterior mediastinum through lymphatics along the inferior phrenic artery. Lymphatics from the upper pole of right adrenal gland may communicate with lymphatics of the liver.

Nerve Supply

Adrenal medulla has got myelinated preganglionic sympathetic fibers. Coeliac and renal plexus give branches to adrenals.

Structure

Adrenal gland has got outer thick cortex and inner thin medulla. Two are independent in development, structure and function. Cortex has got *outer* zona glomerulosa secreting mineralocorticoids; *middle* zona fasciculata screting glucocorticoids; *inner* zona reticularis secreting sex hormones. Adrenal medulla contains chromaffin cells in groups, autonomic ganglion cells with capillaries.

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Embryology

Adrenal cortex develops from *intermediate mesoderm* of coelomic epithelium; medulla is from *neural crest* cells. Fetal adrenal gland is 20 times larger in relation to body weight than adult adrenal gland. In fetus at 4 months of gestation, adrenal gland is 4 times larger than kidney size of that age. During birth adrenal gland becomes 1/3rd of the kidney size.

ADRENALECTOMY

Indications for Adrenalectomy

Unilateral

- Cushing's syndrome – cortisol secreting adenoma.
- Unilateral pheochromocytoma.
- Virilizing tumours.
- Unilateral nonfunctioning tumour > 4 cm in size.
- Adrenocortical carcinoma.
- Solitary adrenal metastasis (should be confirmed by PET scan to rule out other metastatic areas).

Bilateral Adrenalectomy

- Bilateral pheochromocytoma (10%).
- Bilateral nodular adrenal hyperplasia.
- Ectopic ACTH producing tumour.
- Cushing's disease (pituitary related).

Adrenal incidentalomas (4%) are identified on US/CT/MRI which are otherwise asymptomatic clinically. It can be functioning or nonfunctioning. Biochemical evaluation is a must to find out its functional nature if it is so. Incidentaloma more than 4 cm in size, progressive increase in size on repeated imaging, functioning tumour, suspicious of malignancy should be operated. Nonfunctioning cortical adenoma is the commonest type of adrenal incidentaloma.

Preoperative Preparation

CT imaging is the ideal one for diagnosis, to assess extent, involvement, nodal status. MRI is also used often. CT chest is done to check metastases.

In Functioning Tumours:

Relevant investigations like 24 hour urinary catecholamines and metanephrines and plasma metanephrine, VMA; for aldosteronoma ratio of plasma aldosterone concentration (PAC) to plasma renin activity (PRA) is greater than 20:25 with an absolute PAC more than 15 ng/dl, raised 24 hour urine aldosterone level >12 µg on a high sodium diet, raised urinary potassium excretion rate >30 mEq/24 hour; for Cushing's syndrome with cortical adenoma 24 hour urine free cortisol level estimation, dexamethasone test (1 mg dexamethasone is injected at 23.00 hours, morning 8 o'clock plasma cortisol level is assessed, in normal individual plasma cortisol level will be suppressed below 3µg/dl whereas in Cushing's syndrome suppression will not be there, plasma ACTH level (if ACTH is raised MRI head for pituitary disease with inferior petrosal sinus blood sampling is done); for adrenocortical carcinoma 24 hour urine free cortisol and plasma DHEA (dehydroepiandrosterone) level estimation is done. Correction hypokalaemia and hypertension is important.

In Conn's syndrome correction of electrolytes and blood pressure is important. Oral potassium supplementation and spironolactone (200-400 mg daily for 3 weeks) are useful in aldosteronoma.

Hypertension in pheochromocytoma is corrected using α-blocker with phenoxybenzamine 10 mg twice daily up to a total dose of 60 mg/day and increased if needed later. *Plenty of liquid (adequate hydration)* intakes are essential while patient is in the hospital often with hospitalisation. Beta-blocker if at all is given only once patient is fully alpha blocked for 4 weeks and usually given one week prior to surgery to control tachycardia and arrhythmias.

Preoperative intravenous steroid is needed in case of adrenalectomy for Cushing's syndrome. Contralateral gland may be *suppressed or atrophied* in Cushing's syndrome.

CVP line, arterial line, cardiac monitor, urinary catheterisation, nasogastric intubation are required.

Approaches for Adrenalectomy

Laparoscopic Approach

It is ideal for all unilateral adrenal tumours which are benign, less than 6 cm in size. It is the gold standard as access and dissection will be more precise in the depth. Gagner's transabdominal lateral approach is commonly (1962) is used. This gives a wider working space with better visualisation of abdominal contents. It is the preferred method. Anterior transabdominal laparoscopic approach is also used. Retroperitoneoscopic approach is direct approach to adrenal gland but working space is less. Retroperitoneoscopic approach allows lesser respiratory and haemodynamic complications.

Open Approach

It is advocated in tumours larger than 6 cm, previous upper abdominal surgery, malignant adrenal tumour, bilateral adrenal tumours.

Lateral Flank Open Approach:

It is used to reach the adrenal bed. It is like approaching the kidney and is more familiar to surgeons and urologists. Proper padding at different pressure points is important to reduce the chances of rhabdomyolysis and hyperextension neuropraxia **(Fig. 29-3)**.

Open Anterior Transabdominal Approach:

It is used in malignant tumours which are more than 8 cm, with extraadrenal extension, with nodal spread and in case of previous upper abdominal surgery where bowel adhesions are common. Bilateral subcostal incision allows removal of both adrenal glands. This is commonly used approach for bilateral adrenalectomy **(Fig. 29.4)**.

Open Posterior Retroperitoneal (Lumbodorsal) Approach:

It is used in small tumours less than 6 cm which are not approachable through laparoscopy. This approach has become rare as most of these tumours when benign can be approached through laparoscopy. Only tumour less than 6 cm which is malignant but not invaded is approached retroperitoneally. Patient is placed in prone position. Incision is placed along the 11th or 12th rib. 11th or 12th rib is resected. Two incisions on both sides allow bilateral adrenalectomy. Peritoneal opening is avoided in this approach. Postoperative ileus, infection wound dehiscence are less in this approach. Both sides can be approached in same prone position. But abdominal contents cannot be assessed for any pathology.

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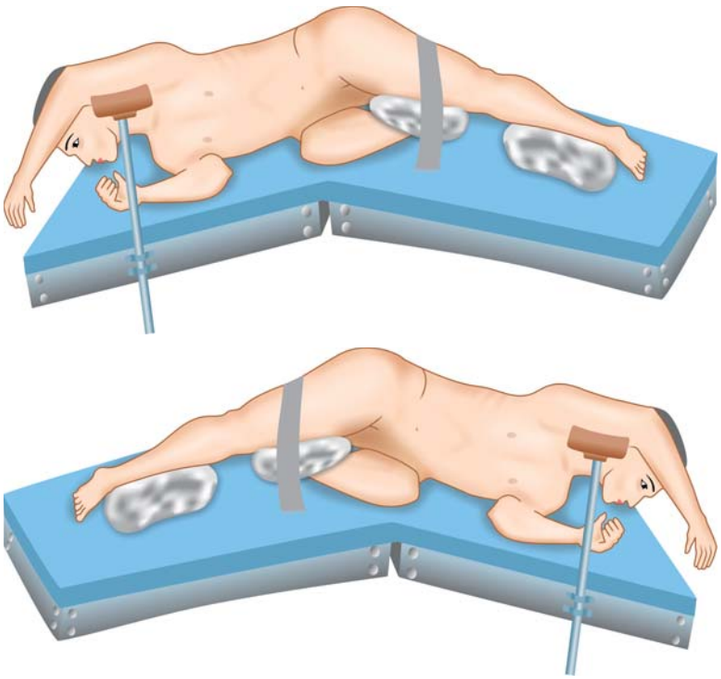


Fig. 29-3: Positions for lateral approach for left and right adrenalectomy.

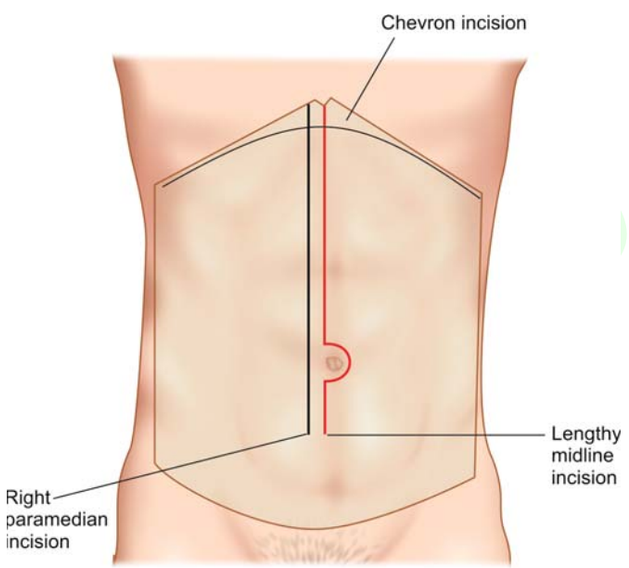


Fig. 29.4: Open abdominal approaches – Chevron incision for bilateral adrenalectomies; midline incision; right paramedian incision.

Hockey stick incision is another incision used for posterior approach which is placed from 10th rib extending downwards and then laterally towards iliac crest. Vertical incision is also can be used. The latissimus dorsi muscle is divided with 12th rib resection subplerally. Serratus posterior muscle is divided. Intercostal nerves (12th) are retained. Paraspinal muscles are retracted medially. Pleura is gently dissected from the diaphragm above; diaphragm is incised to reach Gerota's fascia. Gerota's fascia is incised; kidney is dissected downwards to expose the adrenal gland. Adrenal vein is identified carefully dissected and doubly ligated. Adrenal arteries are also ligated to dissect the gland completely. Pleura if injured can be sutured with a small red rubber tube inside the pleural cavity which is removed after adequate inflation of lung during closure of the wound; otherwise intercostal tube drainage. Diaphragm is closed with sutures. Wound is closed in layers. Postoperative musculoskeletal pain, pleural injury and less access to adrenal vessels are the problems **(Fig. 29-5)**.

Thoracoabdominal Approach:

It is used when there is major vascular invasion like inferior vena cava or extensive upward dissection is needed. Patient is in semilateral position. Midline incision extending into the thorax through 9th or 10th rib to achieve thracoabdominal exposure is used. Incision can also be used at the angle of the 9th to 10th ribs extending across the midline to the midpoint of the contralateral rectus muscle just above the umbilicus. Diaphragm is incised by taking care not to injure phrenic nerve. Liver, IVC and hepatic veins are exposed well. Dissection is carried out as usual **(Fig. 29-6)**.

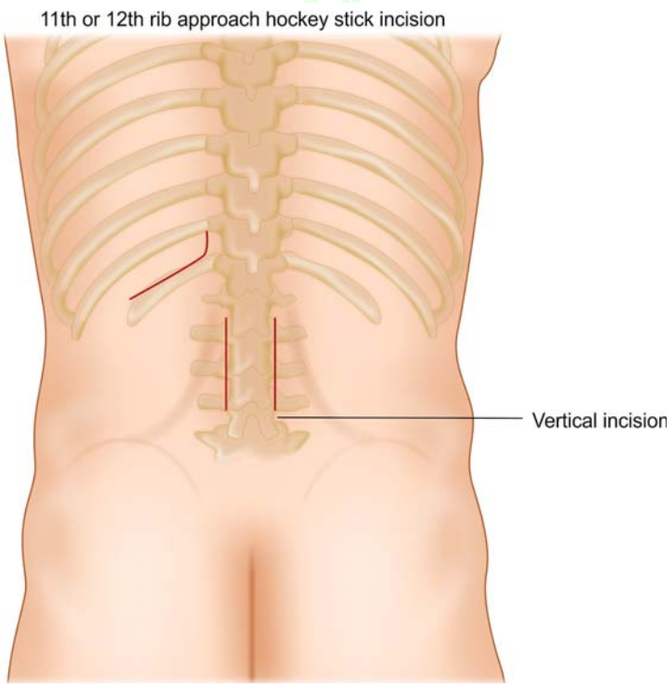


Fig. 29-5: Posterior approach for adrenal gland. It is rarely used now. It is useful in bilateral adrenalectomy.

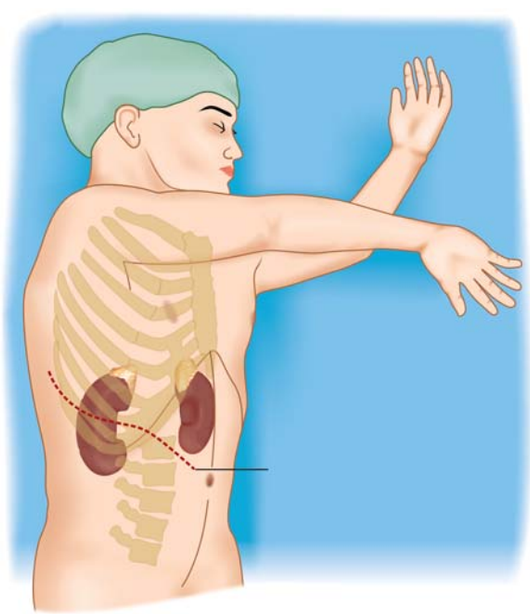


Fig. 29-6: Incision for thoracoabdominal approach.

TECHNIQUE OF OPEN ADRENALECTOMY

Open approach is done through lengthy subcostal incision. Bilateral subcostal incision is used to approach both adrenal glands. Anterior rectus sheath, rectus muscle medially and external and internal oblique and transversus abdominis muscles are divided to enter the peritoneal cavity.

Right Adrenalectomy

Hepatic flexure of the colon is mobilised medially and inferiorly. Triangular ligament of the liver is divided to retract liver medially to exposed right adrenal area. Kocherisation of the duodenum medially adequately is important to expose the IVC properly. Right adrenal gland will be deeper to inferior vena cava at its medial part and in front of the upper pole of right kidney below. Downward traction to right kidney improves the exposure. Resectability of the large tumour should be assessed. Encasement of IVC and liver metastases are contraindications for resection of the tumour. Lymph nodes should be assessed in malignancy and may require removal for radical clearance. Fascia between the right adrenal gland and IVC is incised carefully and dissected away from adrenal gland. While gentle lateral displacement of adrenal gland is done, right adrenal vein which is short and stout entering into the IVC identified. It is doubly ligated carefully or using clips. Right adrenal vein is divided. Often in large tumour right adrenal vein stretches over the tumour; in such situation right adrenal vein is ligated or stapled with appropriate device at its IVC junction. Rarely accessory right adrenal vein may be existing above the level of right adrenal vein which needs careful dissection and ligation or clipping. Arterial branches enter the gland on the medial side from deeper aspect of the IVC, which should be ligated or cauterised using bipolar cautery. Ultrasonic energy device can also be used. Laterally dissection is done between liver and adrenal gland and between kidney and adrenal gland. Right renal vein is safeguarded. Superior polar artery of right kidney will be often very close to the adrenal gland and should not be injured. If tumour involves adjacent structures then enblock removal of adrenal tumour with kidney, hepatic flexure of colon and part of the liver segment can be done. Partial infiltration of the IVC at one place may allow tumour resection by removing the small part of the wall of the IVC which will be repaired using 3 or 4 zero polypropylene suture material. One should not hold the adrenal gland/tumour as tumour spillage can occur. Only *periadrenal fat and thin fascia* should be held to facilitate the dissection. Dissection between adrenal gland and kidney is done last as if it is done earlier, adrenal gland will retract upwards and accessibility becomes difficult. Tumour spillage should be absolutely avoided. After tumour removal haemostasis is maintained. Distilled water irrigation is used on the adrenal bed. Drain is placed to the dissected area **(Fig. 29-7)**.

Left Adrenalectomy

Splenorenal ligament is divided; splenic flexure of the colon is mobilised adequately to retract it downwards. Peritoneum in left paracolic gutter (*Toldt's line*) is incised in its full length; incision is carried upwards through splenic flexure then towards left along the transverse colon in its upper part towards right up to ½ or 2/3rd of its length. Peritoneum in the lower border of the tail of the pancreas is incised. Spleen with tail of the pancreas is mobilised medially and upwards. Renal fascia is incised and superior pole of kidney is dissected. Adrenal gland is exposed. Often large left sided adrenal tumour may be adherent to the tail of pancreas and spleen and in such situation dissection of tail of pancreas and spleen is done through lesser sac by anterior approach. Left adrenal vein joins left renal vein vertically from above downwards after crossing the left renal artery in front. Left inferior phrenic vein joins left adrenal vein. Entire left renal vein should be dissected to have a proper visualisation in large tumour. Left adrenal vein is double ligated securely. It is better to ligate left inferior phrenic vein separately which joins left adrenal vein. Inferior mesenteric vein and splenic vein will be closer in large tumours which should not be injured. Newer energy sources like ultrasonic seal may be useful. Left renal artery runs horizontally just above and behind the left renal vein. Left inferior adrenal artery which arises from left renal artery is identified and ligated. Adrenal vein should be ligated first in functioning pheochromocytoma to prevent the release of catecholamines into the circulation. Periaortic lymph nodes with retroperitoneal fat and adjacent Gerota's fascia are removed along with the tumour in case of adrenal malignancies. Often enblock removal of left kidney, splenic flexure of colon and spleen with tail of the pancreas is done in large aggressive tumours. Occasionally inferior mesenteric vein may require to be ligated in large left adrenal tumour **(Fig. 29-8)**.

In primary hyperaldosteronism and pheochromocytoma, gland is hypervascular and friable. So gland should be held gently over periadrenal fascia using fine forceps. All small vessels should be clipped or haemostasis is achieved using bipolar forceps to prevent haematoma formation which will interfere with further dissection **(Fig. 29-9)**.

Postoperative Care

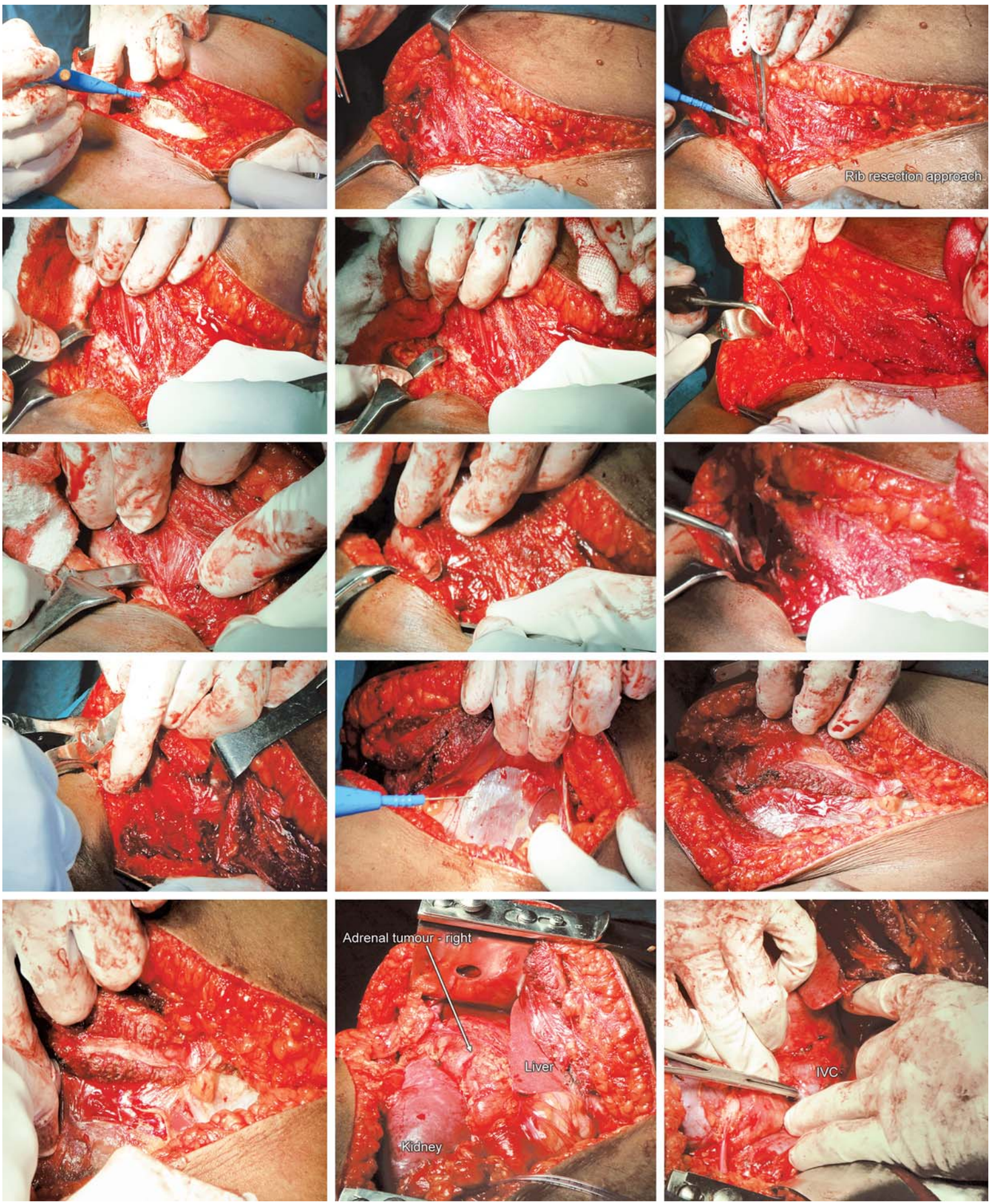
Respiratory physiotherapy, observation, pain control, prevention of sepsis, observation for bleeding are important. Acute adrenal insufficiency can occur in case of bilateral adrenalectomy which presents as sudden haemodynamic instability and circulatory failure. Prompt adequate steroid supplement is essential in these patients.

In adrenalectomy for pheochromocytoma, because patient is on phenoxybenzamine, more intravenous fluids are required after resection to maintain circulatory volume. During surgery sodium nitroprusside infusion (10 µg/kg/minute) is required. Circulating catecholamine/metanephrine/VMA level estimation and 24 hour urinary catecholamines estimation is needed postoperatively and later on yearly. *Hypertensive exacerbations* and tachycardia are likely to occur during induction of anaesthesia and during direct tumour handling. Intraoperative hypovolaemia, postoperative hypotension should be managed well. Central venous line with CVP monitoring and arterial line for monitor is a must.

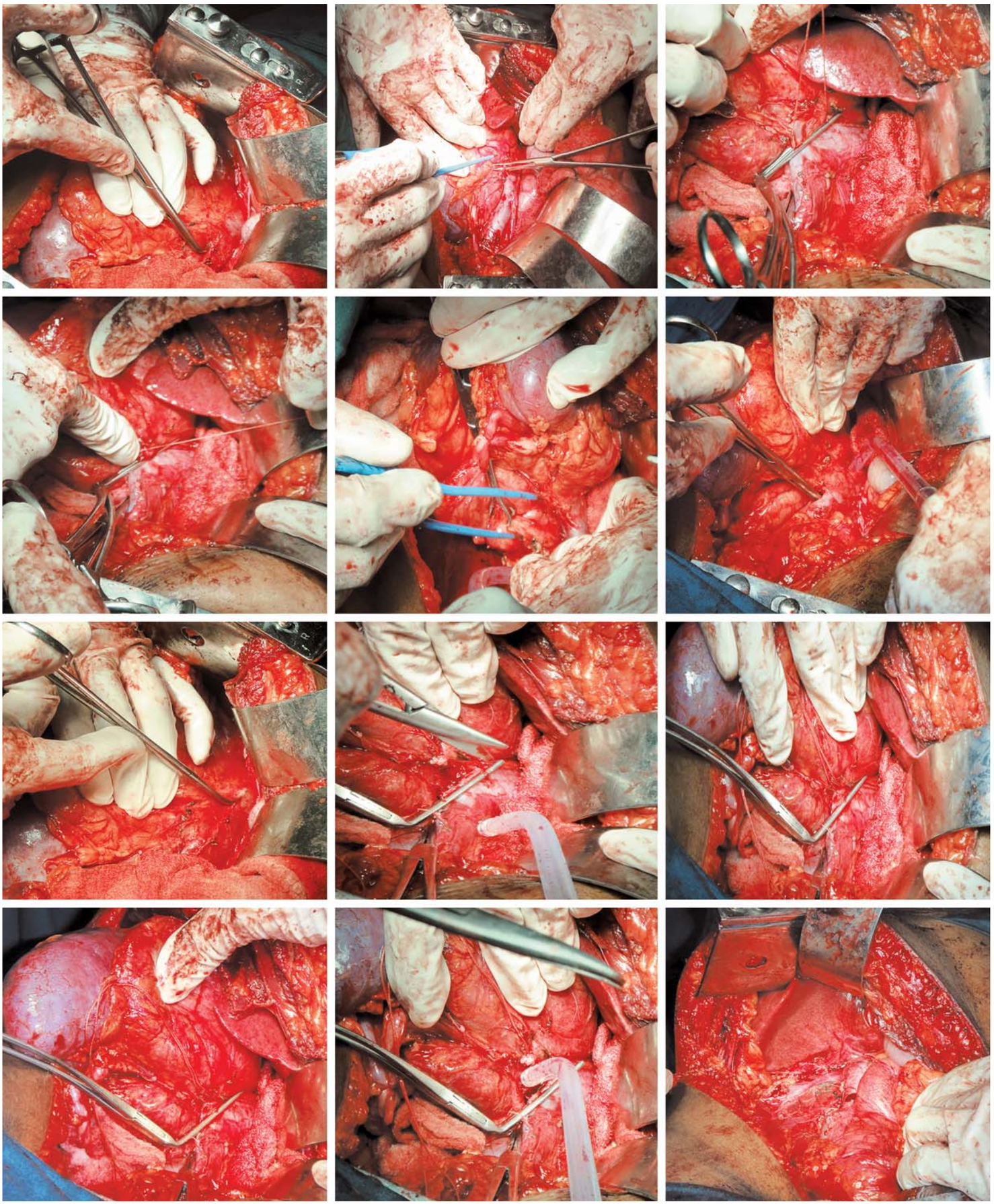
In bilateral adrenalectomy postoperatively patient requires oral *steroid and mineralocorticoid* (fludrocortisone 100 µg/day) for lifelong. Even in Cushing's syndrome due to unilateral functioning cortical adenoma, after unilateral adrenalectomy oral steroid supplement is required for 2 years until hypothalamic pituitary adrenal axis which was suppressed earlier recovers to allow contralateral adrenal gland to function.

In adrenalectomy for aldosteronoma, postoperative hypotension, hyperkalaemia and acidosis can occur. It is corrected by intravenous normal saline infusion rapidly and intramuscular injection of deoxycorticosterone acetate (DOCA, 10 mg twice daily).

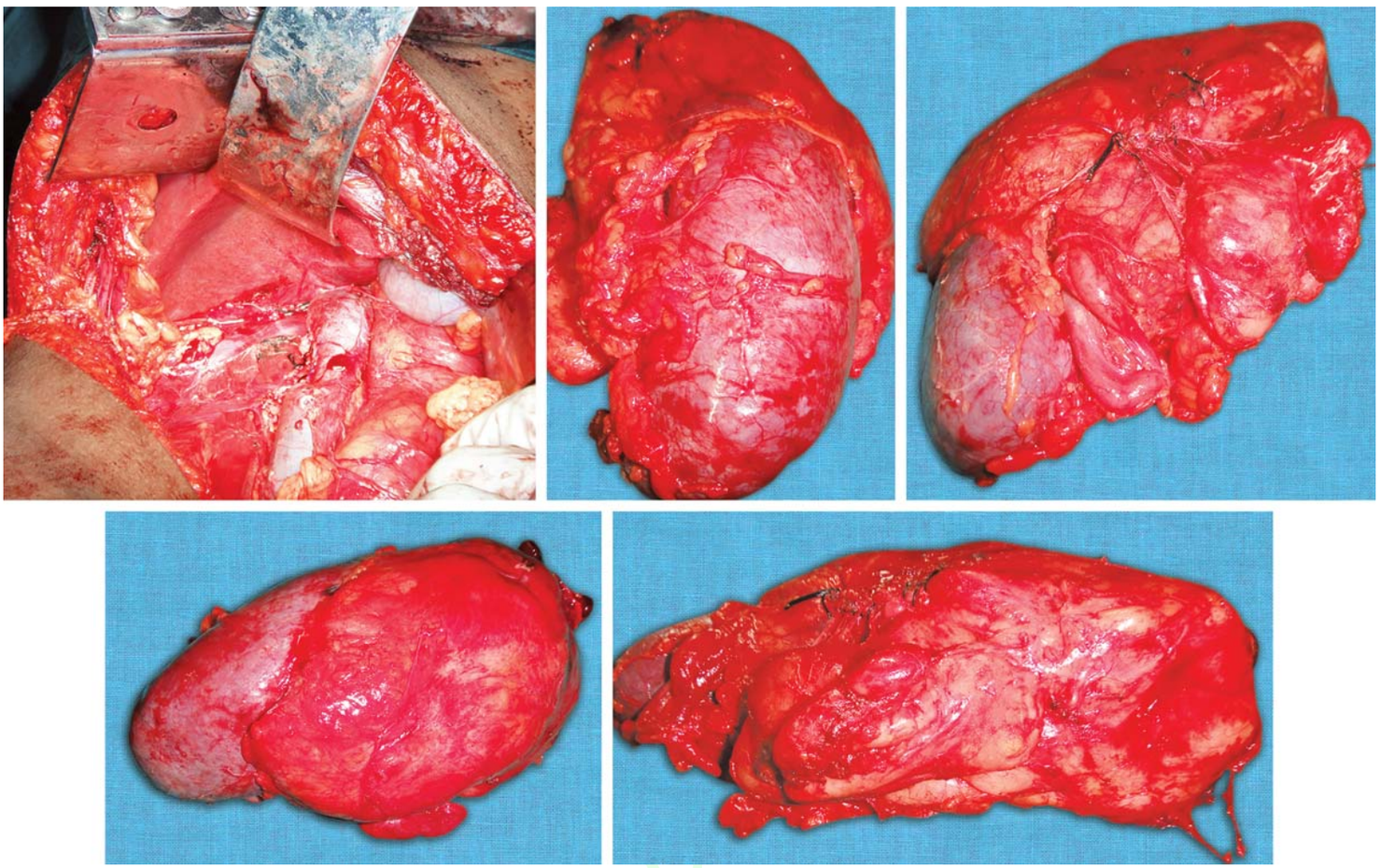
Regular blood sugar estimation is needed after adrenalectomy for functioning pheochromocytoma as sudden reduction in circulating catecholamine can cause hyperinsulinism and hypoglycaemia **(Fig. 29-10)**.


Rib resection approach
Adrenal tumour - right
Liver
Kidney
IVC

Figs 29-7(1)



Figs 29-7(2)



Figs 29-7(3)

Figs 29-7(1 to 3): Right sided adrenal tumour; removed along with kidney while doing adrenalectomy.

Complications of Adrenalectomy

Bleeding which may life threatening can occur from adrenal vein, inferior vena cava, renal vein, liver, spleen, pancreas and kidney tissue injury. Proper ligation of adrenal vein, reconstruction of the inferior vena cava or renal vein, suturing of the liver or kidney injuries is needed. Satinsky clamp is needed for proper suturing of the IVC. Central line, blood transfusion may be required. Haemorrhage is the most common complication after adrenalectomy.

Injury to pleura (pneumothorax) may warrant intercostal tube placement. On table chest X-ray may be needed after closure of the wound. Postoperative pulmonary collapse, pneumonia, ARDS can occur.

Injury to colon, pancreas and spleen can occur. Bowel injury may cause peritonitis, septicaemia. Injury may due to cautery or energy source or during scissor dissection.

Acute adrenal insufficiency may be fatal if steroid supplement is not started adequately.

Hypovolaemia on table and postoperative hypotension is common after resection of pheochromocytoma. Careful monitoring in critical are unit is needed. *Postoperative hypotension* is common after adrenalectomy for functioning pheochromocytoma due to loss of receptor mediated sympathetic tone which needs large quantity of intravenous fluids.

Rebound hyperinsulinism due to reduced inhibitory effect on insulin secretion by sudden reduction in circulating catecholamines (catecholamines inhibit insulin secretion thereby causing hyperglycaemia) leading into *hypoglycaemia*. Regular blood sugar estimation postoperatively is important in patients who underwent adrenalectomy for functioning pheochromocytoma. Weekly urinary catecholamine estimation initially and later yearly is important.

Other complications—Wound infection, sinus formation and postoperative wound pain are other problems.

Pheochromocytoma *in pregnancy* has got 50% maternal mortality; vaginal delivery is contraindicated in pheochromocytoma.

LAPAROSCOPIC ADRENALECTOMY

Gagner in 1992 started first laparoscopic transabdominal lateral flank approach which is commonly used. Transperitoneal anterior approach and retroperitoneal posterior approach ((Mercan, et al) are other approaches used.

Laparoscopic adrenalectomy is the safe, effective '*gold standard*' operation for benign adrenal tumour of less than 6 cm in size. Approach, dissection, haemostasis, recovery, morbidity status, pain, hospitalisation are all factors in favour of laparoscopic adrenalectomy. Bilateral tumours are also better amenable through laparoscopy.

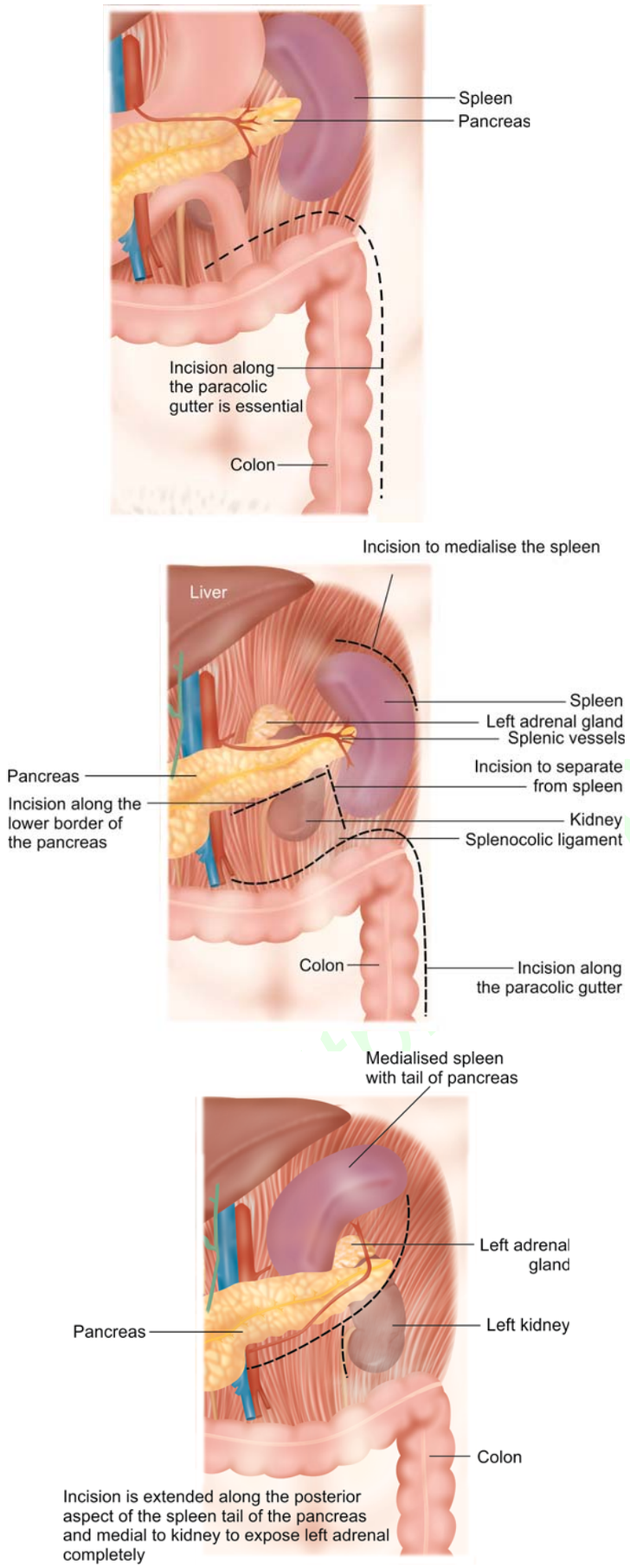


Fig. 29-8: Technique of left adrenalectomy.

Indications	*Contraindications*
Cortisol producing adenoma, aldosteronoma Primary adrenal hyperplasia Pheochromocytoma Non functioning cortical adenoma, incidentaloma Adrenal cyst, ganglioneuroma, myolipoma	Adrenal cortical tumour more than 5-6 cm; > 100 grams weight Malignant pheochromocytoma Adrenocortical carcinoma Any adrenal mass more than 8-10 cm Extensive previous upper abdominal surgery

Tumour more than 6 cm makes laparoscopic dissection difficult especially adrenal veins; causing higher chances of tear in IVC or left renal vein. Larger tumour is more likely to be adrenocortical carcinoma which is an indication for open surgery.

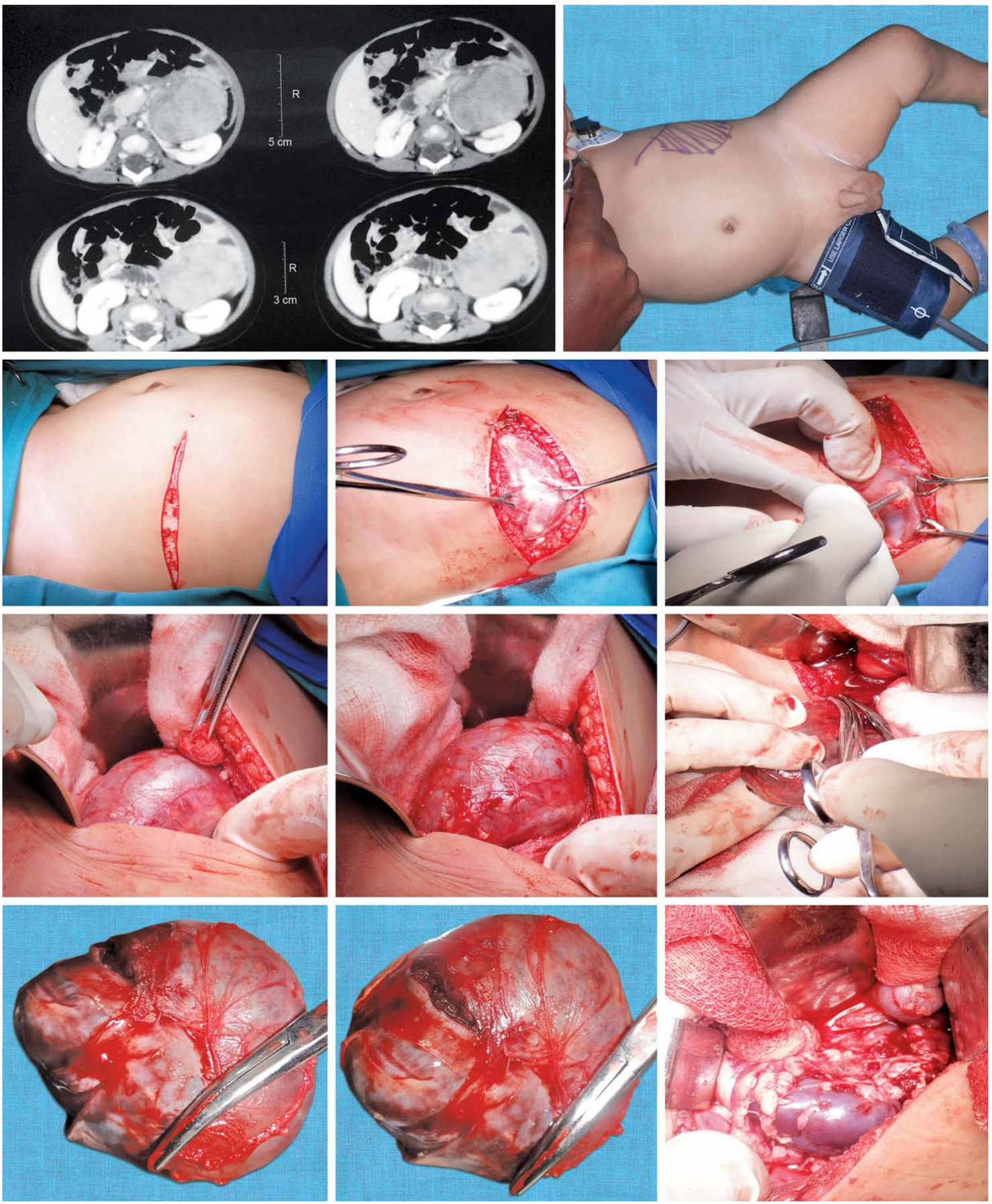
Approaches

Lateral flank transperitoneal approach—This position allows retraction of the adjacent organs by gravity to facilitate the exposure of the adrenal glands; adequate access to retroperitoneum as well as abdominal cavity; gives proper working space and triangulation; other organs in the abdominal cavity can be assessed properly. Additional procedures like gall bladder removal are possible. *Disadvantages*: postoperative ileus and mobilisation of colon is required. Opposite adrenal cannot be approached; if needed needs repositioning of the patient.

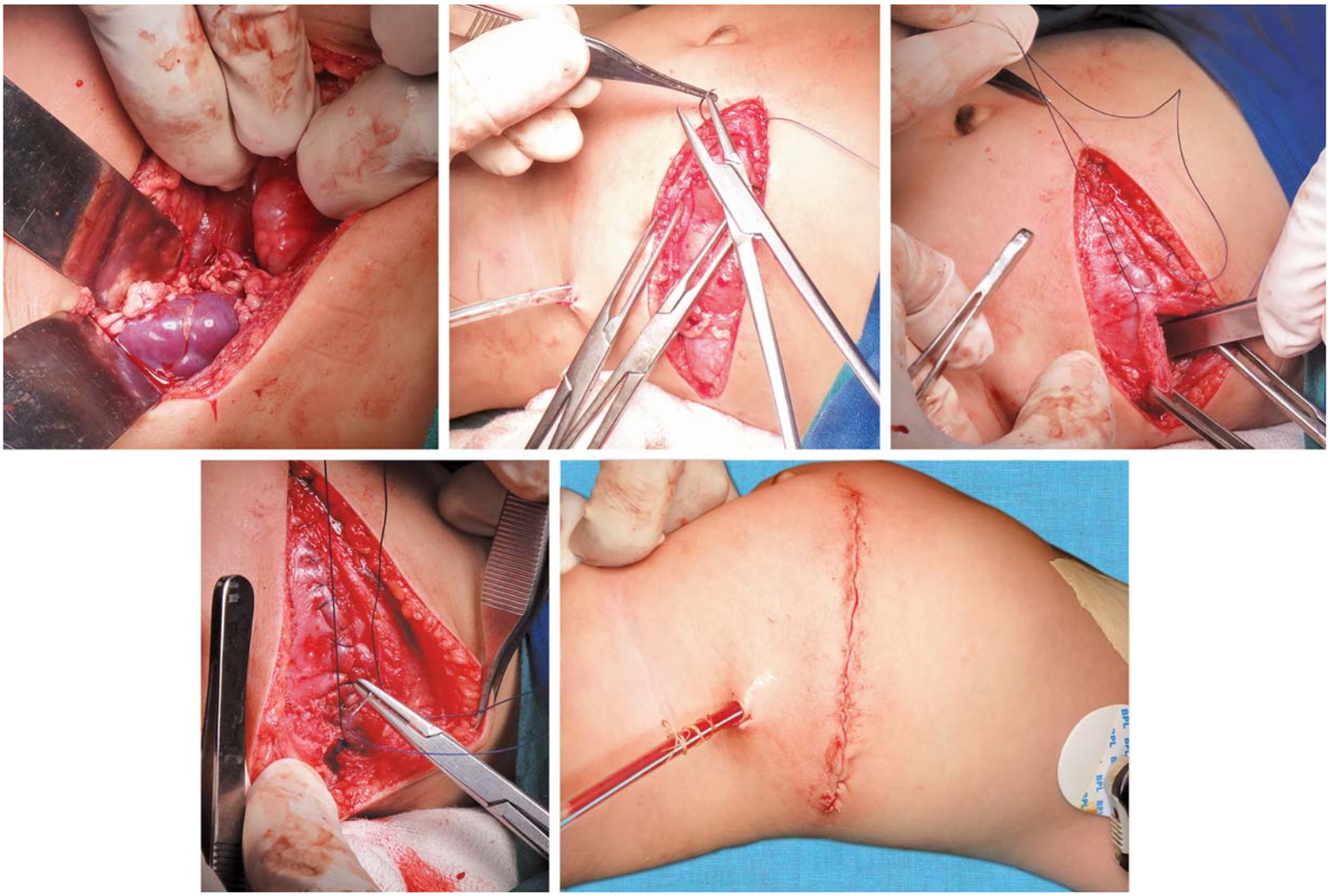
Transperitoneal anterior approach—It is done in supine position which allows access to both adrenal glands. But it is technically demanding with longer operative period. Mobilisation of viscera like colon, spleen, tail of pancreas, liver is needed. Usually left side adrenalectomy is done first; then right side. Reason is once left side is over which is easier, if conversion is required for right side which will be addressed with conversion right side open approach.

Posterior retroperitoneal approach—It gives direct access to adrenal gland without opening the peritoneal cavity and without a need for mobilisation of other organs. It is also useful for bilateral adrenalectomy wherein change of position is not required in Cushing's syndrome, bilateral pheochromocytoma. But it gives less working space and minimum triangulation; orientation of anatomy from behind becomes difficult; on table inadvertent formation of pneumoperitoneum due to peritoneal tear limits the working space further; pleural injury may occur.

Patient is placed in prone/prone jackknife position. By open method through a small incision just below the tip of 12th rib with splitting the muscle layers retroperitoneum is reached. Through balloon or finger dissection space is widened. CO_2 insufflation can also be done using Veress needle under fluoroscopic guidance also but it is difficult. Additional ports are placed as needed. Second port is in the loin at the level of inferior pole of the kidney just above the iliac crest 5 cm laterally below the 11th rib; 3rd port is at the level of midpoint of kidney just lateral to sacrospinalis; 4th port is 2 cm lateral to that. Further ports if needed may be placed. Retro-pneumoperitoneum pressure should be 20-25 mm Hg which creates more working space and reduces the oozing. 30° telescope is used. Dissection is from lateral to medial first ligating the arteries and branches or sealing using harmonic. In right side, on deeper medial dissection IVC is identified; right adrenal vein is carefully dissected and clipped. Left side inferomedially left renal vein with left adrenal vein entering the left renal vein is identified; left adrenal vein after careful dissection is



Figs 29-9(1)



Figs 29-9(2)

Figs 29-9(1 and 2): Left sided adrenalectomy in a child—neuroblastoma.

clipped and divided. Remaining dissection is done using harmonic device. Haemodynamic and respiratory complications are less here.

Lateral retroperitoneal approach – Here retroperitoneum is approached in lateral position. Initial access port is placed in midaxillary line 3 cm above the iliac crest between latissimus dorsi and external oblique muscles. By open method retroperitoneum is reached; using finger or balloon space is created and widened. Additional ports are placed along the same line. Remaining dissection is same as posterior approach. Advantage here is conversion can be done when needed easily as transperitoneal approach.

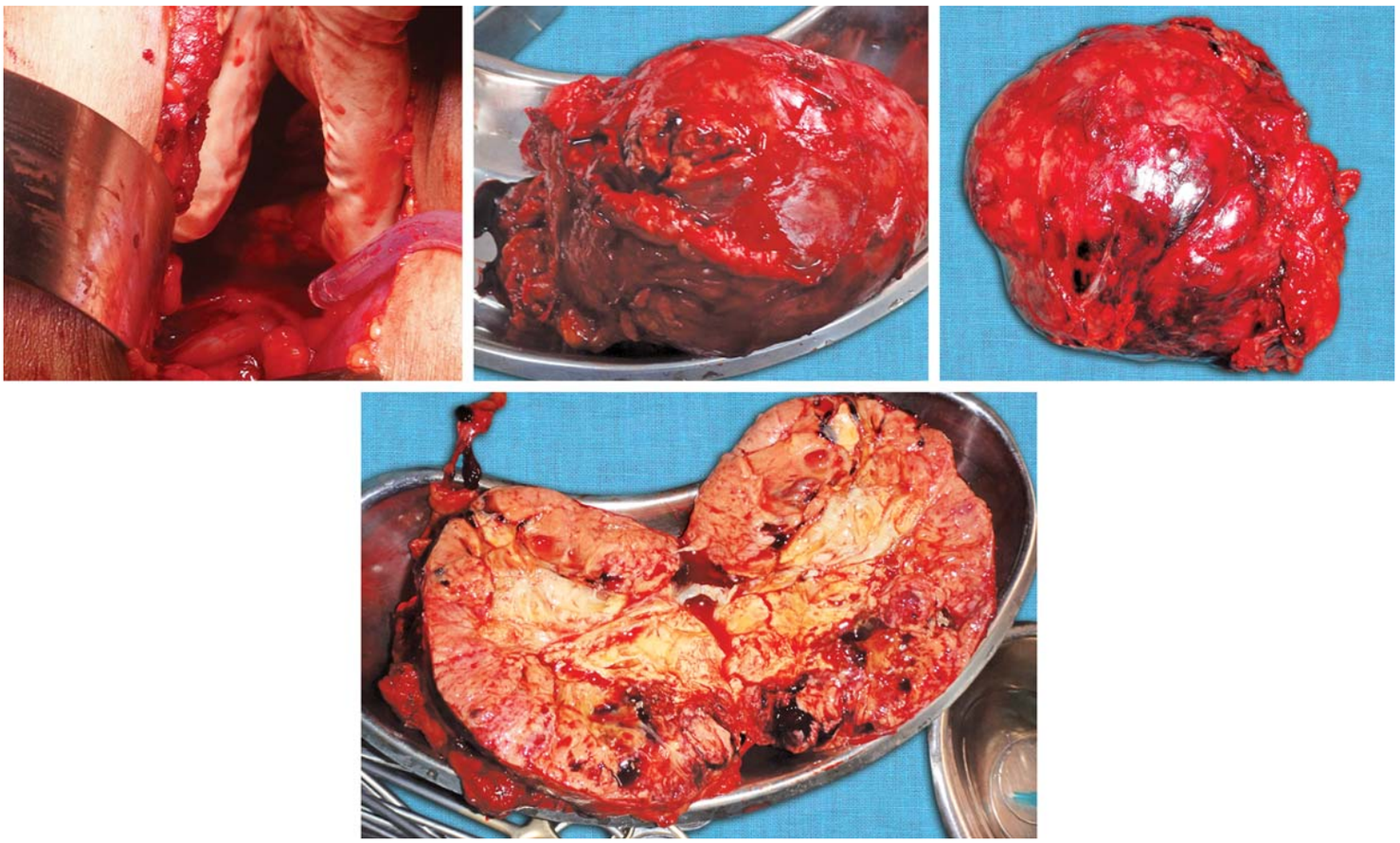
Laparoscopic Right Adrenalectomy

Procedure is done under general anaesthesia with lateral decubitus position with right side upward (left lateral decubitus). Reverse Trendelenburg position (head up) is needed. Nasogastric tube and urinary catheterisation is used usually. Central venous line is needed. Right side up with knee adjacent to table is flexed. Safety straps with padding on all pressure pints and compression stockings to both legs. Usually surgeon stands on the right side with camera operator on opposite side leg end or on the right side of the surgeon and assistant is opposite to surgeon. Position can be varied depends on the surgeon's choice and comfort **(Fig. 29-11)**.

Thirty degree telescope with high definition imaging system and medical monitor is needed. Energy source like harmonic sealer is also useful. Basic laparoscopic instruments, suction irrigation device, right angled instrument are all essential. A laparoscopic ultrasound may be useful often. Through Veress needle initial access is achieved at a point two fingerbreadth below the right costal margin medial to right anterior axillary line; through it one 10 mm port is passed for camera. Another 10 mm port is placed in the midaxillary line behind the first port. Two additional 5 mm ports are placed with a 5 cm gap between along the subcostal line in front. 15 mm pressure pneumoperitoneum is needed.

Right triangular ligament is divided using hook or harmonic energy device from IVC to diaphragm. Liver is rotated medially and superiorly. Liver is kept in retracted position using fixed retractor. Retroperitoneum is exposed. Subhepatic IVC, upper pole of the kidney and adrenal gland will be visualised by further careful dissection. Hepatic flexure if required may be reflected downwards by incising its peritoneal attachment. Duodenum is identified medially and in front to IVC. Duodenum is reflected in front and medially to expose IVC further. Peritoneum between adrenal gland and IVC is incised. Dissection between IVC and medial border of the adrenal gland is done for entire length carefully and meticulously. Adrenal gland is reflected away from IVC. *Right adrenal vein* is identified running into the IVC to join. It is less than 1 cm in length and stout. Adrenal gland

Figs 29-10(1)



Figs 29-10(2)

Figs 29-10(1 and 2): Open left sided adrenalectomy for left sided adrenocortical carcinoma—non functioning.

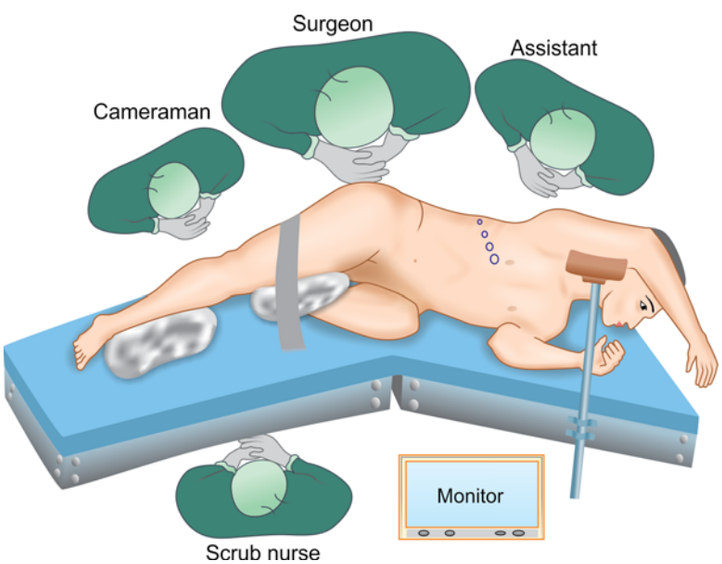


Fig. 29-11: Positions for laparoscopic right adrenalectomy.

is held carefully through its *periadrenal fat* and *thin fascia* and never on the gland substance as it may bleed and breach capsule causing tumour spillage. Right angled dissector is used to isolate, separate and dissect the adrenal vein carefully. Endoclips are placed 2 on the IVC side and one gland side. Right adrenal vein is cut to mobilise the gland from IVC. Endosutures or endovascular stapler can also be used. Arterial branches are divided using clips or harmonic device. Anatomical *variation* of right adrenal vein which may drain at right hepatic or right renal vein instead of IVC should be remembered. Additional *right accessory adrenal vein* may exist above the level of right adrenal vein draining into right hepatic vein. *Arterial branches* are at lower level than adrenal vein and so often it is necessary to divide arterial branches first to facilitate the easier isolation of the right adrenal vein. But *in pheochromocytoma* adrenal vein should be ligated first to prevent early catecholamine release into the circulation. Adrenal gland is elevated off the IVC; posterior border is dissected off the diaphragm then lateral border. Adrenal gland is placed in impermeable pack to retrieve (retrievable bag). Adequate irrigation of adrenal bed using normal saline and also proper haemostasis is essential. Drain if needed is placed. Port sites are closed using vicryl in layers.

Laparoscopic Left Adrenalectomy

Lateral decubitus with left side upward position (right lateral decubitus) is used. Port position is similar counterpart of the right adrenalectomy. Often different port positions are advocated by many. Surgeon stands on the right side of the patient near hip region/abdomen side; camera operator left of the surgeon near left (lower) arm; assisting surgeon near head end above the left arm; staff nurse is extreme right near leg end. Camera operator can stand on the right side of the surgeon also if it seems convenient **(Fig. 29-12)**.

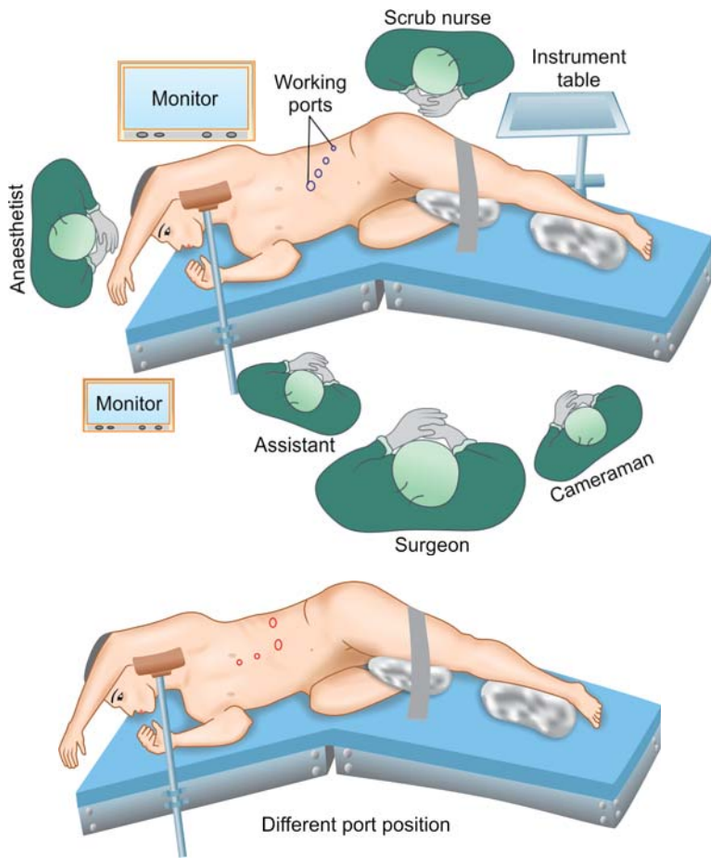


Fig. 29-12: Laparoscopic left adrenalectomy position, port placements.

Splenic flexure of colon is mobilised fully using hook or harmonic device with division of splenocolic attachment. Incision is needed along the entire length of the paracolic gutter along the *line of Toldt* and also along the upper left ½ to 2/3rd of transverse colon. Colon is reflected downwards and towards right. Splenorenal ligament is divided from lower pole of the spleen; splenic attachment to the diaphragm is divided to rotate the spleen and tail of the pancreas medially (rotated off the kidney and left adrenal gland –*open book method*). Short gastric vessels often require to be divided. Left side retroperitoneum is approached. Gerota's fascia is opened to reach the superior pole of the kidney which is dissected free of left adrenal gland.

Adrenal gland is identified between spleen and upper pole of kidney by its *golden orange colour* and fine granular texture. It is often difficult to differentiate adrenal gland (*golden orange*) from tail of the pancreas (*salmon coloured).* Laparoscopic ultrasound is useful to differentiate tail of the pancreas from adrenal gland. Adrenal gland is identified by gentle dissection. Inferomedial border of the gland is dissected first by principle. Inferior phrenic vein joins the left adrenal vein 1.5 cm above the level of the left renal vein. If dissection here finds difficult then gland is mobilised in its upper, lateral and medial borders of the adrenal gland first and later inferomedial border is addressed. *Left adrenal vein* is dissected using right angle instrument and doubly ligated or clips are applied. Renal vessels should be identified and safeguarded. Left renal artery is above and behind the left renal vein. Left adrenal vein joins left renal vein from above crossing the left renal artery vertically in front. Left inferior adrenal artery arises from left renal artery also to be clipped or ligated. Injury can occur to colon, diaphragm, spleen, tail of the pancreas and diaphragm. Drain is often placed after irrigation and haemostasis of the adrenal bed. Ports are closed in layers.

Conversion Rate

Cause for conversion is bleeding from adrenal vein during dissection. 5-10% is the conversion rate. Learning curve raises the conversion rate. When needed conversion should be postponed to minimize the further complications.

Role of Laparoscopic Ultrasound

It is very useful in identifying small tumours especially in left side and in obese patients. It is also useful in assessing the adjacent structures like renal vessels, IVC. Adrenal vein is difficult to identify through laparoscopic ultrasound. It is useful in identifying associated pathology in other organs and also while doing partial adrenalectomy.

Laparoscopic Partial Adrenalectomy/Cortex Sparing Adrenalectomy

It is done *only selectively* in a small peripherally located bilateral benign tumours or unilateral tumour (peripheral aldosteronoma) wherein opposite side adrenalectomy is already done. Tumour should not be lying close to or over the adrenal vein. Tumour is excised with a 0.5 cm margin of normal adrenal gland. Dissection is done using harmonic scalpel. Haemostasis is achieved using ligaseal or bipolar cautery. Adrenal vein can be preserved in this technique. *Problems* are – tumour spillage and recurrence of tumour even in benign lesion.

Complications and Problems of Laparoscopic Adrenalectomy

Haemorrhage is the main complication of laparoscopic adrenalectomy mainly during dissection of adrenal vein causing tear in IVC or left renal vein. Immediate conversion into open and control of haemorrhage is needed. Suring of tear in IVC or left renal vein after applying vascular clamp is the need.

Injury to various organs like liver, spleen, pancreas, kidney, colon, pleura, diaphragm, etc. can occur which should be dealt with accordingly appropriately.

Pancreatitis and pancreatic fistula may develop which is usually managed conservatively.

Respiratory problems like pneumonia, atelectasis, pneumothorax which is managed with antibiotic, intercostal tube drainage, antibiotics. Pneumothorax due to pleural injury and entry of CO_2 into thoracic cavity is specific problem related to laparoscopic adrenalectomy. In such situation patient if maintains the adequate saturation, laparoscopic procedure can be continued; otherwise conversion is needed.

Deep venous thrombosis, pulmonary embolism needs proper heparin prophylaxis.

Postoperative ileus, port site infection, port site hernia should be treated with antibiotics, conservative treatment and hernia repair.

Acute adrenal insufficiency may be fatal which should be treated with hydrocortisone of adequate dose.

Other complications are – nerve compression, compartment syndrome, renovascular hypertension, lymphocele, tumour recurrence, arrhythmias.

Variation in adrenal vein anatomy on the right side may confuse with right renal vein. Any vein which is not amenable to endoclip comfortably should be cautioned and differentiated from right renal vein.

On left side tail of the pancreas may be mistaken for adrenal gland. Often it may require laparoscopic ultrasound to differentiate. Adrenal gland is bright variegated dark yellow with fine granularity whereas pancreas is greyish white in colour. Upper pole segmental renal artery may be mistaken for adrenal artery. If adrenal artery is more than 0.5 mm in diameter then it is better to reconfirm its identity.

During retraction, liver or spleen may get lacerated during laparoscopy. Cautery injury to adjacent organs can also occur.

In *obese patients*, dissection of adrenal may be difficult due to large quantity of fat covering the adrenal gland. Laparoscopic ultrasound may be useful in such situation.

In *potentially curable adrenal malignancy*, laparoscopic approach is not advised until now.

Remember

- Careful selection of patient for laparoscopic adrenalectomy or open method is important.
- Laparoscopic adrenalectomy is the gold standard for benign adrenal tumours, tumours less than 6 cm sized.
- Malignant adrenal tumours, tumour more than 6-8 cm, previous upper abdominal surgery needs open adrenalectomy.
- Hormonal assessment is a must in all adrenal tumours to identify whether they are functioning or nonfunctioning tumours.
- In pheochromocytoma, on table hypertensive exacerbations are observed. After surgery, hypotension can occur which should be controlled. Postoperative hypoglycaemia is another complication after surgical extirpation.
- Adrenal vein should be ligated first ideally. Ligation of the adrenal vein is crucial step in adrenalectomy.
- Right adrenal vein is short and stout joins IVC posterolaterally. Right adrenal vein begins at the superior part of the hilum of the right adrenal gland. Right adrenal arteries runs from their origin behind the IVC to enter the right adrenal gland.
- Right adrenal gland is little more away and above than right renal vessels compared to left adrenal gland which is close to left renal vessels.
- During dissection adrenal capsule should not be breached to prevent tumour spill over. Gland should be held only over periadrenal fat and fascia using fine forceps.
- Ideally gland after removal should not be morcellated instead it should be retrieved using a retrieval impermeable bag.

Chapter

30

Surgeries in Hernia

Surgical Anatomy of Inguinal Canal

Superficial inguinal ring is a triangular opening in the external oblique aponeurosis and is 1.25 cm above the pubic tubercle. The ring is bound by a superomedial and inferolateral crus. Normally the ring does not admit the tip of little finger.

Deep inguinal ring is a U-shaped (or *Lambda* shaped) condensation of the transversalis fascia, lies 1.25 cm above the inguinal ligament midway between the symphysis pubis and the anterior superior iliac spine (mid inguinal point).

Inguinal canal: In infants both superficial and deep rings are superimposed without any obliquity of the inguinal canal. In adults it is 3.75 cm long, directed downwards and medially from the deep to superficial ring.

In males inguinal canal transmits the spermatic cord, ilio-inguinal nerve (outside the cord within the inguinal canal) and genital branch of the genito-femoral nerve (within the cord). Cord is covered by cremaster muscle which is a continuation of internal oblique muscle, internal spermatic fascia which is a continuation of transversalis fascia. Cord contains testicular artery, artery of vas (a branch of superior vesical artery which is derived from the anterior division of internal iliac artery), cremasteric artery, pampiniform plexus of veins, genital branch of genitofemoral nerve, sympathetic plexus and lymphatics. In females, inguinal canal contains round ligament, indistinct sparse cremaster, cremasteric vessels, ilioinguinal nerve, and genital branch of genitofemoral nerve. Inguinal canal in female is called as *canal of Nuck*. Round ligament (in females) is much more intimately adherent to peritoneum than spermatic cord (in males) **(Figs 30-1 and 30-2)**.

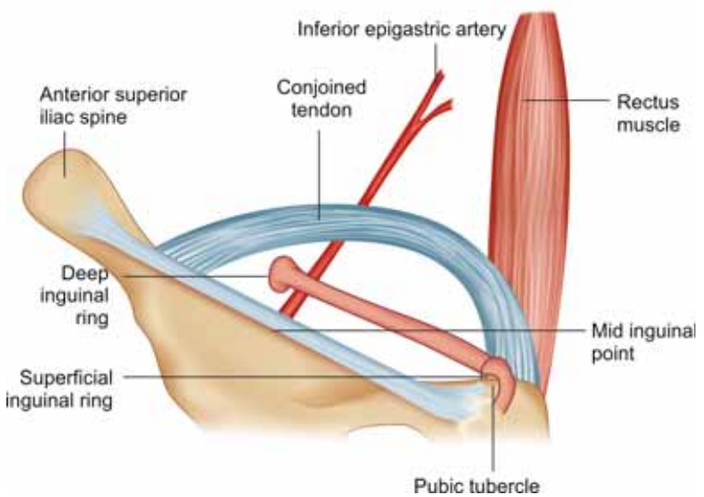


Fig. 30-1: Surgical anatomy of inguinal canal.

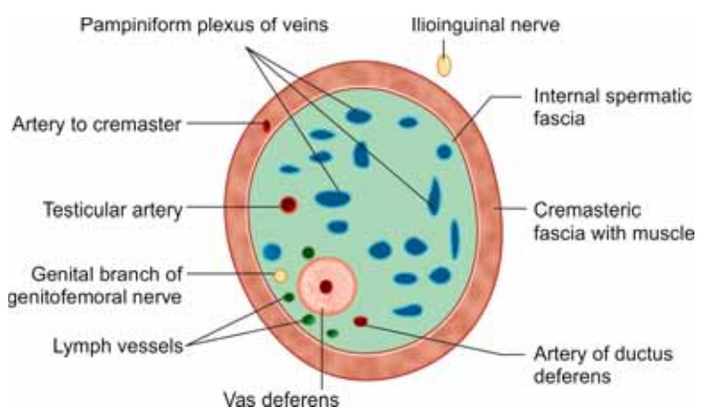


Fig. 30-2: Contents of spermatic cord.

Boundaries of Inguinal Canal

In front: External oblique aponeurosis and conjoined muscle laterally.

Behind: Inferior epigastric artery, fascia transversalis and conjoined tendon medially.

Above: Conjoined muscle (arched fibres of internal oblique).

Below: Inguinal ligament (*Poupart's*) and lacunar ligament (*Gimbernat*).

External ring is a triangular opening in the external oblique aponeurosis lying 1.25 cm above the pubic tubercle. Its superomedial crus is formed by external oblique aponeurosis and inferolateral crus by inguinal ligament.

Internal ring is a normal opening in the transversalis fascia and transverses aponeurosis which is U shaped or lambda (λ) shaped; it is 1.25 cm above the mid inguinal point (between anterior superior iliac spine to pubic symphysis).

An indirect inguinal hernia (hernia though deep ring) travels down the canal on the lateral and anterior aspect of the spermatic cord; whereas the direct hernia pops out directly forward through the posterior wall of the inguinal canal. Neck of the indirect sac is lateral to inferior epigastric vessels but direct sac emerges medial to the inferior epigastric vessels with a wide neck. Saddle-bag or pantaloon hernial sac has got both medial and lateral component. Inguinal hernia is above and medial to the pubic tubercle. Femoral hernia is below and lateral to pubic tubercle **(Figs 30-3 and 30-4)**.

Direct hernia occurs through *Hesselbach's* (1814) triangle which is bound by inferior epigastric artery laterally, lateral border of rectus muscle medially, inguinal ligament below. It is divided into medial and lateral halves by obliterated umbilical artery (medial umbilical ligament). So direct hernia is classified as *medial or lateral depending on which part of the Hesselbach's triangle, it is arising from.* Lateral umbilical ligament is formed by inferior epigastric arteries. Medial type actually is called as *external supravesical hernia* and this fossa is called as *external supravesical fossa* **(Fig. 30-5)**.

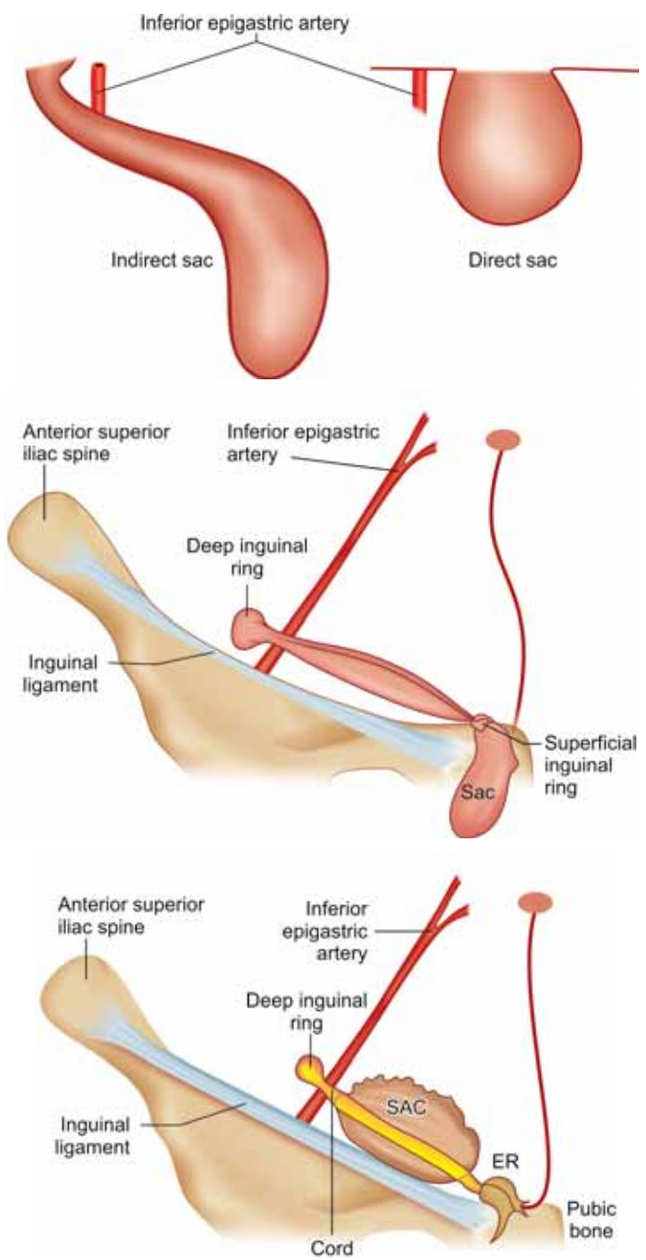


Fig. 30-3: Surgical anatomy of direct and indirect inguinal hernia sac.

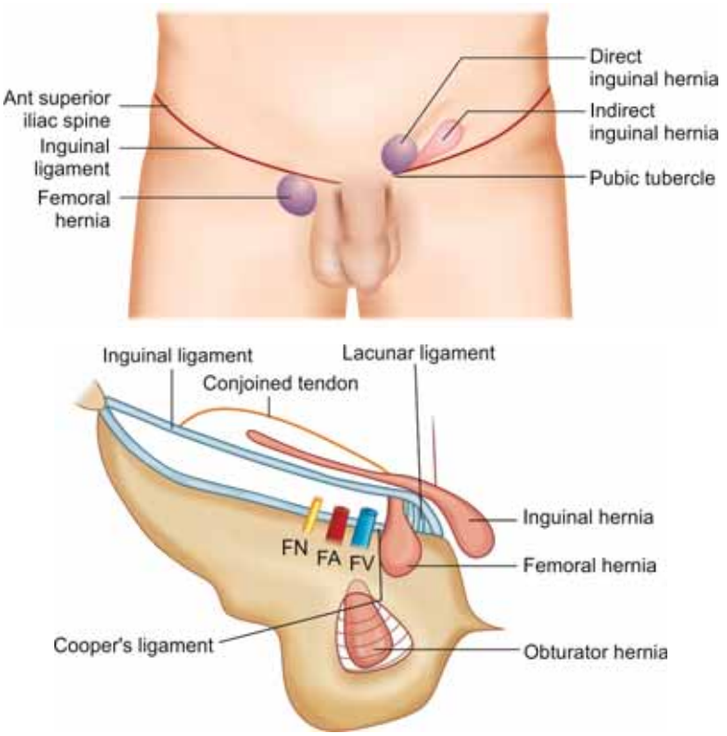


Fig. 30-4: Anatomical relations and locations of the inguinal, femoral and obturator hernias.

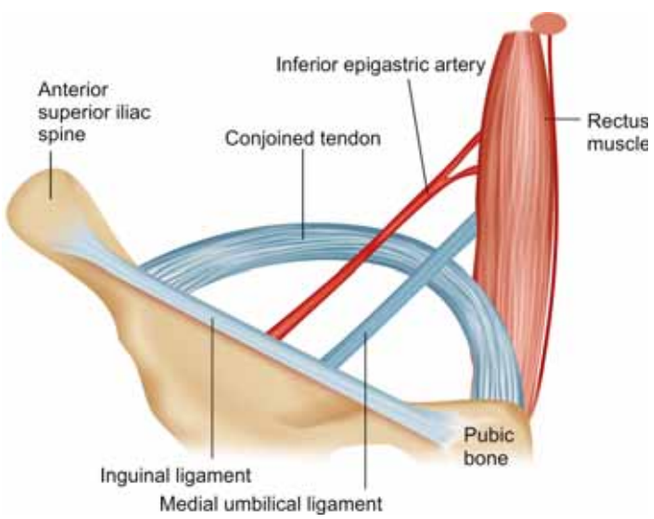


Fig. 30-5: Surgical anatomy of Hesselbach's triangle.

Inguinal Defense Mechanisms

Obliquity of inguinal canal creates flap valve mechanism by approximating anterior and posterior walls of the canal. Cooper described external oblique aponeurosis as outer barrier of the inguinal canal causing step down effect for the spermatic cord.

Shutter mechanism of internal oblique forms anterior, roof and posterior wall of the inguinal canal. Roof apposes to floor like a shutter.

External ring is *guarded* by conjoined tendon behind and reflected part of inguinal ligament in front. Internal ring is *guarded* by fleshy internal oblique. Contraction of external oblique aponeurosis causes *pinch cock/slit valve* effect by approximation of two crura of external ring.

Cremaster muscle on contraction helps cord to plug the external ring—*ball valve mechanism*.

Hormones also play a role to maintain inguinal muscles.

Anatomy of Abdominal Wall

Anterior Abdominal Wall

The anterior abdominal wall is a musculofascial dynamic structure which maintains intraabdominal pressure for various physiological functions. It has got three paired flat muscles, two recti abdominis muscles and linea alba in midline. These are anteriorly related to skin, subcutaneous tissue and superficial fascia; posteriorly related to transversalis fascia and peritoneum. *External oblique fascia* (external layer of the fascia of external oblique muscle is also called as *innominate fascia of Gallaudet*) is thin fascial covering of external oblique muscle and fascia which forms intercrural fibers of the superficial inguinal ring; and it extends below into the scrotum as external spermatic fascia.

External oblique muscle arises from middle of body of lower eight ribs running below, front and medially inserting into xiphoid process, linea alba, pubic symphysis, pubic crest, pectineal line of pubis and anterior 2/3rd of outer lip of the iliac crest. It is supplied by lower six thoracic nerves. Lower free border of the external oblique aponeurosis forms inguinal ligament. Triangular opening in its aponeurosis above the pubic crest is called as superficial inguinal ring **(Fig. 30-6)**.

Internal oblique muscle arises from lateral 2/3rd of inguinal ligament, anterior 2/3rd of intermediate part of iliac crest, thoracolumbar fascia; runs upwards, forwards and medially to insert into lower four ribs and cartilages, xiphoid process, pubic crest, pectineal line of pubis. It is supplied by lower six thoracic nerves, 1st lumbar nerve. Aponeurosis below the level of umbilicus remains as a single layer forming the anterior rectus sheath and linea alba. Above aponeurosis splits into anterior lamina which passes medially in front of rectus abdominis and posterior lamina which passes behind rectus abdominis which ends below midway between umbilicus and pubic symphysis as linea *semicircularis of Douglas* (arcuate line). *Semilunar line of Spieghel* lies in lateral border of the rectus sheath from pubic tubercle to the tip of the costal cartilage of 9th rib **(Fig. 30-7)**.

Transverse abdominis muscle originates from lateral 1/3rd of inguinal ligament, anterior 2/3rd of inner lip of iliac crest, thoracolumbar fascia, lower six cartilages with fibers running horizontally forwards inserting into an aponeurosis extending from xiphoid process, linea alba, pubic crest, pectineal line of pubis. Lowest fibers fuse with lowest fibers of internal oblique to form conjoined/conjoint tendon. It is supplied by lower six thoracic and first lumbar nerves. Neurovascular plane of abdomen lies between internal oblique and transverse abdominis muscles **(Fig. 30-8)**.

Rectus abdominis muscle arises from lateral part of pubic crest (lateral head) and anterior pubic ligament (medial head) running vertically upwards to insert into xiphoid process and 7th, 6th and 5th costal

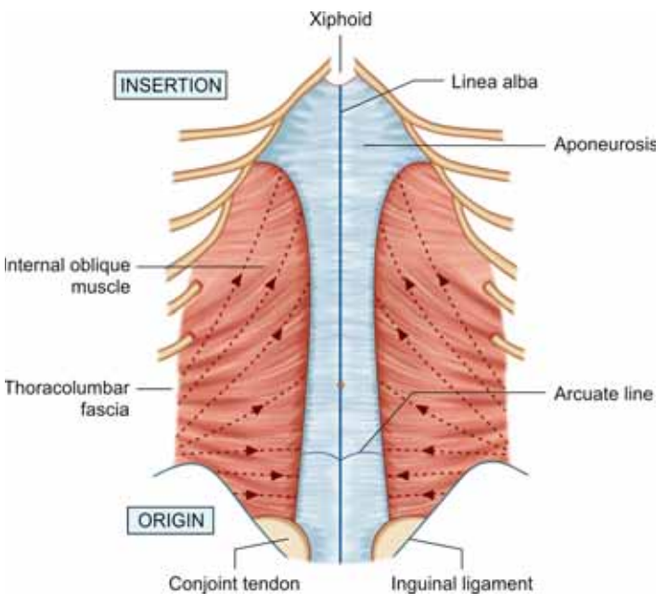


Fig. 30-7: Internal oblique muscle.

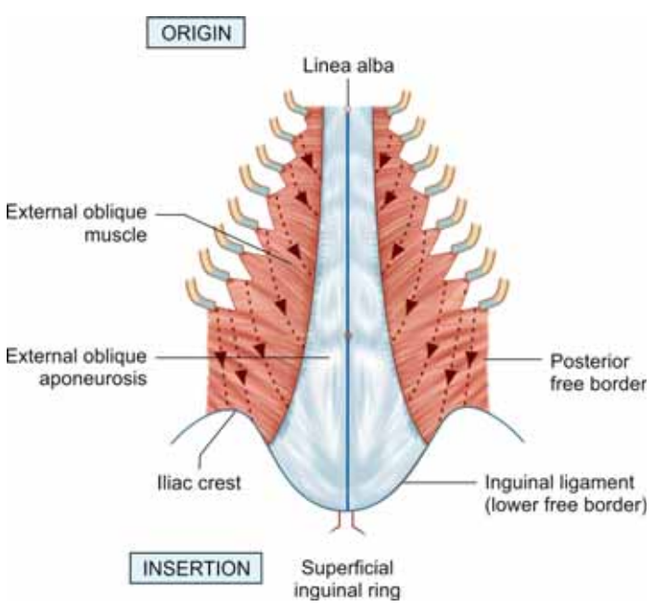


Fig. 30-6: External oblique muscle.

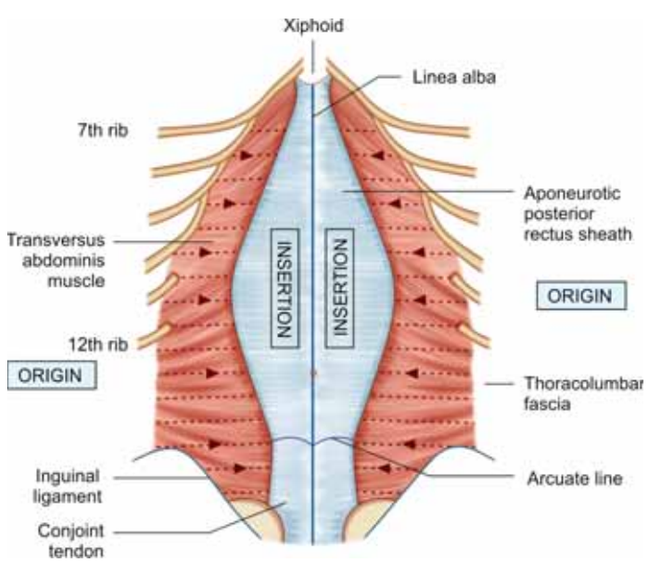


Fig. 30-8: Transverse abdominis muscle.

cartilages. It is supplied by lower six thoracic nerves. There are three tendinous intersections; one at xiphoid, one at umbilicus, one between two which are adherent to anterior half of muscle and anterior wall of rectus sheath. They are due to embryologic segmental origin of muscle which adds to the power of muscle **(Figs 30-9 and 30.10)**.

Inguinal ligament is formed by thickened posteriorly folded lower border of the external oblique aponeurosis extending from anterior superior iliac spine to pubic tubercle; lateral ½ is oblique and rounded and medial ½ is horizontal and grooved. The pectineal part of the inguinal ligament (lacunar) (triangular) is related in front to medial end of the inguinal ligament behind to pectin pubis; apex is attached to pubic tubercle; base directing laterally forms medial wall of femoral ring. Cooper's pectineal ligament is thickened pectineal fascia which is attached to the pectin pubis lateral to the base of the lacunar ligament. Aponeurotic fibers from the inferior crus of the external ring passing superomedially to linea alba is called as *Colles' reflected part of the inguinal ligament.*

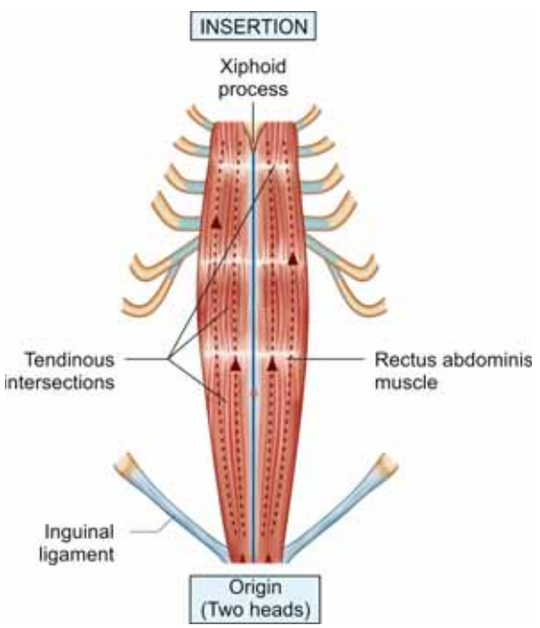


Fig. 30-9: Rectus abdominis muscle.

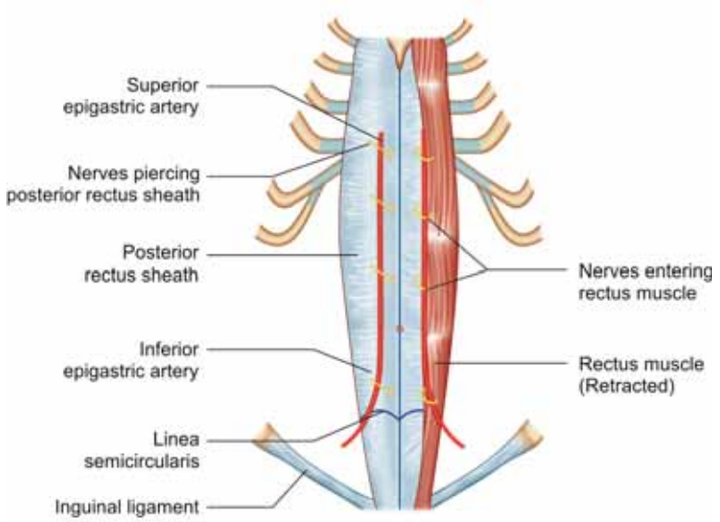


Fig. 30-10: Abdominal wall anatomy behind the rectus muscle.

Cremaster muscle is muscle fascicule embedded in cremaster fascia *(Scarpa's sheath)* which are attached to inguinal ligament laterally, internal oblique, transverse abdominis and conjoint tendon, pubic tubercle and pubic crest medially. It is seen properly only in males; sparse in females. It is supplied by genital branch of genitofemoral nerve (L1). It suspends the testis in elevated position. It closes during raise in intraabdominal pressure; it protects nerves of the inguinal canal. During hernioplasty if cremaster is excised, testis may hang like clapper bell due to loss of suspensory and retractile function of the cremaster. So if cremaster is excised, medial cut end should be sutured to inguinal ligament or pubic tubercle. Stroking medial aspect upper thigh will cause reflex contraction of cremaster with elevation and retraction of testis—*cremasteric reflex* which is absent in upper motor neuron disease. Reflex is through femoral branch (stroking of medial thigh) of genitofemoral nerve to genital branch of genitofemoral nerve (cremaster muscle) through spinal cord.

Pyramidalis is a small triangular rudimentary muscle arising from anterior surface of body of pubis running upwards and medially in front of the rectus abdominis to insert into linea alba; which is supplied by T12 subcostal nerve which is tensor of linea alba **(Fig. 30-11)**.

Deep Nerves of the Abdominal Wall

Lower five intercostal and subcostal (lower six thoracic) nerves and iliohypogastric and ilioinguinal nerves supply the anterior abdominal wall. *Lower five intercostal nerves* pass through the slips of origin of transversus abdominis muscles; runs between transversus abdominis and internal oblique; pierces the posterior lamina of internal oblique aponeurosis to reach rectus sheath; then passes behind the rectus sheath in front of the epigastric vessels, pierces the rectus muscle to continue as anterior cutaneous nerve. Before piercing it supplies the anterior rectus sheath transversus abdominis, internal oblique, external oblique and rectus abdominis. During its course it also gives lateral cutaneous nerve of the abdominal wall through flat abdominal muscles. *Battle's incision* which is pararectal incision will injure these nerves causing weakening of the rectus muscle and so is avoided.

Subcostal nerve, anterior primary ramus of 12th thoracic nerve after travelling behind the diaphragmatic lateral arcuate ligament, passes in front of the quadratus lumborum and then pierces the transversus abdominis to run like other intercostal nerves. It supplies pyramidalis muscle and gluteal region as lateral cutaneous branch.

Iliohypogastric nerve arises from the anterior division of L1 nerve runs away from lateral margin of psoas major muscle in front of quadratus

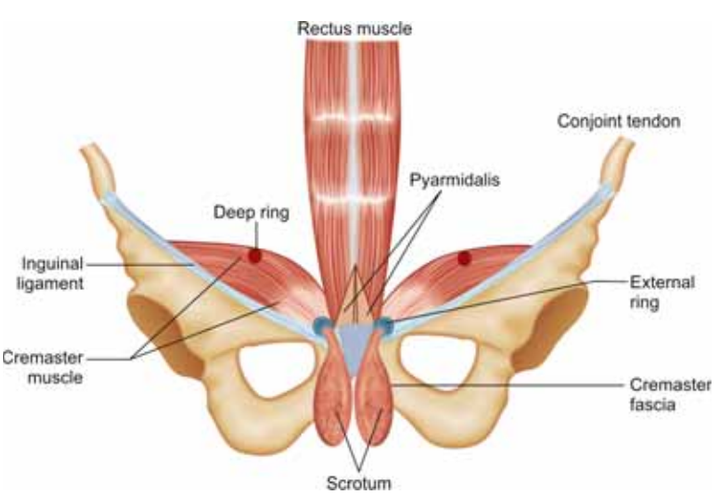


Fig. 30-11: Anatomy of pyramidalis and cremaster.

lumborum behind kidney and colon to pierce transversus abdominis just above the iliac crest; runs between transversus abdominis and internal oblique; pierces the internal oblique 2.5 cm above the anterior superior iliac spine, run between internal oblique and external oblique to reach 2.5 cm above the superficial inguinal ring where it pierces the external oblique aponeurosis to supply skin around the area.

Ilioinguinal nerve also arises from anterior division of L1 nerve runs over the quadratus lumborum, iliac crest pierces the transversus abdominis 3.5 cm medial to anterior superior iliac spine; runs between transversus abdominis and internal oblique for a short distance to pierce internal oblique just below and medial to iliohypogastric nerve lateral to deep inguinal ring; runs in inguinal canal outside the cord is males or round ligament (in females), passes through superficial inguinal ring; runs in front of the scrotum to supply anterior part of the scrotum.

The genitofemoral nerve arises from ventral divisions of L1, L2 nerves; passes through the medial part of the psoas major muscle running below in front of the muscle; just above the deep ring it divides into medial genital and lateral femoral branches. Genital branch after piercing the psoas sheath runs in front of the external iliac artery and passes through deep ring to enter the inguinal canal within the spermatic cord in males or round ligament in females. It supplies cremaster muscle, runs in the cord to reach anterolateral aspect of the scrotum and supplies that part. In females it gives sensory branches to round ligament and labium majus. Femoral branch passes along with the femoral artery to supply skin over the femoral triangle.

Lateral cutaneous nerve of thigh (lateral femoral cutaneous nerve) arises from dorsal divisions of L2, L3 of lumbar plexus comes out at lateral border of the psoas major muscle passing on the inner lower short part of the quadratus lumborum to run on the main bulk of the iliacus muscle downwards and laterally; pierces the transversus abdominis, internal oblique and external oblique through and through (without travelling in between these muscles); passes behind the lateral part of the inguinal ligament 2-2.5 cm medial to anterior superior iliac spine. It supplies the skin over upper lateral part of the thigh and anterior part of the gluteal region after dividing into anterior and posterior branches **(Fig. 30-12 to 30-14)**.

Femoral nerve arises from dorsal divisions of L2, L3, L4 nerves of lumbar plexus, runs in the lower lateral border of the psoas major muscle in a groove between psoas major and iliacus muscles to reach the thigh along the lateral most compartment of the femoral canal. It supplies the iliacus muscle.

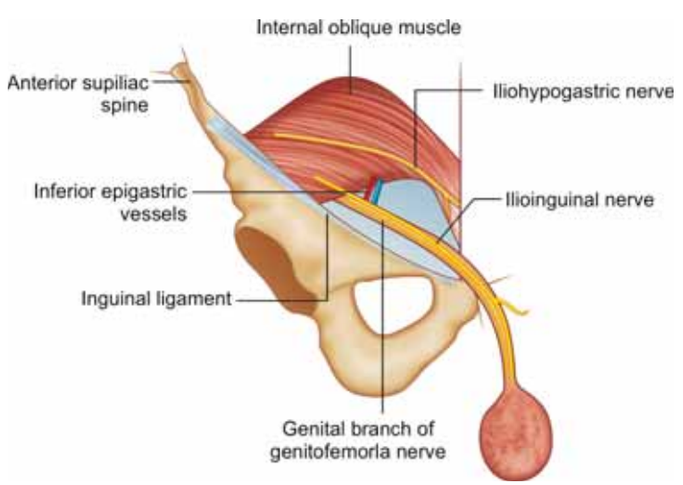


Fig. 30-12: Nerves in the groin. Ilioinguinal, iliohypogastric and genital branch of genitofemoral nerves are important three nerves which surgeon will come across during the open inguinal hernia surgery.

Obturator nerve arises from ventral divisions of L1, L2, L3 nerves of lumbar plexus runs on the medial aspect of the psoas major muscle; passes forwards and below into the pelvic brim where it is crossed by internal iliac artery and ureter to enter the obturator canal. In the canal it divides into anterior and posterior divisions. Anterior division supplies pectineus, adductor longus, gracilis and often adductor brevis muscles and hip joint. Posterior division supplies obturator externus, adductor magnus and often adductor brevis muscles, through genicular branch which runs in adductor canal, popliteal fossa, and oblique popliteal ligament supplies the knee joint. This genicular branch often gets compressed in obturator hernia to cause referred pain in knee joint (*Howship Romberg sign*).

Muscles of the Posterior Abdominal Wall

They are psoas major, psoas minor, quadratus lumborum and iliacus. *Psoas major* arises from body and transverse processes of all lumbar vertebrae to insert into the tip and medial part of the lesser trochanter of the femur after passing behind the inguinal ligament along with the iliacus tendon (lateral part of the lesser trochanter). It is supplied by L2, L3, L4 spinal nerves. *Psoas minor* is small muscle in front of the psoas major arises from bodies of T12 and L1 vertebrae to insert into the pectin pubis and iliopubic eminence. It is supplied by L1. *Iliacus* arises from upper 2/3rd of inner aspect of fossa of ilium, upper lateral part of the sacrum to insert into lateral part of the lesser trochanter along with psoas major. It is supplied by femoral nerve. *Quadratus lumborum* arises from transverse process of L5 vertebra and inner lip of iliac crest to insert into medial part of the anterior surface of 12th rib and transverse processes of upper four lumbar vertebrae. It is supplied by spinal nerves T12 to L4.

Fascia Transversalis (Cooper's Fascia)

It is the fascia that lines the inner surface of the transversus abdominis muscle separated from the peritoneum by extraperitoneal connective tissue. In front it is adherent to linea alba above the umbilicus; behind merges with anterior layer of thoracolumbar fascia and renal fascia; above with diaphragmatic fascia; below it is attached to inner lip of iliac crest, inguinal ligament; medially it is attached to pubic tubercle, pubic crest and pectineal line which prolongs down as anterior layer of femoral sheath. It also forms internal spermatic fascia around the cord. Deep inguinal ring is U/lambda/oval shaped opening 1.25 cm above the mid inguinal point (between pubic symphysis and anterior superior iliac spine) which is lateral to inferior epigastric artery, transmits spermatic cord in males and round ligament in females. In the inguinal area transversalis fascia is *bilaminar* enclosing the inferior epigastric vessels. *Space of Bogros* is extension of the retropubic *space of Retzius* which is located beneath the posterior lamina of transversalis fascia and in front of the peritoneum. Inlay preperitoneal mesh repair is done by placing mesh in this space. Thickening of the transversalis fascia at medial side of the internal ring and in front of the inferior epigastric vessels is called as *interfoveolar Hesselbach's ligament*.

Endoabdominal Fascia

Endoabdominal fascia is connective tissue that lines inner aspect of the entire abdominal musculature. Part in relation to transversus abdominis is called as fascia transversalis. It forms iliac, diaphragmatic and renal fascia.

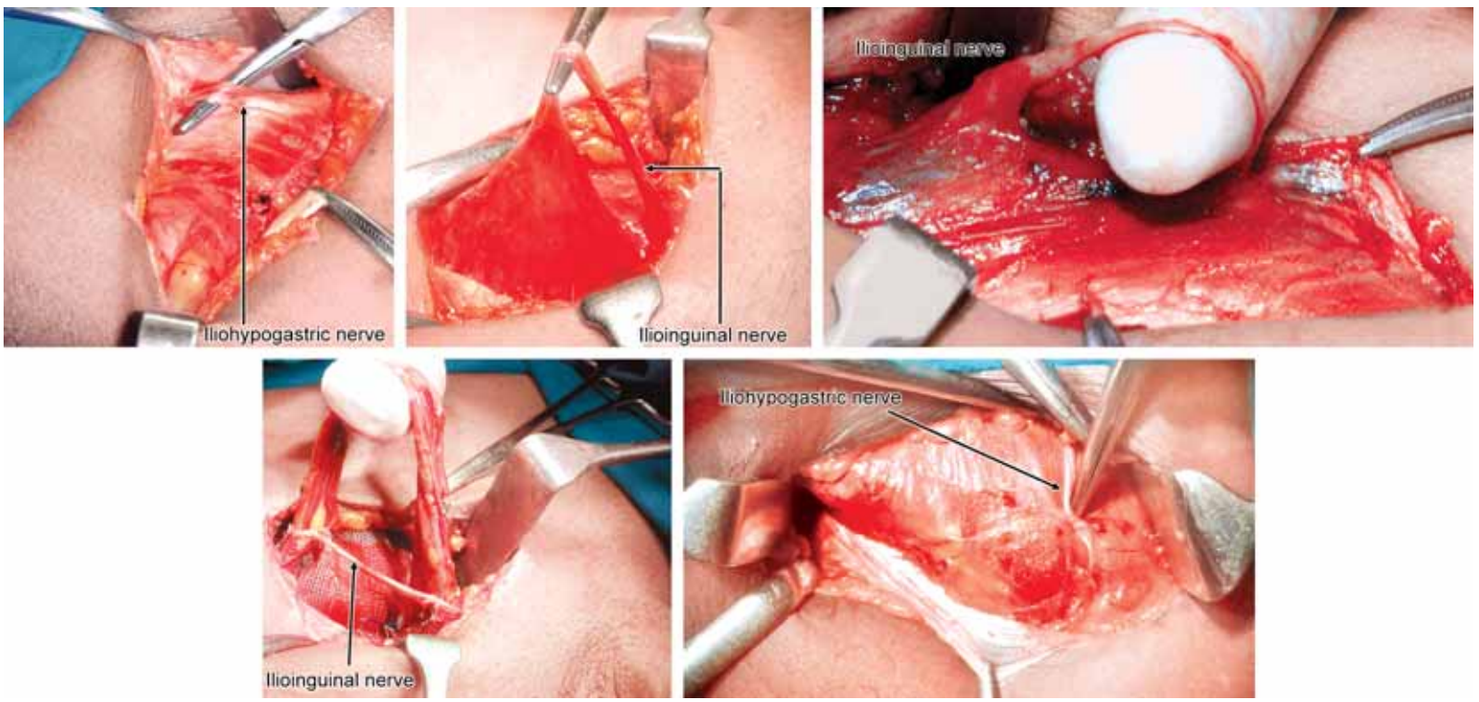


Fig. 30-13: Ilioinguinal nerve and iliohypogastric nerves.

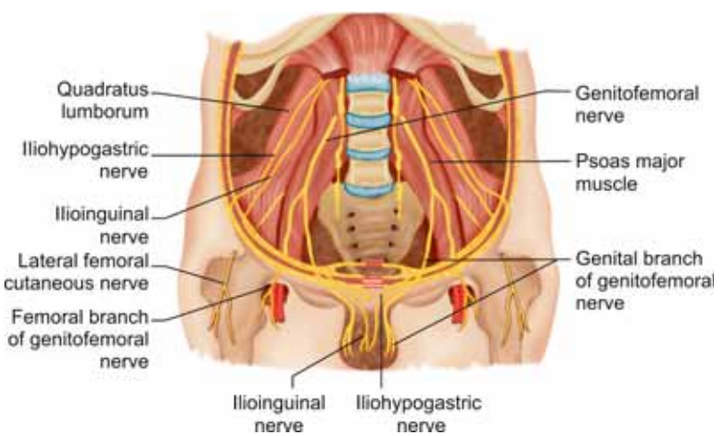


Fig. 30-14: Anatomy of different nerves in relation to groin hernia.

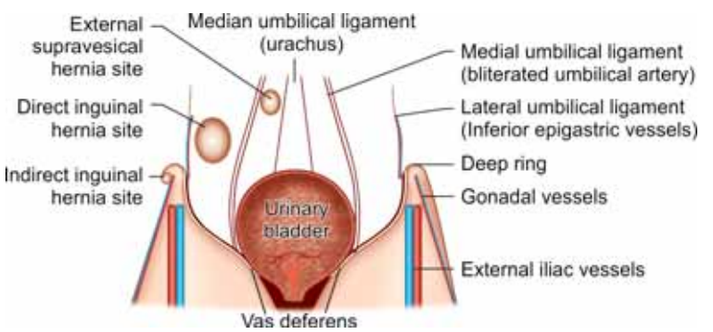


Fig. 30-15: Ligaments related to groin and hernia surgery.

Iliopubic Tract (Bandelette of Thomson)

Iliopubic tract is confused with inguinal ligament. It is an aponeurotic band extending from iliopectineal arch (thickened medial part of the iliopsoas fascia) and anterior superior iliac spine to superior ramus of the pubis forming deep musculoaponeurotic layer with transversus abdominis muscle, aponeurosis and transversalis fascia; it runs medially along inferior margin of the deep ring, anterior margin of the external iliac vessels, femoral sheath to attach to the pectineal ligament of Cooper **(Fig. 30-15)**.

Blood Supply of Abdominal Wall

It is divided into superficial and deep vessels. ***Superficial vessels*** are superficial epigastric, superficial circumflex iliac and superficial external pudendal arteries—are branches of femoral artery. They travel towards umbilicus in subcutaneous plane. Superficial epigastric artery communicates with opposite superficial epigastric artery and all three communicate with deep arteries.

Deep arteries are posterior intercostal arteries (10, 11), anterior branches of four lumbar and subcostal arteries and deep circumflex iliac artery. Deep arteries travel between transversus abdominis and internal oblique muscles. Recti are supplied by superior and inferior epigastric arteries. *Superior epigastric artery* is one of the two terminal branches of the internal thoracic/mammary artery. It originates at 6th intercostal space enters the abdomen between costal and xiphoid origin of the diaphragm, enters the rectus sheath from above, behind the 7th costal cartilage. It descends downwards communicating with inferior epigastric artery behind the rectus muscle. Branches are muscular, cutaneous, hepatic along the falciform ligament and anastomotic to opposite side artery.

Inferior epigastric artery (IEA) originates from external iliac artery just above the inguinal ligament, runs upwards and medially in the extraperitoneal connective tissue between peritoneum and posterior lamina of transversalis fascia initially medial to internal ring; pierces the transversalis fascia at the lateral border of the rectus muscle; runs in front of the arcuate line supplying the rectus and ends by anas-

tomosing with superior epigastric artery. Branches are—muscular, cremasteric, pubic, and cutaneous. *Cremasteric branch* after travelling laterally towards deep ring supplies cremaster and runs along the spermatic cord. Pubic branch runs medially along the pubic bone to communicate with pubic branch of anterior division of obturator artery. Often obturator artery may be replaced by this pubic branch of inferior epigastric artery as abnormal/aberrant obturator artery. This pubic branch crosses over femoral ring and Cooper's ligament. This may be injured during fixation of mesh in TEP repair or femoral hernia repair causing torrential bleeding from both cut ends. As medial cut end retracts deep into the obturator fat and fascia it is difficult to control bleeding. This area is often called as *circle of death*. Inferior epigastric vein is medial to IEA **(Fig. 30-16)**.

Deep circumflex iliac artery arises from lateral side of the external iliac artery behind the inguinal ligament which after piercing the transversalis fascia runs along the iliac crest; at its middle it again pierces the transversus abdominis and internal oblique to reach adjacent to anterior superior iliac spine where it anastomoses with superior gluteal, superficial circumflex iliac, lateral circumflex femoral arteries. Here it also gives ascending branch which runs in abdominal wall which may be injured in TEP causing large haematoma.

Bendavid circle: It is the circle where venous network is situated in *space of Bogros* formed by branches of inferior epigastric, iliopubic, suprapubic, and retropubic veins. They communicate with aberrant obturator vein which is commonly existing (70%). During laparoscopy (TEP/TAPP) due to high insufflation pressure veins will collapse and will not bleed during dissection but bleeds later in postoperative period.

Triangle of doom is observed in laparoscopic hernia procedure. It is a triangle formed medially by vas deferens, laterally by testicular vessels and peritoneal reflection below with the apex at internal ring. External iliac vessels lie in this triangle and so extreme care should be taken while dissecting the hernia sac in this triangle.

Preperitoneal Space of Nyhus

It is the space between transversalis fascia and peritoneum. Medially, it is in front of the urinary bladder and behind pubic bone as retropubic space of Retzius (1858). Laterally it continues as space of Bogros (1823). Below it is limited at iliopubic tract; laterally to anterior superior iliac spine and iliopsoas fascia. Iliopubic tract is analogue of the inguinal ligament, extends from Cooper's ligament to anterior superior iliac spine which divides endoscopic view of pre-peritoneal space into *superior compartment* (contains inferior epigastric artery, Hesselbach's triangle, cord structures and is site of inguinal hernia) and *inferior compartment* (contains femoral canal, iliac vessels (vein medially and artery laterally) iliopsoas muscle, genitofemoral nerve, lateral femoral cutaneous nerve). External iliac vessels lie in a triangle formed by gonadal vessels laterally, vas deferens medially and peritoneal reflection inferiorly (*triangle of doom*). Aberrant obturator artery which is an occasional branch of inferior epigastric artery replacing its pubic branch travels across Cooper's ligament, which during fixation of mesh can cause torrential haemorrhage—*circle of death. Triangle of pain* is formed by gonadal vessels medially, iliopubic tract laterally and peritoneal reflection below. Genitofemoral nerve and lateral cutaneous nerve of thigh traverse this triangle. Injury to these nerves either by dissection or by tacks causes severe post operative pain. Tacks/staplers should not be placed in this triangle.

Endoscopic hernia repair needs dissection and exposure of the entire myopectineal orifice from midline to anterior superior iliac spine

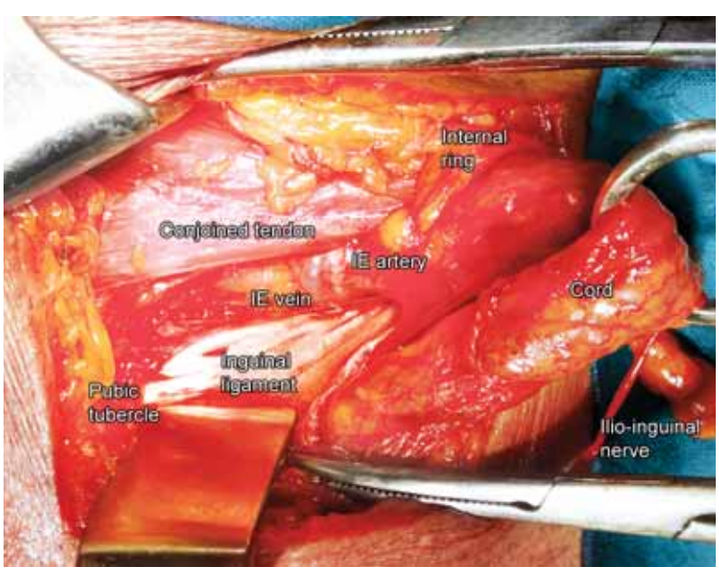


Fig. 30-16: Inferior epigastric vessels—on table look.

Fruchaud's (French Surgeon) Myopectineal Orifice (MPO)

It is an osseo-myo-aponeurotic tunnel. *It is through this tunnel that all groin hernias occur.* It is bound medially by lateral border of rectus sheath; above by the arched fibres of internal oblique and transverse abdominis muscle; laterally by the iliopsoas muscle; below by the pectin pubis and fascia covering it.

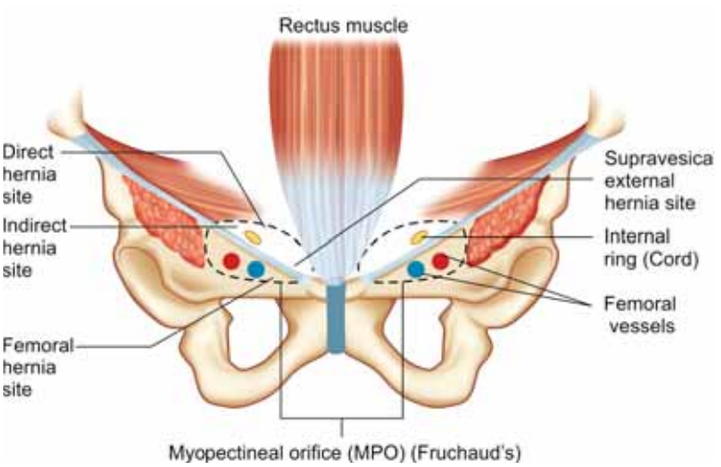


Fig. 30-16A: Myopectineal orifice of Fruchaud's.

Fossae of the Anterior Abdominal Wall

There are three fossae on the inner surface of the anterior abdominal wall above the ligament and below the umbilicus. *Lateral fossa* is lateral to lateral umbilical ligament (which contains inferior epigastric artery) which is the site of indirect inguinal hernia. Lateral fossa contains deep inguinal ring. *Medial fossa* is between lateral and medial umbilical ligament (obliterated umbilical artery). Here direct hernia develops. *Supravesical fossa* is between medial and median (obliterated urachus) umbilical ligament which is the site of external supravesical hernia. Internal supravesical hernia develops in

relation to urinary bladder directly, as anterior prevesical, posterior retrovesical and lateral paravesical.

NEWER CLASSIFICATIONS OF GROIN HERNIA

Gilbert Classification

***Type I*:** Hernia has got snug internal ring through which a peritoneal sac passes out as indirect sac.

Type II: Hernia has a moderately enlarged internal ring which admits one finger but is lesser than two fingerbreadth. Once reduced it protrude during coughing or straining.

Type III : Hernia has got large internal ring with defect more than two fingerbreadth. Hernia descends into the scrotum or with sliding hernia. Once reduced it immediately protrudes out without any straining.

Type IV: It is direct hernia with large full blow out of the posterior wall of the inguinal canal. The internal ring is intact.

Type V: It is a direct hernia protruding out through punched out hole/defect in the transversalis fascia. The internal ring is intact.

Type VI: Pantaloon/double hernia.

Type VII: Femoral hernia.

TYPE VI and VII are Robbin's modifications **(Figs 30-17A and B)**.

NYHUS Classification

It is based on size of the internal ring and posterior wall weakness.

Type I: Indirect hernia with normal deep ring.
Type II: Indirect hernia with dilated/widened deep ring.
Type III: Posterior wall defect.
  a. Direct.
  b. Pantaloon hernia: Indirect with posterior wall weakness.
  c. Femoral hernia.
Type IV: Recurrent hernia.

BENDAVID Classification

Type I: Antero-lateral defect (indirect).
Type II: Antero medial. (direct).
Type III: Postero-medial (femoral).
Type IV: Posterior-prevascular hernia.
Type V: Antero-posterior defect: Inguino-femoral hernia.

INDIRECT (OBLIQUE) INGUINAL HERNIA (FIG. 30-18)

This is the most common type of hernia. It is more common in younger age group as compared to direct inguinal hernia which is more common in elderly. It is more common on right side in 1st decade but in 2nd decade the incidence is equal on both sides. Hernia is bilateral in 30% of cases. Sac is thin in indirect type. Neck is narrow and, lies lateral to inferior epigastric vessels **(Fig. 30-19)**.

Types: (1) *Bubonocele*, where the hernia is limited to inguinal canal; (2) *Funicular where p*rocessus vaginalis is closed just above the epididymis. Contents of the sac can be felt separately from testis, which lies below the hernia. (3) *Complete (Scrotal*) where testis appears to lie within the lower part of hernia. It can occur in any age group. It occurs in a congenital preformed sac (*processus vaginalis*). More commonly contents descend into the pre-existing sac only when there are precipitating causes which force the content down **(Fig. 30-20 to 30-22)**.

SURGERIES FOR INGUINAL HERNIA

History of Hernia Surgery

Original Eduardo Bassini (Padua, 1889) repair is though an anterior approach. He opened posterior wall of inguinal canal and did a sutured three layered repair. In modified Bassini repair transverse arch is sutured to the shelving edge of inguinal ligament as single layered interrupted sutures.

De Chauliac differentiated inguinal from femoral hernias (1363). Kaspar Stromayr differentiated direct and indirect hernias in 1559. Ambroise Pare (1550) used trusses in hernia. John Hunter, Astley Paston Cooper (1841) Franz Hesselbach, Antonio Scarpa (1832), Pieter Camper, Jules Germain Cloquet (1883), Bogros, Retzius contributed in understanding anatomy of the groin.

Figs 30-17A and B: Bilateral direct hernia.

Fig. 30-18: Complete indirect hernia

La Roque, GL Cheatle, JP Hoguet, AK, Henry, McVay, McEvedy, Lotheissen, McArthur (used strips of external oblique aponeurosis to approximate conjoined tendon to inguinal ligament), Kirschner (used thigh fascial grafts), Gallie (used strips of fascia lata for repair using his specialized needle *Gallie's needle*), Handley (used silk with staylace darning), Meick (used first multifilament Nylon), Haxton (used monofilament Nylon), Moloney (Nylon darn procedure, 1948) are the others who contributed to hernia surgery.

Halsted (John Hopkins Baltimore) did four layered repair shifting cord anterior to the external oblique aponeurosis thus bringing superficial and deep ring directly very close causing higher chances of recurrence.

EE Shouldice (1945) of Toronto did repair of transversalis fascia under local anaesthesia as a tension free 4/6 layered tissue repair.

Usher from Texas in 1958 first used Marlex mesh in posterior wall for repair as tension eliminating.

Lichtenstein (1970) did rolled plug mesh repair of femoral hernia. Newman (New Jersey) did tension free inguinal hernia onlay mesh repair. Lichtenstein and Amid made this technique popular worldwide with certain modifications.

Nyhus from Chicago and Condon from Milwaukee popularized open posterior repair from higher approach. Their technique probably became basis for TEP/TAPP.

Stoppa and Rives (France) evoluted giant reinforcement of the visceral sac by blocking Fruchaud's myopectineal orifice (MPO) bilaterally.

EH Phillips and JB McKeran started TEP in 1990. Arregui started TAPP in 1992 **(Fig. 30-23)**.

Anaesthesia Used for Inguinal Hernia Repair

General/spinal/epidural or local anaesthesia can be used to do inguinal hernia repair.

Local anesthesia is becoming popular; for open approach. General anesthesia is needed in children, for TAPP and TEP procedures.

Technique of Local Anesthesia

Around 50-60 mL of xylocaine 0.5% is used. Plain xylocaine 0.5% or xylocaine 0.5% with adrenaline can be used. Plain xylocaine—dose is 2 mg/kg body weight. Xylocaine with adrenaline—dose is 7 mg/kg body weight **(Fig. 30-24)**.

Two Methods are Used

1. *Nerve block method (Point block)*
   10 mL of xylocaine is infiltrated 2 cm above and medial to anterior superior iliac spine to block the iliohypogastric nerve. Midinguinal point is infiltrated with 10 mL xylocaine. Area around the pubic tubercle place is infiltrated with 10 mL xylocaine. 10 mL of xylocaine is infiltrated just below the inguinal ligament lateral to femoral artery to block the genital branch of genitofemoral artery. Line of skin incision is infiltrated with 10 mL of xylocaine. Later neck of the hernial sac is infiltrated with 10 mL of xylocaine.
2. *Field block method (Shouldice method)*
   Skin of around 4 cm wide area is infiltrated including the subcutaneous plane as first layer from anterior superior iliac spine to pubic symphysis. Skin, subcutaneous and two layers of superficial fascia (Camper and Scarpa's) are incised. Area deep to external oblique aponeurosis is infiltrated with 10 mL of xylocaine. External oblique aponeurosis is incised. Exposed inguinal canal and hernial sac is infiltrated with 10 mL of xylocaine to continue with the dissection.

Different Surgeries (Fig. 30-25)

Herniotomy in Infants

In infants, whether it is hernia or hydrocele, *only herniotomy* is done through inguinal approach (*Michaelis plank operation)*. High ligation is the procedure of choice. Few advocated bilateral inguinal herniotomy in all children with unilateral/bilateral inguinal hernias. Hernia here is due to patent processus vaginalis and always indirect.

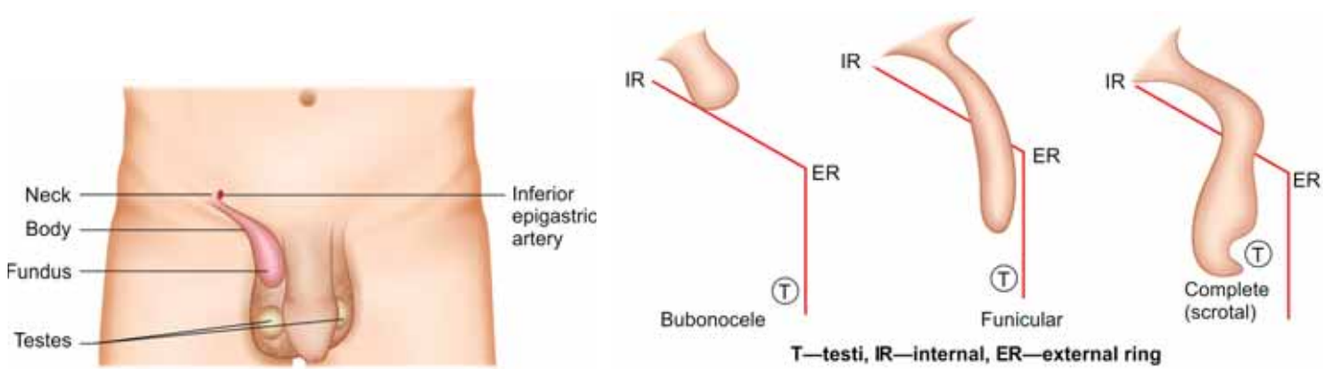


Fig. 30-19: Surgical anatomy of indirect hernia and types of indirect inguinal hernia.

Fig. 30-20: Bubonocele.

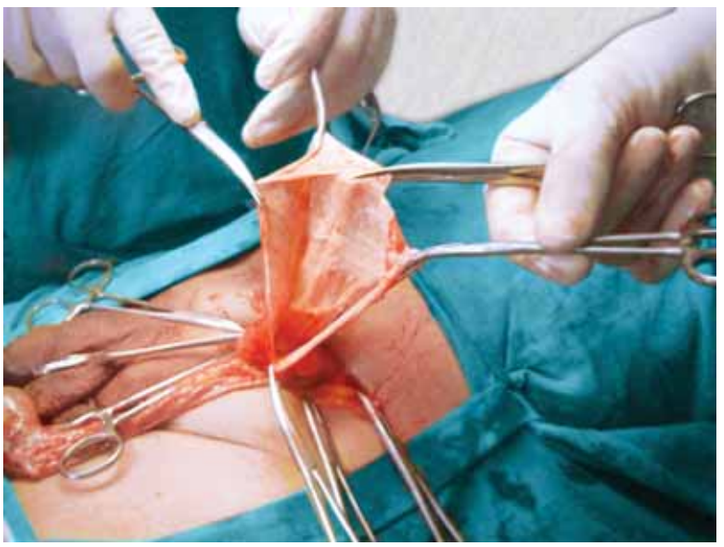


Fig. 30-22: Indirect hernial sac

Fig. 30-21: Enterocele in a hernial sac.

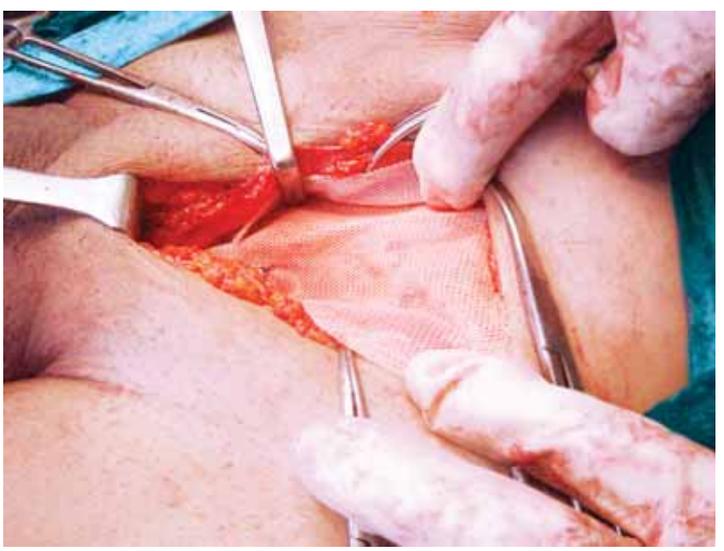


Fig. 30-23: Mesh plasty has become standard now.

It is common in boys (9:1); common on right side; 15% bilateral. Often presentation is like hydrocele. It is often associated with undescended testis. Incarceration of bowel is very high in male infants with inguinal hernia. It is near 30% in premature or child less than 1 year. From 1 year to 18 years age group incarceration is around 15%. In girls, ovary and fallopian tubes are common content; strangulation of ovary is common. Conservative treatment should not be done in childhood inguinal hernia **(Fig. 30-26 to 30-28)**.

Inguinal canal approach: Technique is same as in adults but more care and meticulous technique is needed. Superficial inguinal ring should not be opened to avoid the scarring of the superficial inguinal ring. Vas deferens should not be held with haemostat or forceps. Fine non toothed Adson's forceps can be used if only needed. Whenever sac is complete distal part is left alone after transecting the sac; proximal part is ligated high above the level of the deep ring. Before ligating one should ensure that contents are pushed properly into the peritoneal cavity. Usually hydrocele is due to infantile hernial sac and so there is no need to do a separate incision for hydrocele; instead distal part of the sac is opened for an adequate length, followed by removal of fluid content and later sac is left open like that. Separate hydrocele or encysted hydrocele if present, should be dealt through same incision. Repair is not needed along the floor of the inguinal canal; and it will disturb the shutter mechanism if repair is done. Transversalis fascia should not be injured. *Very rarely* when direct sac is present posterior wall may be repaired by suturing conjoined tendon to inguinal ligament using 3 interrupted polypropylene sutures. But a surgeon should remember that *in children there is no repair in inguinal hernia*. Wound is closed in layers. Contralateral exploration is often advocated by many as a routine practice.

Inguinal incision without opening the inguinal canal approach: In infants variation in approach can be undertaken but with difficulty. Here medial inguinal incision is made. Cord structures coming

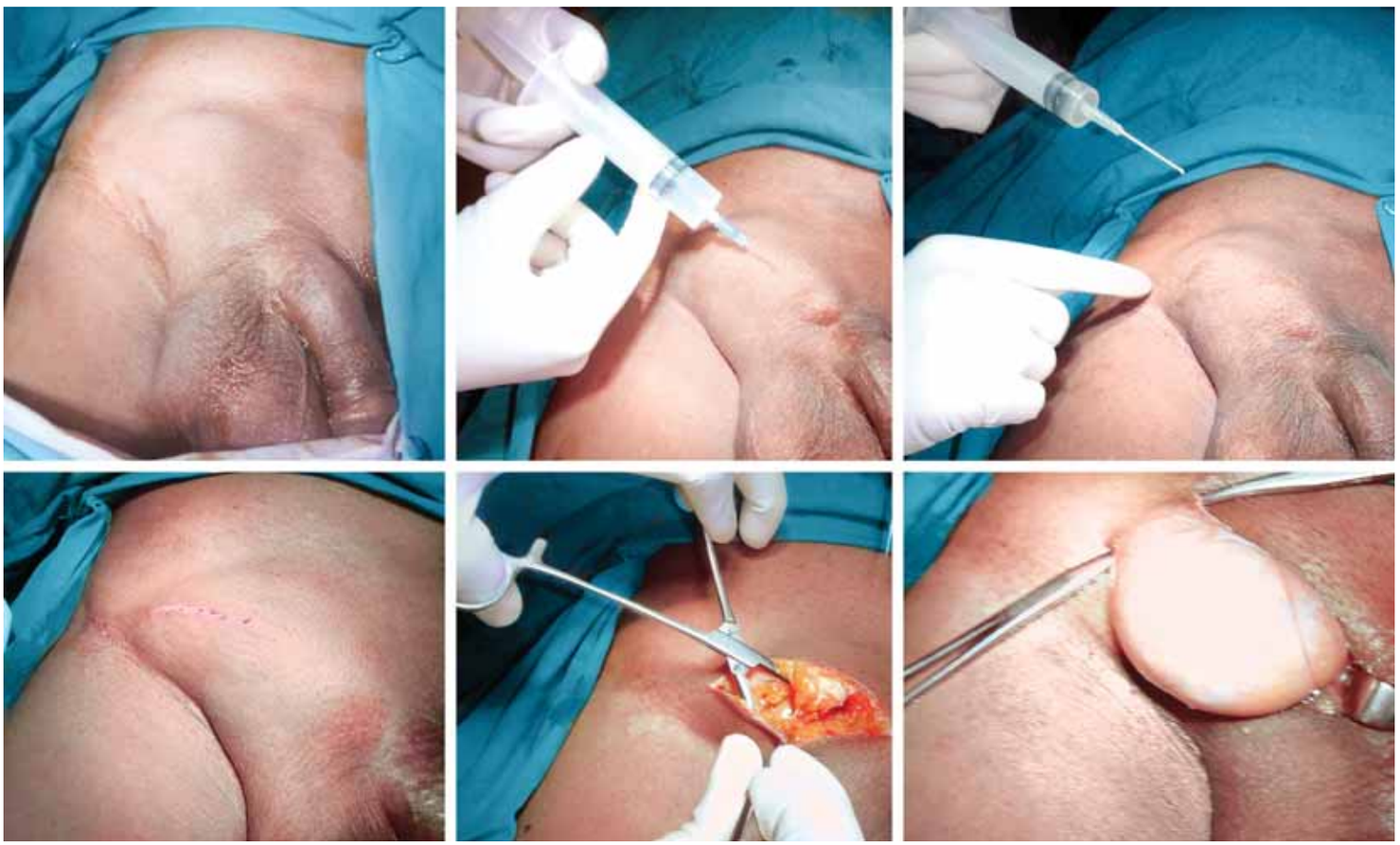


Fig. 30-24: Open inguinal surgery is commonly done under local anaesthesia.

Fig. 30-25: Large hernia needs catheterization before surgery.

out of the superficial inguinal ring is identified without opening the superficial inguinal ring and external oblique aponeurosis. Inguinal canal in infant is very short with superficial and deep rings lying at same level. Sac once identified by careful meticulous dissection and traction, can be reached up to deep ring. Proximal sac is ligated with transfixation. Distal sac is left open. One should avoid injuring vas, testicular veins in the cord as they are very fine in infants. Use of bipolar cautery (not monopolar) is essential. Wound is closed in layers.

Suprainguinal preperitoneal open approach is also used. External oblique, internal oblique and transverse abdominis are split after skin and subcutaneous layer incision. Transversalis fascia is incised. Preperitoneal space is entered to identify the indirect sac which is dissected. Proximal part of the sac is ligated and distal part is cut and left open to retract below.

Transperitoneal laparoscopic approach is present alternative where the hernial sac is ligated proximal to deep ring by placing polypropylene purse string sutures on both sides.

In incarcerated hernia if strangulation is found even after release of the constriction band, then laparotomy approach is better and safer (lower abdomen horizontal incision) to do resection and anastomosis of the bowel.

Complications: Recurrence (< 1%), haematoma, seroma, injury to vas, post herniotomy hydrocele, testicular atrophy. Recurrence is due to injury to transversalis fascia (leads into direct hernia later), missed sac, improper ligation of the sac, sepsis, connective tissue disorders. As vas deferens and testicular vessels are very fine structures in infants and children injury may occur which should be avoided. If injury to vas occurs it should be repaired using 8 zero polypropylene sutures using microscope.

In Adults

It includes *herniotomy i.e.* excision of hernial sac and ***herniorrhaphy or hernioplasty*** (strengthening of the posterior wall of inguinal canal either by repair or mesh).

Herniotomy

Anaesthesia: Spinal or G/A or local anaesthesia.

Procedure

After cleaning and draping, skin is incised 1.25 cm above and parallel to the medial two third of inguinal ligament. Two layers of superficial fascia (outer Camper's fascia and inner Scarpa's fascia) are incised. Superficial pudendal and superficial epigastric vessels are ligated with catgut or cauterized. Self retaining mastoid or similar retractor is placed to retract the skin edges. External oblique aponeurosis is incised along its long axis parallel to the line of skin incision. Incision is extended on either ends of the incision; medially it is extended to cut the margins of the superficial ring. Upper leaf is reflected above and held with haemostat; using peanut dissection upper leaf is raised adequately to visualize conjoined tendon and lateral rectus sheath. Lower leaf is reflected downwards to visualize and expose the inguinal ligament. Entire inguinal ligament is dissected medially and exposed with its shelving edge and iliopubic tract. Ilioinguinal nerve is safeguarded. Cremasteric muscle (box) with its fascia is opened longitudinally as medial and lateral flaps. Cremaster vessel is ligated and cremaster muscle is excised after ligating proximally and distally. Cremasterectomy is not essential. Even though it exposes cord and posterior inguinal wall well; it causes hanging testis without support (*clapper in bell*). Many advocate stitching the distal sutured part to pubic tubercle after cremasterectomy, so that it will give support to testis partially. It is not mandatory to excise entire cremaster. If there is a lipoma of the cord *it should be* excised; but normal fat in the cord should not be removed. If removed it may cause testicular oedema and hydrocele. Cord structures are dissected. Sac lying anterior and lateral to cord is identified and is pearly white in color. Dissection is usually started from the fundus and extended towards the neck which is identified by the extra peritoneal fat. The neck is narrow and is lateral to inferior epigastric artery. *High dissection beyond the deep ring* is done. Sac is opened at the fundus. Finger is passed to release any adhesions. Sac is twisted so as to prevent the content from coming back. It is transfixed using absorbable suture material (chromic catgut 2-0 or vicryl) and is excised (redundant sac) distally **(Figs 30-29 to 30-33)**.

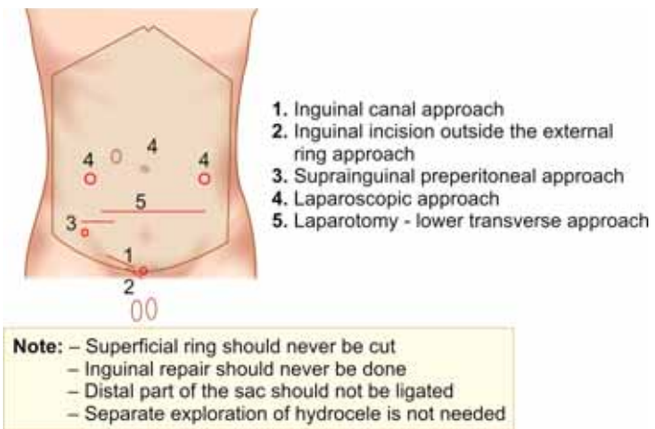

1. Inguinal canal approach
2. Inguinal incision outside the external ring approach
3. Suprainguinal preperitoneal approach
4. Laparoscopic approach
5. Laparotomy - lower transverse approach
Note: – Superficial ring should never be cut
– Inguinal repair should never be done
– Distal part of the sac should not be ligated
– Separate exploration of hydrocele is not needed

Fig. 30-26: Different approaches for herniotomy in infants and children.

Fig. 30-27: Right sided inguinal hernia in a child.

Fig. 30-28: Incision for right sided inguinal hernia in a child.

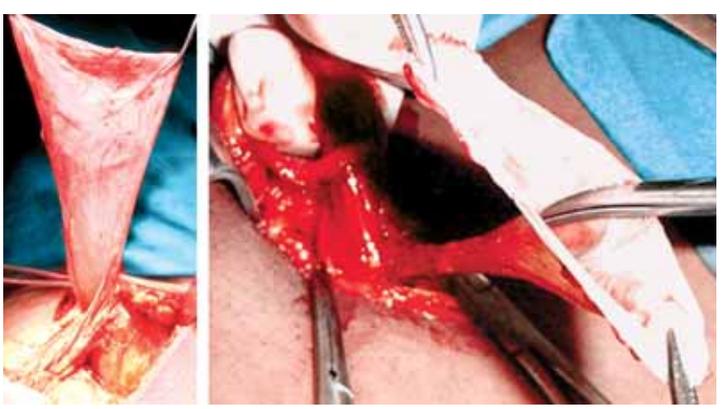


Fig. 30-29: High dissection above the internal ring is required in indirect sac.

Fig. 30-30: Lipoma of the cord is a common entity; when present it should be excised.

Hernia Repair

Repair may be
- *Pure tissue repair:* Shouldice, Mac Vay (still very useful repair) and modified Bassini
- *Prosthetic repair:* Lichtenstein, Rives, Gilbert, Stoppa, TEP, TAPP

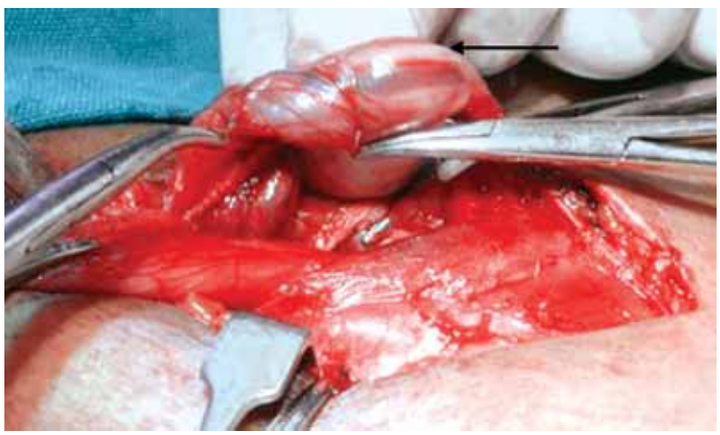


Fig. 30-31: Vas deferens should be identified and safeguarded especially in children.

Fig. 30-32: Indirect sac after opening at the fundus is twisted to avoid contents getting entangled prior to transfixation.

It means repair or strengthening of the posterior wall of the inguinal canal. By principle defective first layer which is transversalis fascia should be used in repair. Strengthening can be done by tissue or prosthetic repair. Strengthening by tissue repair has got various approaches where transversalis fascia or tendinous fascio-aponeurotic upper part is approximated to iliopubic tract or Cooper's ligament or shelved edge of the inguinal ligament. Upper leaf taken for repair should be tendinous fascioaponeurotic layer not fleshy red muscle. Non absorbable monofilament sutures like polypropylene should be used ideally. In few centers delayed absorbable sutures are used but it is not considered to be ideal. Prosthetic repair is done by placing mesh or prosthesis by onlay/inlay/sublay/sublay intraperitoneal method. Tissue prosthesis like tensor fascia lata or temporal fascia are not used now. Polypropylene mesh is commonly used with different modifications. Approach for repair may be ***anterior*** through inguinal canal (for tissue repair and mesh repair either onlay or sublay) or ***posterior*** through high suprainguinal preperitoneal.

Modified Bassini's Herniorrhaphy

Conjoined tendon and inguinal ligament are approximated using interrupted non absorbable monofilament sutures (polypropylene); medial most stitch is taken from the periosteum of pubic tubercle (*called as key or Bassini's stitch)*; external oblique is closed and other layers are closed. Bassini originally used silk suture for the repair (1887). He also used triple layer of upper leaf which contains transversalis fascia, transversus abdominis and internal oblique muscles in this repair. Care should be taken not to injure iliac vessels (mainly vein) while taking bite from inguinal ligament. It is often practiced to take bites in inguinal ligament at different levels to prevent tearing of the fibers of inguinal ligament. Laterally repair is done beyond the line of internal ring. Few advocate horizontal mattress sutures starting from conjoined tendon to inguinal ligament and from inguinal ligament to conjoined tendon **(Figs 30-34 to 30-36)**.

Complications of Herniorrhaphy
- Haemorrhage.
- Haematoma.
- Infection (5%).
- Haematocele.
- Post herniorrhaphy hydrocele, lymphocele.
- Hyperaesthesia over the medial side of inguinal canal due to injury to ilioinguinal or iliohypogastric nerve.
- Recurrence.
- Osteitis pubis.
- Injury to urinary bladder/bowel.
- Testicular atrophy, penile oedema rarely can occur.

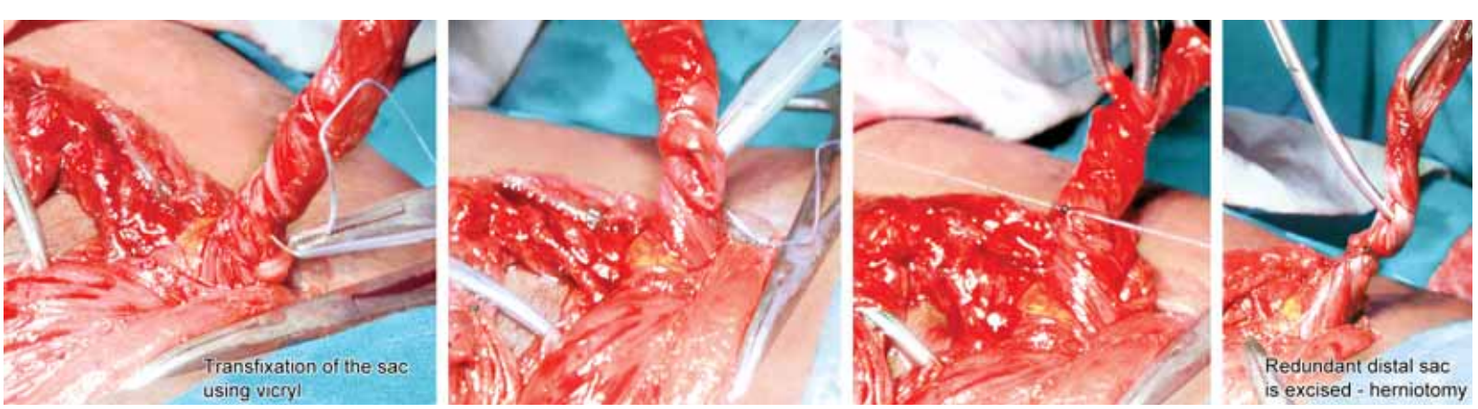


Fig. 30-33: Technique of transfixation of the sac.

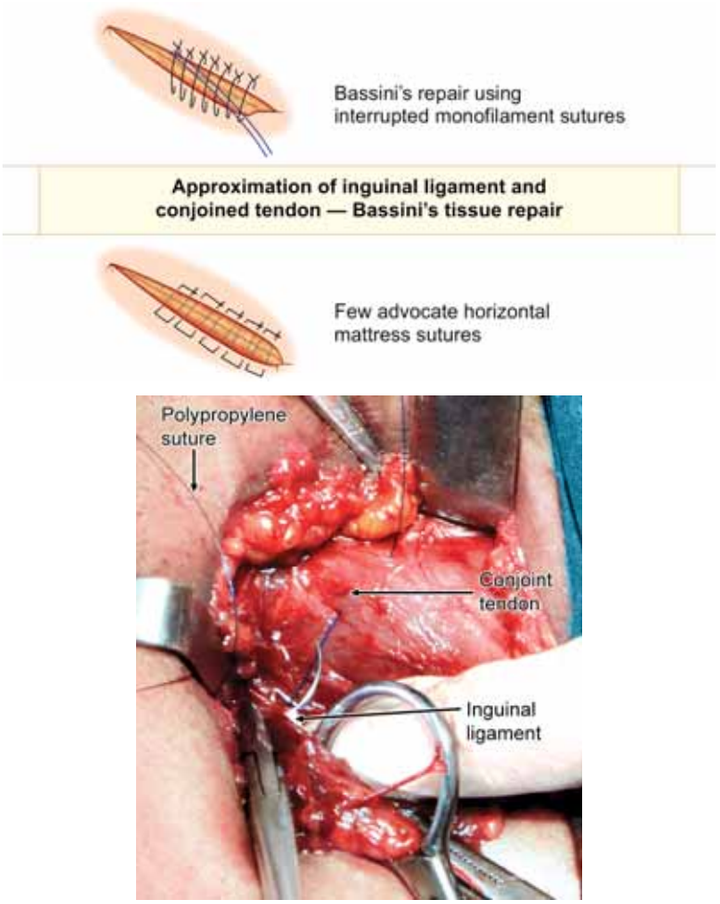


Fig. 30-34: Bassini's tissue repair. It is not commonly used now; it is useful in strangulated inguinal hernia or when there is infection where mesh is contraindicated.

Lytle`s Repair (William James Lytle)

Often internal ring is narrowed by placing interrupted sutures over the medial side of the ring to the transversalis fascia using either silk or polypropylene (to narrow the ring and push the cord laterally) **(Fig. 30-37)**.

Halsted (USA) – Tanner (London) Slide Operation

To reduce the tension in the repair area, relaxing incision is placed over the lower rectus sheath so that conjoined tendon is allowed to slide downwards **(Fig. 30-38)**.

Abrahamson Nylon Darning

Continuous intervening network of non absorbable sutures are placed between conjoined tendon and inguinal ligament to give good support to posterior inguinal wall.

Koontz`operation (Koontz AR – New York, 1963)

In old people after taking consent, orchidectomy is done along with removal of full cord, testis and total closure of posterior inguinal wall by repair so as to reduce the recurrence.

Removal of Cord in the Inguinal Canal

Cord is removed from the inguinal canal by ligating both at external and internal ring. But testis is retained (for psychological reason) and closure of inguinal canal by repair is done.

Mc Vay Operation – 1940 - (Cooper's Ligament Repair)

It is repaired by placing interrupted sutures between the edge of transversus abdominis to Copper's ligament starting from pubic tubercle medially towards femoral sheath and later continued as suture repair between transversus abdominis and iliopubic tract laterally up to the entrance of cord. It is a pure tissue repair. It requires relaxing vertical/curvilinear oblique incision at the lateral border of the anterior rectus sheath from pubic tubercle to a point superiorly for 4 cm. It covers all three groin defects (myopectineal orifice)—indirect, direct and femoral.

Nyhus (Original) Iliopubic Repair

To have a suprainguinal approach, a transverse incision is made two fingerbreadths above the pubic symphysis to expose the rectus sheath. Left index finger is passed into the external ring; level of internal ring is confirmed. Anterior rectus sheath is incised horizontally above the level of the deep ring; lateral part of lower end of the rectus is retracted. Posterior rectus sheath is opened. External oblique, internal oblique and transversus abdominis muscles are cut along the length of the incision. Transversalis fascia is cut to reach the preperitoneal space. If it is direct sac it is dissected without opening and isolated. Sac is inverted using absorbable purse string suture. If it is an indirect sac, it is dissected proximally high up, opened and ligated. Transaponeurotic arch (transverse abdominis muscle and transversalis fascia) is sutured below to Copper's ligament and iliopubic tract. Nyhus mesh repair is done similarly through this approach by placing mesh and suturing to Cooper's ligament **(Fig. 30-40)**.

Andrew's Operation

It is overlapping of the external oblique aponeurosis.

Condon Procedure

It is anterior iliopubic tract repair by suturing the transversus abdominis to iliopubic tract from pubic tubercle to deep ring; then extending lateral to the cord. In direct sac relaxing incision is made on the lower rectus before tying all placed sutures.

Shouldice Repair

Even though transversalis fascia is thin, it is a tough layer and so double breasting of this fascia using continuous sutures (with non absorbable material) strengthens the posterior wall of the inguinal canal.

It is a multilayered repair. Continuous sutures provide *even distribution of tension* throughout the repair. It was originated at *Shouldice hernia clinic in Toronto* by Shouldice (EE Shouldice 1930) where it was usually done under local anaesthesia. Often cremasteric resection is done in Shouldice in order to have proper revelation of the posterior inguinal wall. Cremasteric vessels (located at lateral part of the cord along with genital branch of genitofemoral nerve) need ligation during cremasterectomy. After doing herniotomy as in any other inguinal hernia, transversalis fascia is incised along the line of the

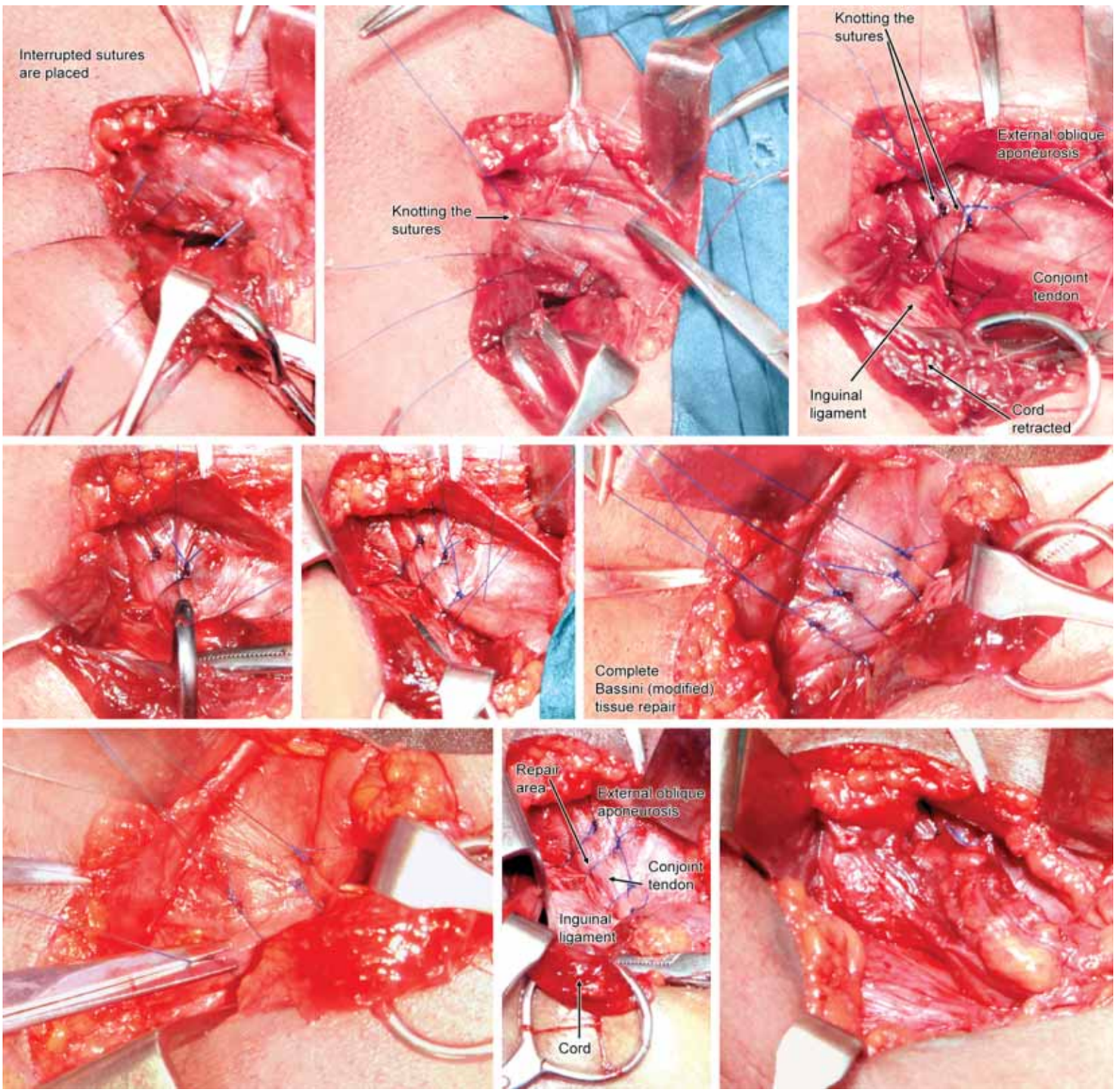


Fig. 30-35: Bassini's repair. It is a type of tissue repair.

wound from deep ring to pubic tubercle. Upper medial flap is elevated without elevating lower lateral flap. If there is redundant part of the transversalis fascia it should be excised to leave adequate amount of clean cut edges. Superior pubic vein is located on the deeper surface of the iliopubic tract which should not be injured while operating. Cribriform fascia of thigh is incised deep to the inguinal ligament to free the lateral flap of external oblique aponeurosis and also to visualize femoral opening.

First suture line: Lower lateral flap of fascia is sutured to posterior deep part of the elevated upper flap using continuous sutures from pubic tubercle to internal ring which is tied at deep ring without cutting / ending.

Second suture line: Using same suture which is not cut, free margin of upper flap is sutured to the shelving edge of the inguinal ligament from deep ring towards pubic tubercle. It causes double-breasting of the transversalis fascia. Knot is placed at the end over the pubic tubercle. First and second line sutures are done using a single suture material.

Third suture line: The conjoined tendon and anterior to the shelving part of the inguinal ligament is sutured from internal ring to pubic tubercle continuously and tied without cutting.

Fourth suture line: Same uncut suture is again sutured back continuously between conjoined tendon and anterior fibers of the inguinal ligament to reach internal ring (**Fig. 30-41**).

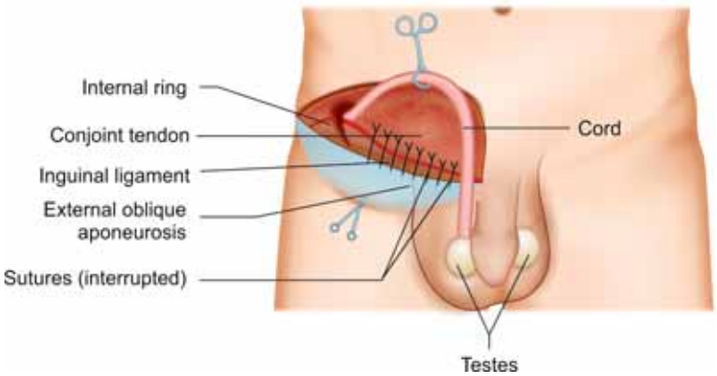


Fig. 30-36: Modified bassini repair.

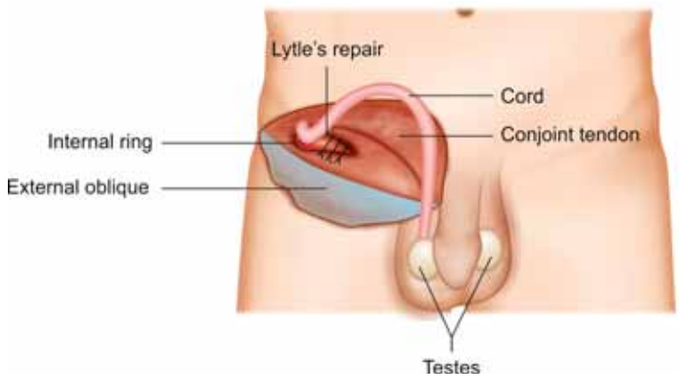


Fig. 30-37: Lytle's repair is narrowing the internal ring.

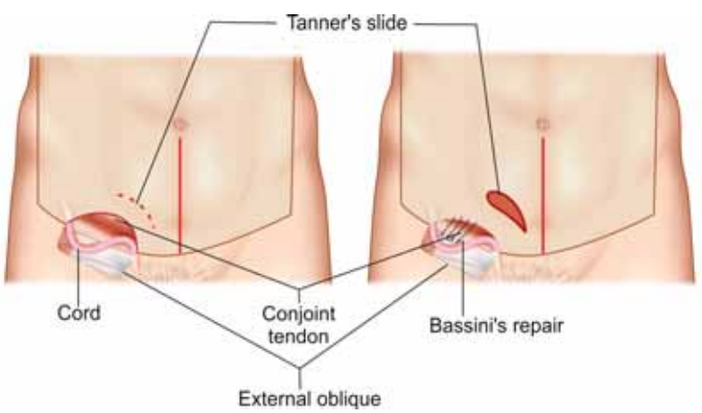


Fig. 30-38: Tanner slide operation.

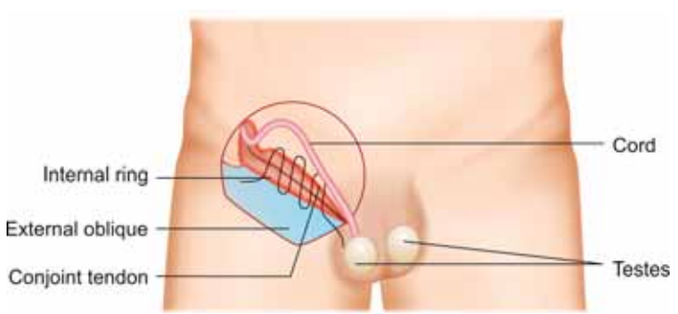


Fig. 30-39: Darning in inguinal hernia.

External oblique aponeurosis is sutured in two layers (5th and 6th suture lines; double-breasting) in front of the cord in original Shouldice repair. Hence this original Shouldice repair is 6 layered procedure.

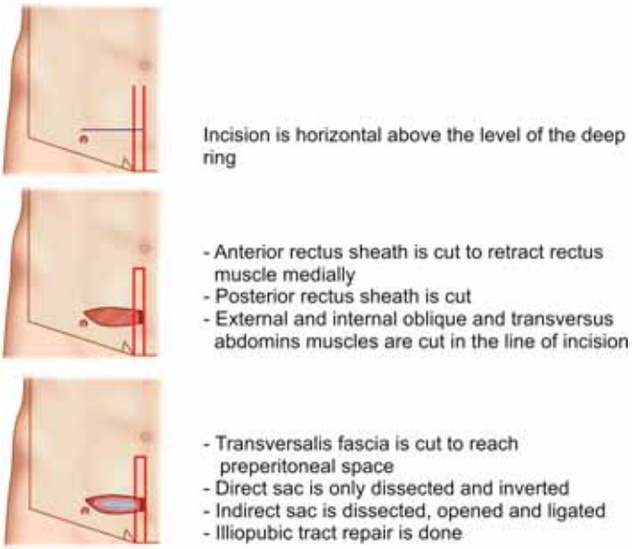

Incision is horizontal above the level of the deep ring
- Anterior rectus sheath is cut to retract rectus muscle medially
- Posterior rectus sheath is cut
- External and internal oblique and transversus abdomins muscles are cut in the line of incision
- Transversalis fascia is cut to reach preperitoneal space
- Direct sac is only dissected and inverted
- Indirect sac is dissected, opened and ligated
- Illiopubic tract repair is done

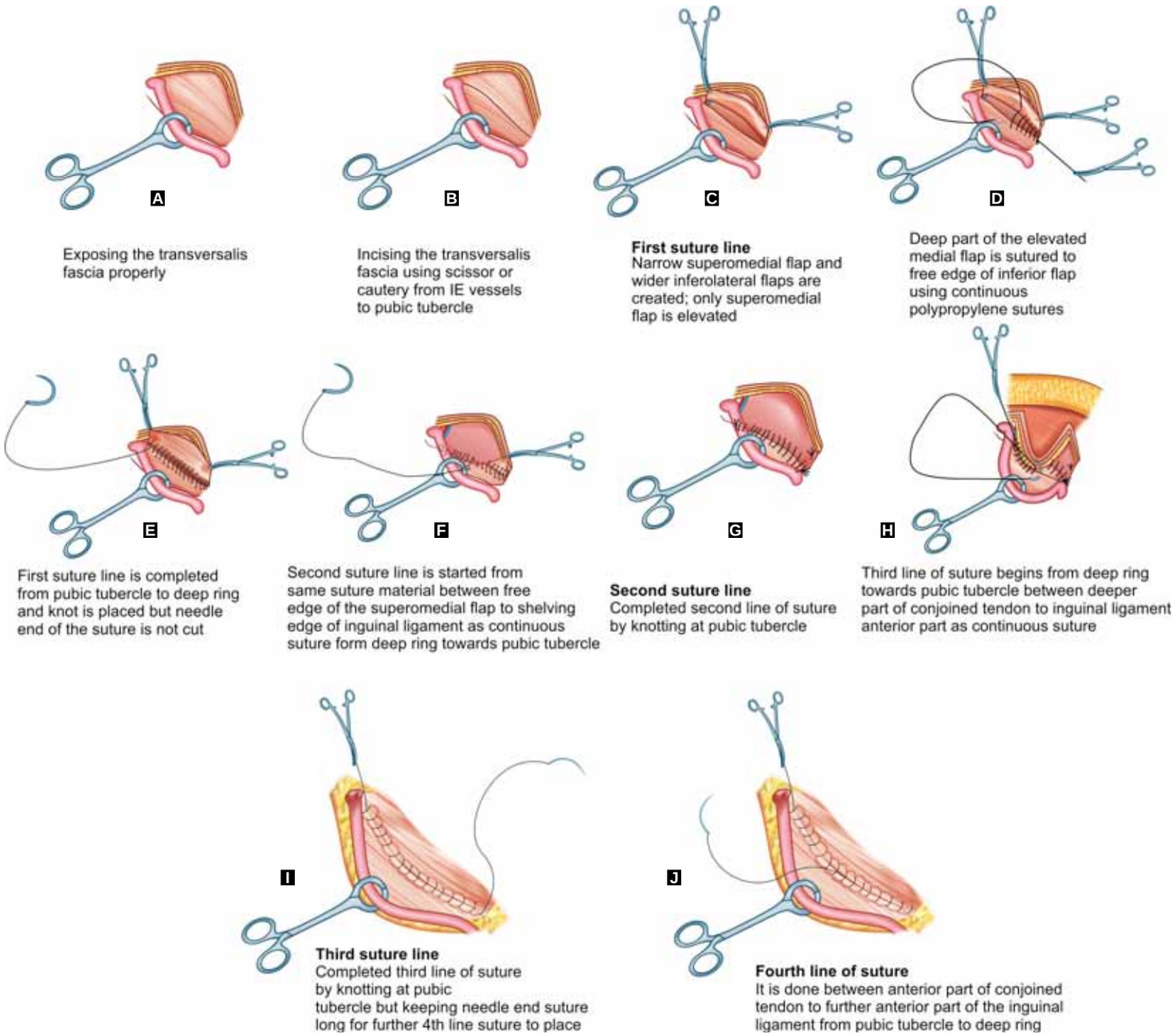
Fig. 30-40: Nyhus iliopubic tissue repair. Same plane after similar dissection mesh can be placed.

First two layers of transversalis fascia, next two layers of conjoined tendon and last two layers of external oblique aponeurosis. Suture material used here is 34 gauge fine steel wire (in original Shouldice repair) or polypropylene or polyethylene. Nowadays external oblique is sutured as a single layer. Often it is difficult to close external oblique aponeurosis. Medial part of the cut end of the cremaster is sutured to pubic bone or inguinal ligament to prevent drooping of the testis. Recurrence rate in Shouldice repair is 1 %.

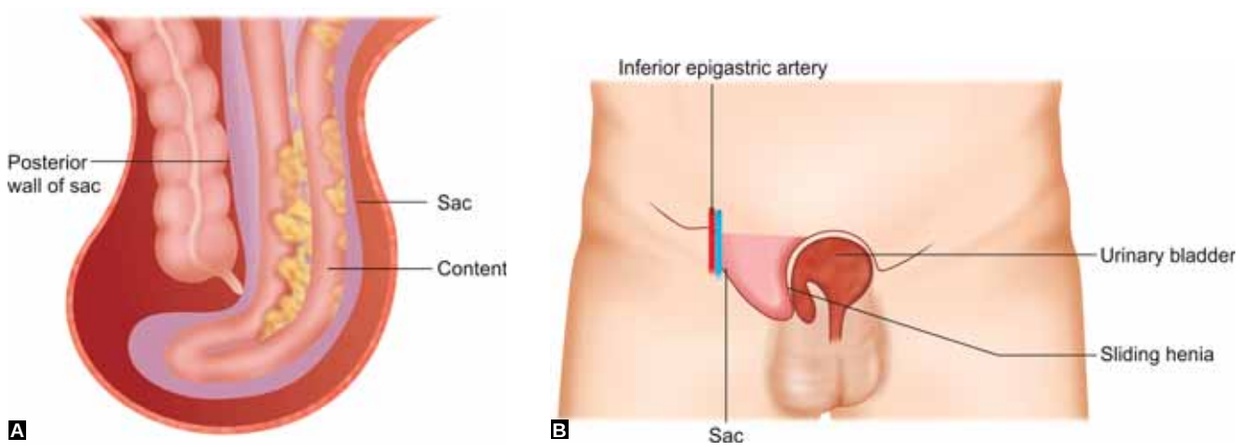
Berliner modified Shouldice repair: It involves double-breasting of the transversalis fascia like in Shouldice repair and single layer closure of the external oblique aponeurosis without any additional two-layered repair of conjoined tendon to inguinal ligament.

Repair of Sliding Hernia

In *LaRoque repair* deep ring is incised above and below; reefing of the sigmoid colon mesentery is done which forms the posterior wall of the inguinal canal so that entire sigmoid is replaced into the peritoneal cavity. Posterior wall of the sac should not be separated from large bowel or bladder. If tried it may lead to faecal or urinary fistulas. Often sac can be excised partially; this partially excised sac can be pushed into peritoneal cavity. Right sided sliding hernia will have caecum and appendix in its posterior wall; caecum should not be separated from posterior wall of the sac which may otherwise create faecal fistula. Appendix should not be removed as it may precipitate sepsis. Appendices epiploicae from sigmoid colon should not be removed as there are chances that they may contain small colonic diverticula which may get opened to contaminate the field. Bladder will be present on medial side of the sac and sac should not be separated; if bladder injury occurs it should be sutured in two layers of vicryl. Inside out purse string suture on the opened sac is applied and the sac with its posterior wall is pushed into the abdominal cavity. Urinary catheterization is a must **(Fig. 30-42)**.


A
Exposing the transversalis fascia properly
B
Incising the transversalis fascia using scissor or cautery from IE vessels to pubic tubercle
C
First suture line
Narrow superomedial flap and wider inferolateral flaps are created; only superomedial flap is elevated
D
Deep part of the elevated medial flap is sutured to free edge of inferior flap using continuous polypropylene sutures
E
First suture line is completed from pubic tubercle to deep ring and knot is placed but needle end of the suture is not cut
F
Second suture line is started from same suture material between free edge of the superomedial flap to shelving edge of inguinal ligament as continuous suture form deep ring towards pubic tubercle
G
Second suture line
Completed second line of suture by knotting at pubic tubercle
H
Third line of suture begins from deep ring towards pubic tubercle between deeper part of conjoined tendon to inguinal ligament anterior part as continuous suture
I
Third suture line
Completed third line of suture by knotting at pubic tubercle but keeping needle end suture long for further 4th line suture to place
J
Fourth line of suture
It is done between anterior part of conjoined tendon to further anterior part of the inguinal ligament from pubic tubercle to deep ring

Figs 30-41A to J: Technique of Shouldice repair.



Figs 30-42A and B: Sliding hernia is common in left side; exclusively seen in males. Posterior wall of the sac should not be separated in sliding hernia; if done will injure the colon or urinary bladder. Insertion of urinary catheter is a must prior to surgery. It is usually indirect type; huge hernia which is often irreducible is typical. Posterior wall is formed by sigmoid colon or urinary bladder. Contents are small bowel and omentum.

Hernioplasty (Figs 30-43 and 30-44)

Approach to preperitoneal space

Anterior trans inguinal approach (Anandale)

- Condon approach
- Rive's repair

Posterior approach

- Supra inguinal (Nyhus)
- Grid Iron: (Kugel's)
- Midline: Cheatle-Henry's-Stoppa's GPRVS
- McEvedy's: oblique incision (rectus sheath)
- Laparoscopic: TEP (Dulucq); TAPP (Arrigue/Dion and Morin)

Advantages of preperitoneal approach are: L**ess chance of** damage to nerves and spermatic cord and testicular atrophy. It is most tension free approach. Entire MPO in Bogros space is covered with prosthesis beyond the pubic symphysis (beyond 2.5 cm) and anterior superior iliac spine (2.5 cm). Coverage should be 2/3rd over anterior abdominal wall; 1/3rd beyond and below Cooper's ligament.

Disadvantages are: It involves more extensive dissection of preperitoneal space; requires larger mesh reinforcement; it makes future entry for surgical approach difficult (especially for uro/vascular surgeries). Risk of damage to major vessel (iliac vein), bowel and bladder, extraperitoneal hematoma are high.

Selection for posterior approach: All recurrences after anterior/onlay repairs; all Nyhus type 3 and 4 hernias; incarceration; TEPP to open conversion. It is *avoided* in patients who are unfit for regional anesthesia, bleeding tendency, concurrently with TURP/bladder surgery, known malignancy.

Technical tips and requirements are: Good visibility and retraction, regional/ideally general anesthesia, exact full knowledge of preperitoneal anatomy (both for operating surgeon and camera man/assistant). Larger mesh (15 x 15/15 x 10 cm) is needed; two point fixation to Cooper's ligament.

Complications are: Haematoma (avoid in patients taking aspirin/clopidogrel); seroma—in inguinal/scrotal space—aspiration is done.

Recurrences are due to: Inadequate creation of space, inadequate mesh overlap, mesh migration—(fixation to Cooper's ligament is needed mainly in direct defect).

Fig. 30-43: Giant inguinal hernia. It requires open hernioplasty.

Lichtenstein's Inguinal Hernia Mesh Repair Under Local Anaesthesia

20 mL of xylocaine 2% mixed with 10 mL of bupivacaine 0.5%, 50 mL of normal saline, 1 mL of 1:1000 adrenaline solution with hyalase

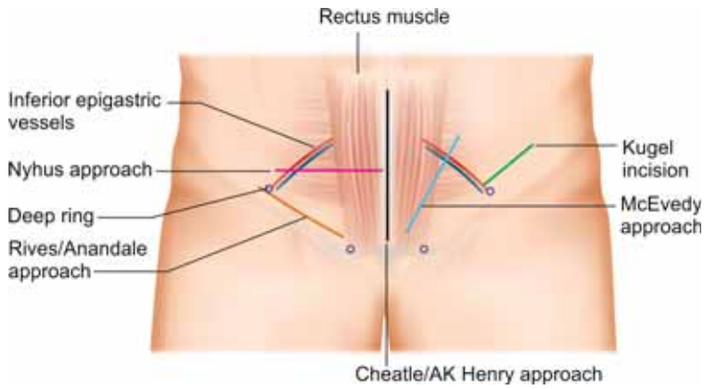
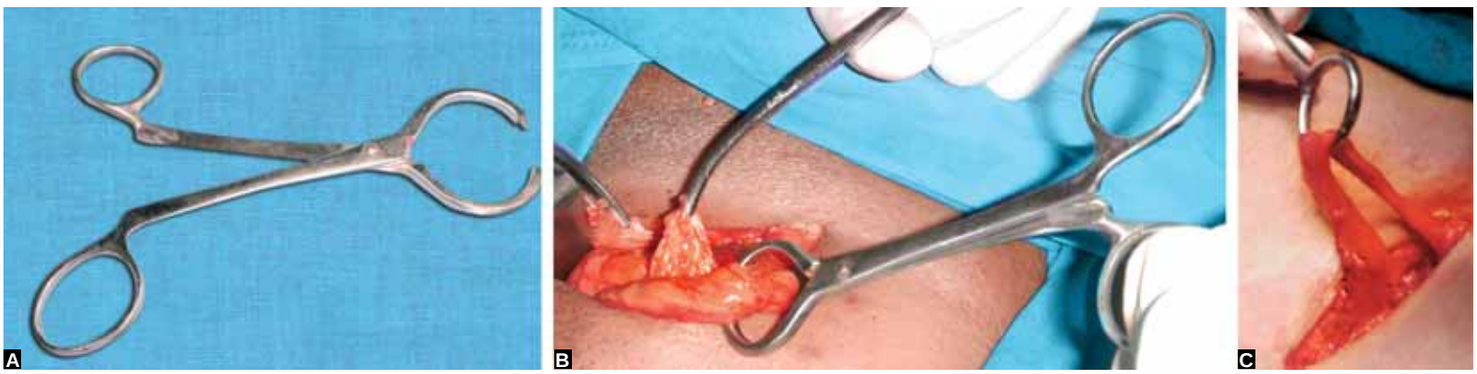


Fig. 30-44: Different approaches for preperitoneal inguinal hernia (groin hernia) surgeries.

solution is used for local anaesthesia. Different combinations are in use. 50:50 of xylocaine 1% with 0.5% bupivacaine with 1 in 2,00,000 epinephrine in normal saline is also used. 45-50 mL of this prepared solution is sufficient. Propofol sedation with intravenous drip may be added. Anaesthetic agent is injected layer by layer. 5ml is injected into subdermal plane along the line of incision using 25 G long needle; 3 mL is injected intradermally; 10 – 20 mL is injected deep subcutaneously. After skin and subcutaneous incision, subaponeurotic injection of anaesthetic agent is done (10 mL) first at lateral end of the incision to anaesthetize all three nerves of the inguinal canal; then along the line of the incision up to the pubic tubercle.

Procedure

After cleaning and draping, line of skin incision is marked using marking pen at 1.25 cm above and parallel to the medial 2/3rd of inguinal ligament. Using 24G or 26G long spinal needle, prepared anaesthetic agent is injected into the skin underneath along the marked line of incision and in subcutaneous plane below and above. Skin is incised. Using cautery or scalpel blade skin incision is deepened. Two layers of superficial fascia, outer Camper and inner Scarpa's fascia are incised. Often these superficial epigastric, superficial circumflex, superficial external pudendal veins are ligated using fine absorbable sutures (3 zero vicryl/catgut). External oblique aponeurosis is identified by its shining fibers. It is exposed above, below up to inguinal ligament and medially up to pubic tubercle and midline. Around 20 mL of local anaesthetic solution is injected underneath the external oblique aponeurosis medially and laterally. External oblique aponeurosis is incised using no 15 scalpel blade or cautery. Cut edges of the aponeurosis are held with artery forceps. Aponeurosis is incised medially and laterally along the line of the incision. Medially it is extended often up to the external ring to open it. Two leaves of the aponeurosis are elevated above to visualize the conjoined tendon and below to visualize the shining inguinal ligament (Poupart's). Self retaining mastoid retractor can be used to expose the canal clearly. Iliohypogastric nerve is identified above and medially which after piercing the internal oblique enters the external oblique. In the inguinal canal cord is covered by cremasteric muscle and internal spermatic fascia; external spermatic fascia covers the cord below the level of the superficial inguinal ring. Ilioinguinal nerve is in the inguinal canal outside the cord which enters the canal through a gap between external and internal oblique muscles, passes through superficial inguinal ring. Genital branch of genitofemoral nerve passes through the cord structures. Both nerves supply the (L1) anterior 1/3rd



Figs 30-45A and B: Cord holding forceps.

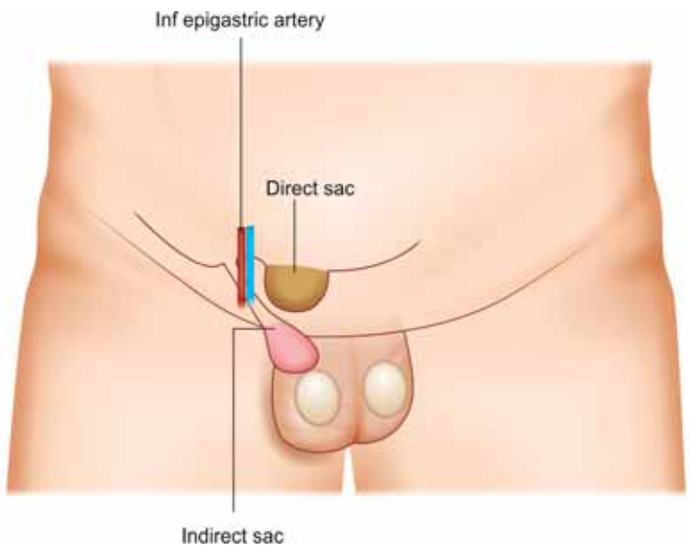


Fig. 30-46: In case of direct sac, always one should dissect the cord and look for indirect sac (pantaloon hernia); otherwise if present and missed recurrence can occur.

of the scrotum and penis. Posterior 2/3rd of the scrotum is supplied by the posterior scrotal nerves and perineal branch of the posterior cutaneous nerve of the thigh (S3). Ilioinguinal nerve is safeguarded after careful dissection. Partial injury or entrapment of this nerve can cause persistent pain in the medial aspect of the thigh and the scrotum. Injury to iliohypogastric nerve causes pain in the inguinal region on medial aspect and in lower abdomen near midline. This *inguinodynia* may be due to entrapment by suture or mesh or due to partial injury of these nerves. Complete transection of the nerve can cause anaesthesia of skin of this region **(Figs 30-45 and 30-46)**.

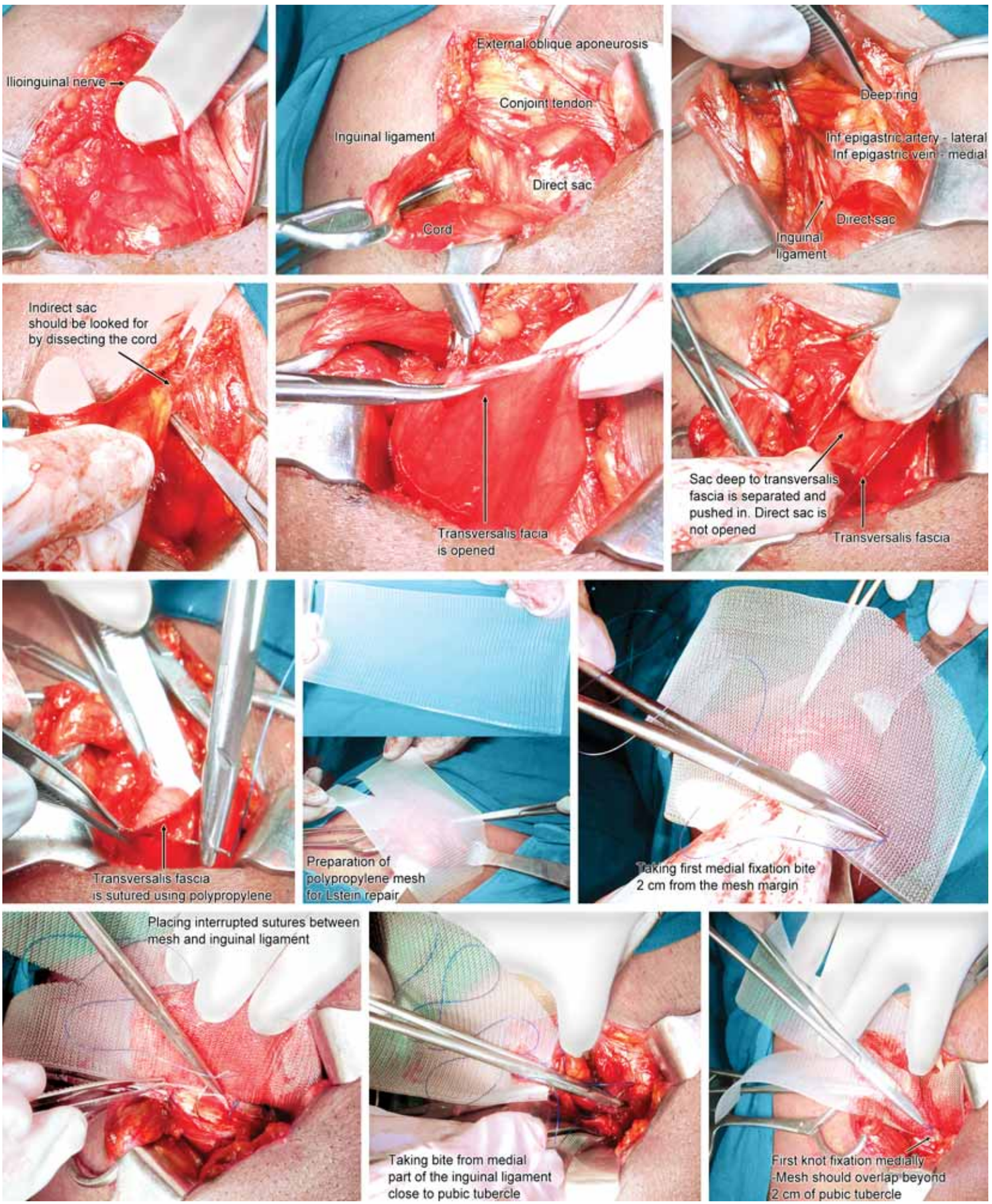
Cremaster muscle (cremaster box) is opened. Many advocate excision of cremaster to achieve good repair but it causes loss of support to cord and testis causing flapper in bell like problem due to hanging testis. Chances of inguinodynia are increased as the protection to genital nerve and paravasal nerves is removed. Even though it is not proved it is thought that one of the causes of distressing dysejaculation could be due to cremaster dysfunction after cremasterectomy. Medial dissection is done beyond the pubic tubercle. Hernial sac is identified. Sac is pearly white in colour which is anterolateral in position with respect to cord in case of indirect sac. Fundus, body and neck of the sac are dissected using scissor or cautery. Cord is held using hernia ring (Collingwood Stewart) or thin gauze or penrose drain and kept aside (usually below the inguinal ligament). Cord is dissected 2 cm beyond the pubic tubercle. Neck of the sac is identified by its narrow area, being lateral to inferior epigastric vessels and by presence of extraperitoneal pad of fat. Sac is dissected *high up above* the level of the internal ring ***(high dissection)***; sac is opened on the summit of the fundus; held with two artery forceps; finger is passed into the sac to confirm that all contents are reduced; if not, by finger dissection adhesions are released and contents are reduced completely; sac is twisted adequately so that no contents will return back to the sac during ligation; sac is transfixed high above the internal ring using 3 zero vicryl or monocryl and ligated. Presently it is thought that high dissection is more important than high ligation; but usually it is common to advocate high ligation of the sac. Redundant sac is excised to complete the herniotomy. There is presently a debate on ligation of sac as ligation of sac increases the chances of postoperative pain due to mechanical pressure, ischaemia and irritation of somatic peritoneal nerve. It is also found that without ligation of indirect sac will not increase the chances of recurrence **(Fig. 30-47)**.

If sac is extending into the scrotum as complete type and if there is difficulty in dissecting such sac from scrotum, then distal part of the sac is left in situ open after transecting at superficial ring level. Important aspect here is distal part of the sac should not be ligated *(Wantz technique)* and if ligated it will lead into hydrocele. In direct hernia, sac is medial to inferior epigastric vessels and is usually not opened unless there is obstruction. Direct sac is pushed underneath. Transversalis fascia is identified and cut along the line of incision obliquely as medial lower and lateral upper flaps. It is common to do plication of this fascia even though it is not mandatory (using continuous non absorbable monofilament polypropylene sutures) **(Figs 30-48 and 30-49)**.

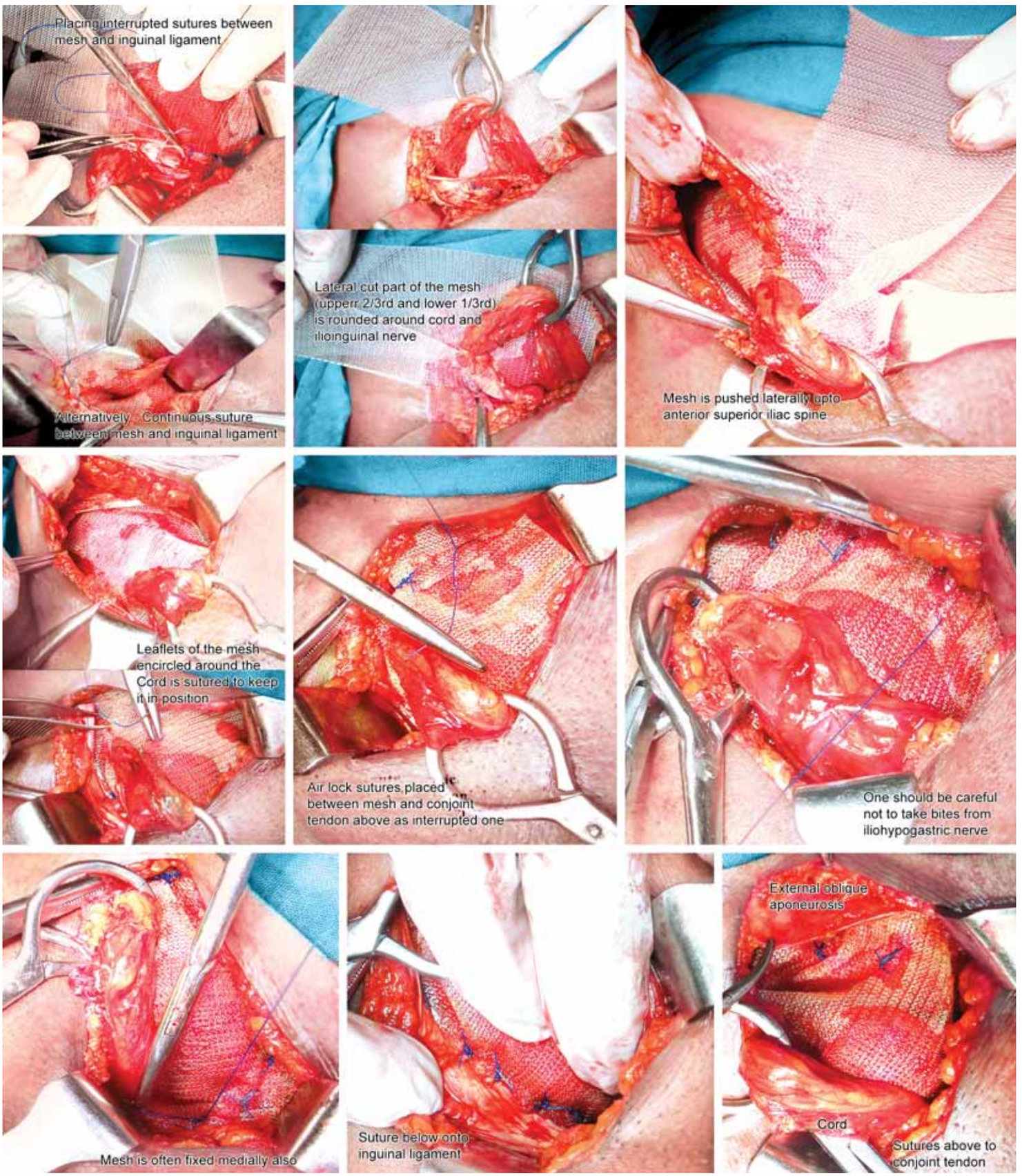
Inguinal canal is exposed well using Langenbeck retractor above and Czerny's retractor below and medially. Cord is kept away below. Polypropylene mesh is used for repair (10 × 6 cm size); size is decided based on the width of the defect; adequate sized mesh covering 2.5 cm above and medially should be used. Often mesh of required size is cut. Mesh is sutured below to the inguinal ligament; medial most suture is taken from a point very close to the pubic tubercle. One should be sure that mesh covers well medial to the pubic tubercle (2 cm beyond). Size of the mesh used is usually 15 × 8 cm. Size should accommodate defect well beyond pubic tubercle (2 cm), superior margin (4 cm) and deep ring (6 cm) laterally. Presently it is thought that light weight large pore combined absorbable and non absorbable mesh is better than only nonabsorbable mesh. As part of the mesh gets absorbed in 120 days; support by mesh well achieved with very less incidence of distressing mesh inguinodynia (due to ilioinguinal and iliohypogastric nerves getting adherent to the mesh). Suturing of mesh is done using interrupted non absorbable monofilament polypropylene or polyethylene sutures below to inguinal ligament. Continuous sutures

Cleaning and draping
Anterior superior iliac spine
Incision above and parallel to inguinal ligament
Pubic tubercle
SC tissue and two layer of superficial fascia (Camper and Scarpa) are incised
External oblique aponeurosis is incised
Edges of the external oblique aponeurosis are held with two haemostats
Edges of the external oblique aponeurosis is cut up to external ring and laterally beyond deep ring level
Ilioinguinal nerve
External oblique aponeurosis
Conjoint tendon
Inguinal ligament below

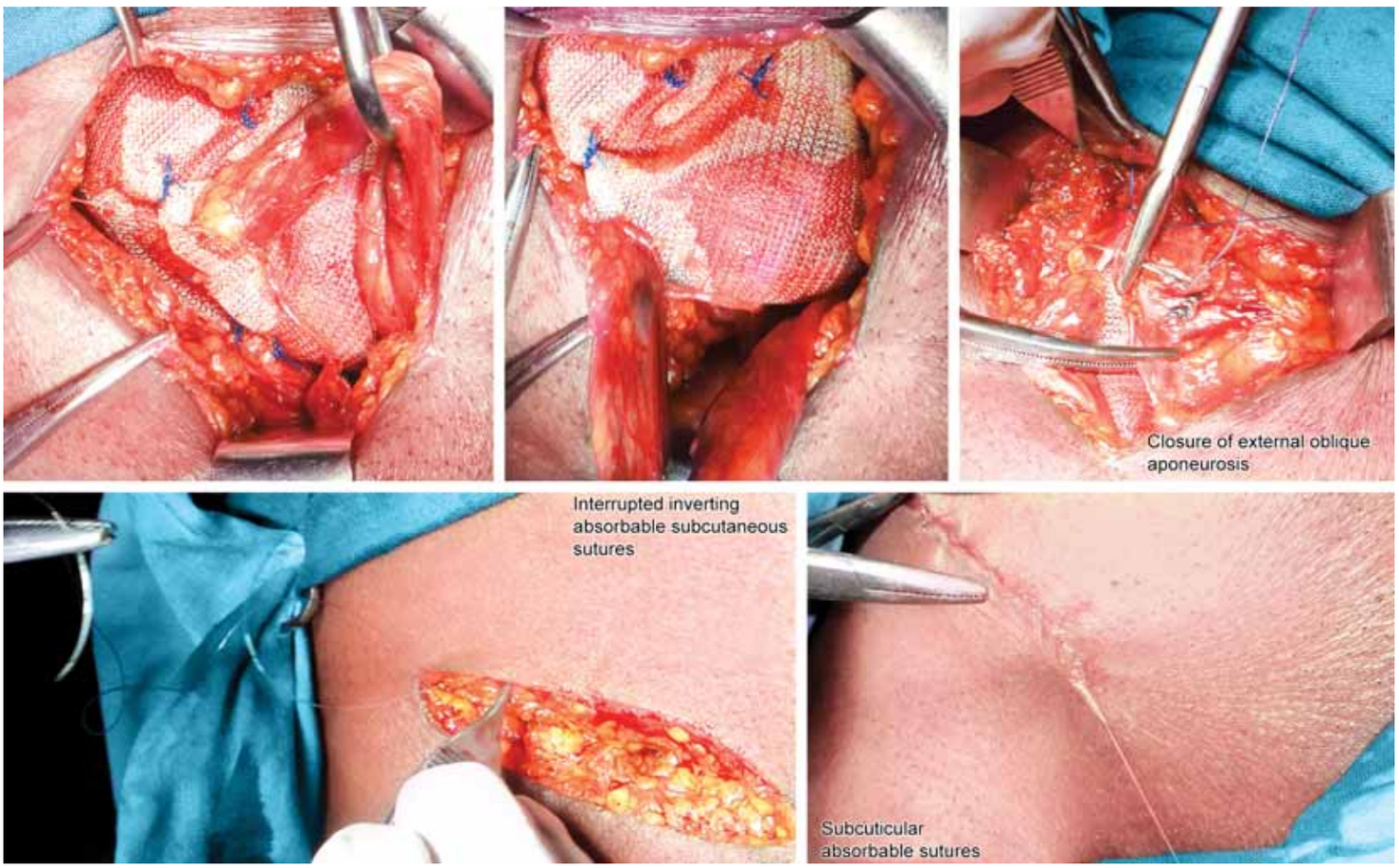
Figs 30-47(1)


Ilioinguinal nerve
External oblique aponeurosis
Conjoint tendon
Inguinal ligament
Direct sac
Cord
Deep ring
Inf epigastric artery - lateral
Inf epigastric vein - medial
Direct sac
Inguinal ligament
Indirect sac should be looked for by dissecting the cord
Transversalis facia is opened
Sac deep to transversalis fascia is separated and pushed in. Direct sac is not opened
Transversalis fascia
Transversalis fascia is sutured using polypropylene
Preparation of polypropylene mesh for Lstein repair
Taking first medial fixation bite 2 cm from the mesh margin
Placing interrupted sutures between mesh and inguinal ligament
Taking bite from medial part of the inguinal ligament close to pubic tubercle
First knot fixation medially -Mesh should overlap beyond 2 cm of pubic tubercle

Figs 30-47(2)


Placing interrupted sutures between mesh and inguinal ligament
Alternatively Continuous suture between mesh and inguinal ligament
Lateral cut part of the mesh (upperr 2/3rd and lower 1/3rd) is rounded around cord and ilioinguinal nerve
Mesh is pushed laterally upto anterior superior iliac spine
Leaflets of the mesh encircled around the Cord is sutured to keep it in position
Air lock sutures placed between mesh and conjoint tendon above as interrupted one
One should be careful not to take bites from iliohypogastric nerve
Mesh is often fixed medially also
Suture below onto inguinal ligament
External oblique aponeurosis
Cord
Sutures above to conjoint tendon

Figs 30-47(3)


Closure of external oblique aponeurosis
Interrupted inverting absorbable subcutaneous sutures
Subcuticular absorbable sutures

Figs 30-47(4)

Figs 30-47(1 to 4): Lichtenstein hernioplasty—mesh repair.

Figs 30-48A to C: Direct sac—inguinal hernia.

also can be used while suturing lower flap of mesh to inguinal ligament. Mesh is sutured below to inguinal ligament up to the level of deep ring not beyond (if so femoral nerve may occasionally get injured). It is important to keep needle facing forward to avoid taking inadvertent bite of femoral/iliac vessels (mainly vein) especially in thin individuals. Even though it happens rarely, in such situation without get panicked on seeing the sudden torrential bleed from the site of needle bite, one should gently pull out the suture without allowing further tear of the bitten tissue and sufficient pressure should be applied using a mop to stop the bleeding. Practicing knot tying in such situation would not be correct as tying may further tear the vessel. Occasionally, further exposure of the major vessel may be a needed to control the bleeding using 4 zero vascular continuous suture. Laterally mesh is partially cut horizontally (3 cm upper flap × 2 cm lower flap) so as to enclose the cord and ilioinguinal nerve; lower flap of the cut part is narrower than upper flap. Often few surgeons excise a circular piece of mesh to accommodate cord and remaining tails of the mesh is crossed laterally and sutured. It is important to place lateral tails beyond the incision area (6 cm from deep ring) under the external oblique up to the level of anterior superior iliac spine. Lastly upper end of the mesh is sutured

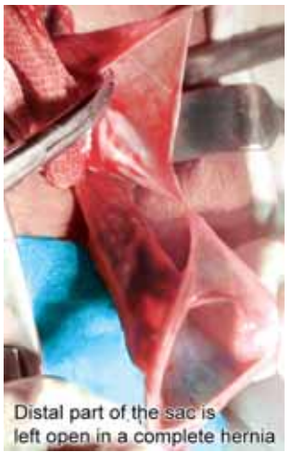


Fig. 30-49: Distal part of the sac should not be ligated; it is left open probably by giving slit on its wall. If ligated, distal part forms a cavity where fluid may collect forming hydrocele.

to the conjoined tendon in front with loose sutures (*air lock sutures*) just to keep mesh in place. It is often of practice to use absorbable sutures in these upper part so that nerve entrapment in case if occurs (iliohypogastric nerve) will get corrected or may not cause much problem; for same reason only loose sutures are used just to keep mesh in place (air lock). It is also allowed to place continuous sutures below to inguinal ligament. But it is not ideal to place continuous sutures above. Mesh should be sutured with relaxation to bear the forward protrusion pressure of the transversalis fascia during standing. Pressure difference between intraabdominal area and abdominal wall in lying down position is 8 cm of water; which rises to 80 cm in standing position. Mesh placed should bear this pressure change effectively to prevent recurrence of hernia **(Figs 30-50A and C)**.

Cord and ilioinguinal nerve is placed back in the inguinal canal. External oblique is sutured using absorbable vicryl sutures. Subcutaneous interrupted sutures are placed. Skin is closed with continuous subcuticular monocryl 3 zero sutures or monofilament 3 zero interrupted sutures. Waterproof dressing is placed.

Postoperatively patient is asked to take normal diet. Intraoperative intravenous antibiotic is given. Patient is asked to take analgesics and oral antibiotics for 3-5 days.

Procedure can be done as a day care surgery unless the patient is old, with cardiac or respiratory problems. Dressing is changed and wound is observed in 5-7 days. Sutures if non absorbable are removed in 7 days.

Different Types of Hernioplasty

Onlay mesh repair is placing mesh in front: It is sutured above to conjoined tendon and below to inguinal ligament using monofilament non absorbable suture material.

Inlay mesh repair is done by placing mesh deep to conjoined tendon at par with muscular or aponeurotic plane (*bridging)*.

Lichtenstein tension free onlay mesh repair (1984) where the cord is encircled with mesh which is often done under local anaesthesia. Suturing of mesh is done similar to onlay mesh repair. It has got less recurrence rate.

Nyhus preperitoneal mesh repair (sublay)

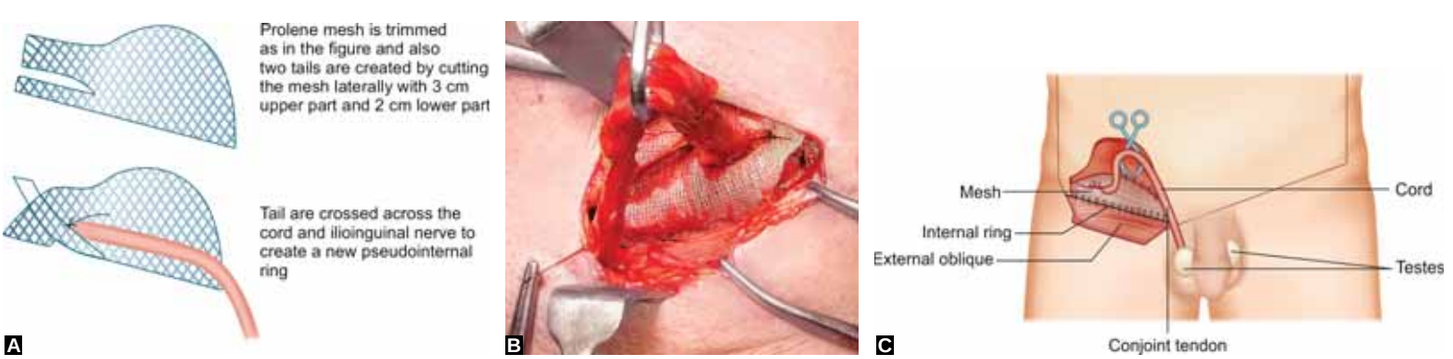
It is done through *suprainguinal* horizontal incision (*posterior approach)* above the pubic symphysis and internal ring. Preperitoneum is approached through lateral border of the lower part of rectus muscle by making an opening in the posterior rectus sheath. Mesh is placed in the preperitoneal space deep to the cord, conjoined tendon, and transversalis fascia. Below, it is folded deep to the iliopectineal ligament of Cooper and sutured to it using two or three interrupted non-absorbable sutures. It is sutured to transverse abdominis above and transversalis fascia from deep.

Modified Rives preperitoneal mesh repair (Read – Rives - sublay)

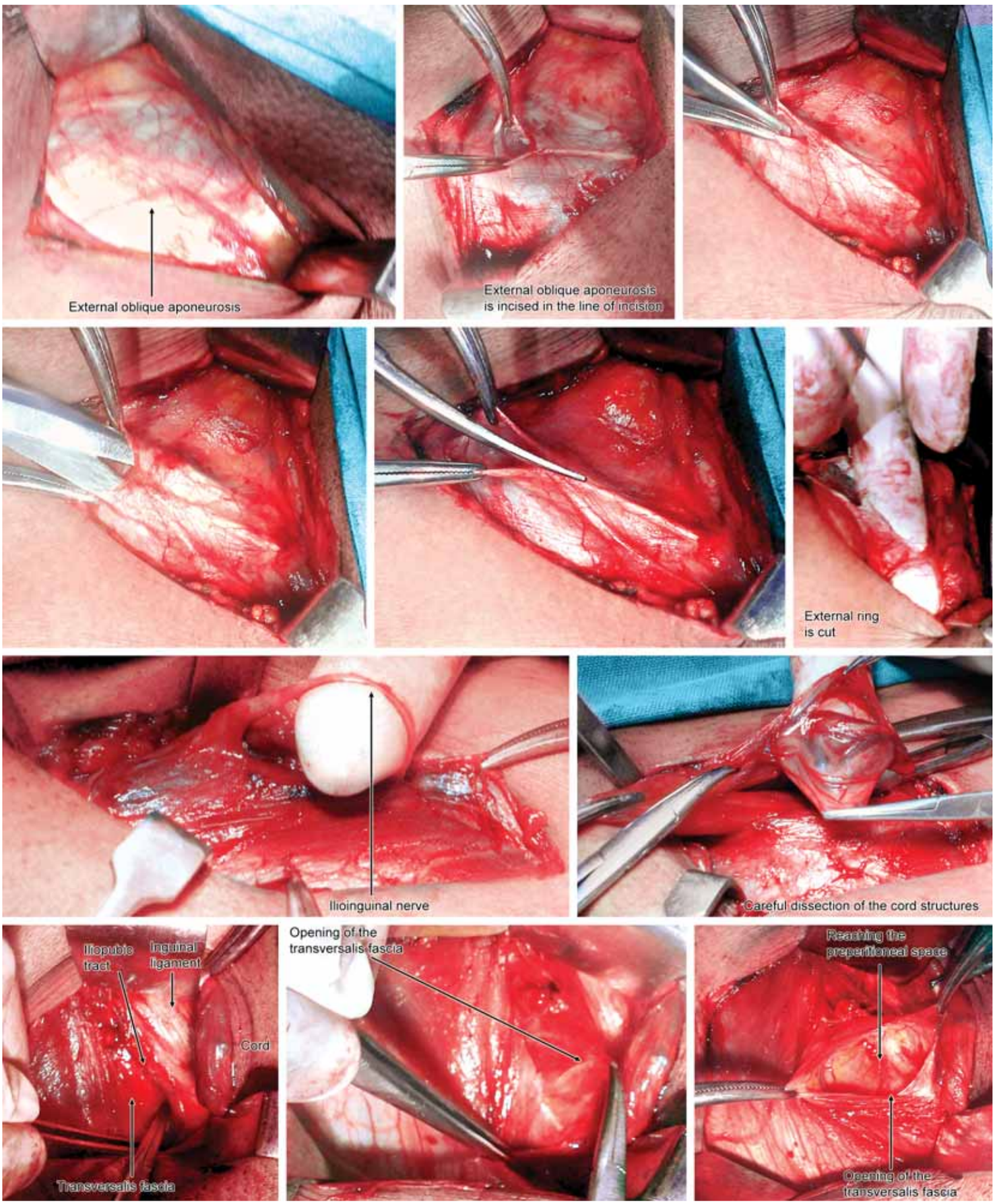
It is preperitoneal mesh repair through *transinguinal approach (anterior approach)*. Direct sac is inverted with sutures. For indirect sac a *high dissection and ligation* is done. Here mesh is placed in preperitoneal space, folded and sutured below to iliopectineal ligament, above to the transverse abdominis in deeper plane. Often transversalis fascia opened earlier is sutured back using non-absorbable suture material in front of the placed mesh (**Figs 30-51 and 30-52)**.

Stoppa's (Rene S Stoppa) giant prosthesis reinforcement of visceral sac (GPRVS- sublay)

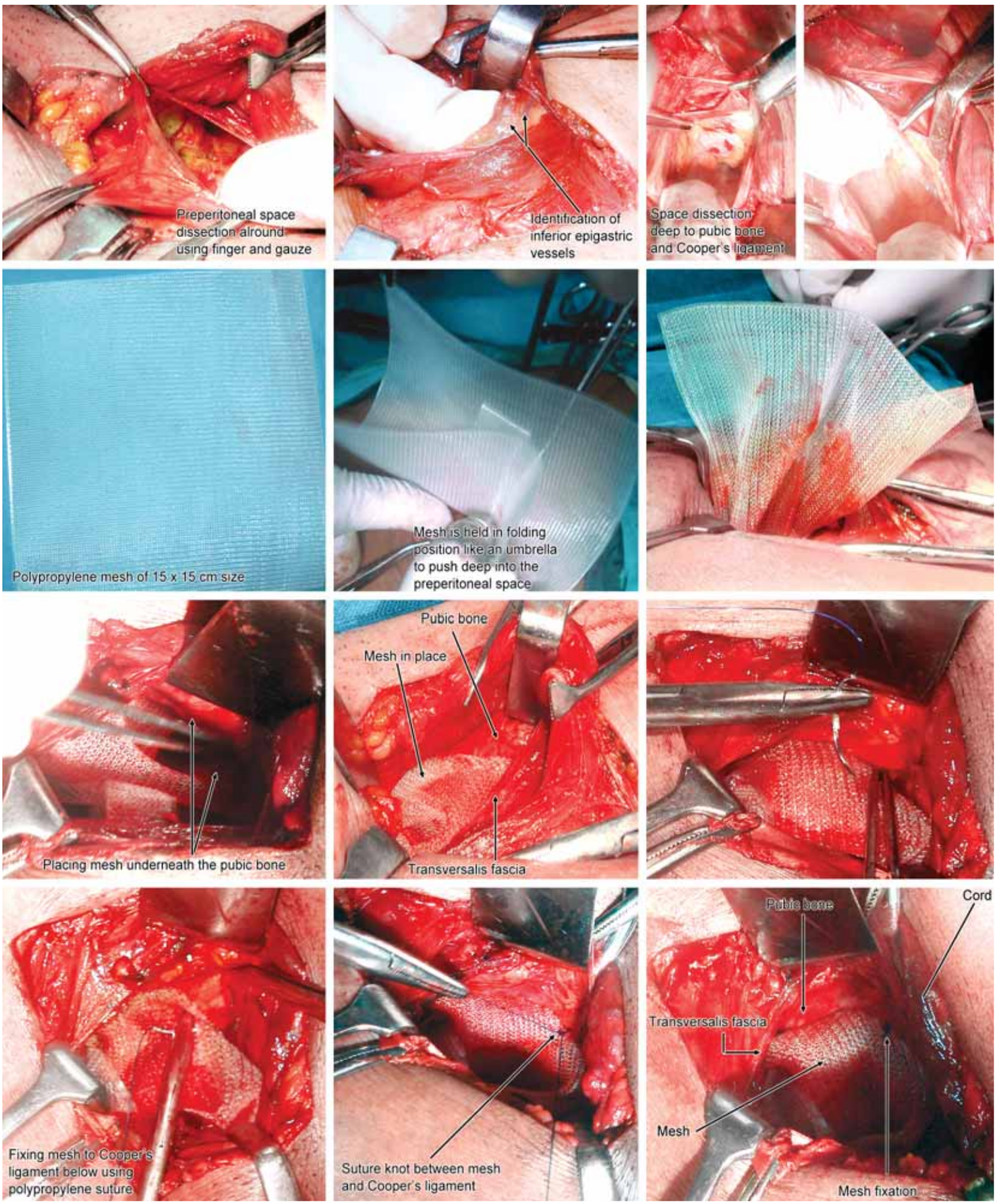
It is done in large hernias, hernias in elderly, bilateral hernias, recurrent and re-recurrent hernias, hernia with very lax abdomen, obesity and hernia with collagen diseases like Marfan's syndrome. Horizontal length (size) of the mesh is 2 cm less than distance between two anterior superior iliac spines and vertical length (size) is distance between the umbilicus and pubic symphysis (26 × 15 cm). Dacron polyester mesh is better than polypropylene mesh which is supple, lightly adherent but rapidly fixing. Large mesh is placed between peritoneum and lateral, inferior, anterior abdominal wall


Prolene mesh is trimmed as in the figure and also two tails are created by cutting the mesh laterally with 3 cm upper part and 2 cm lower part
Tail are crossed across the cord and ilioinguinal nerve to create a new pseudointernal ring
A
B
Mesh
Cord
Internal ring
External oblique
Testes
Conjoint tendon
C

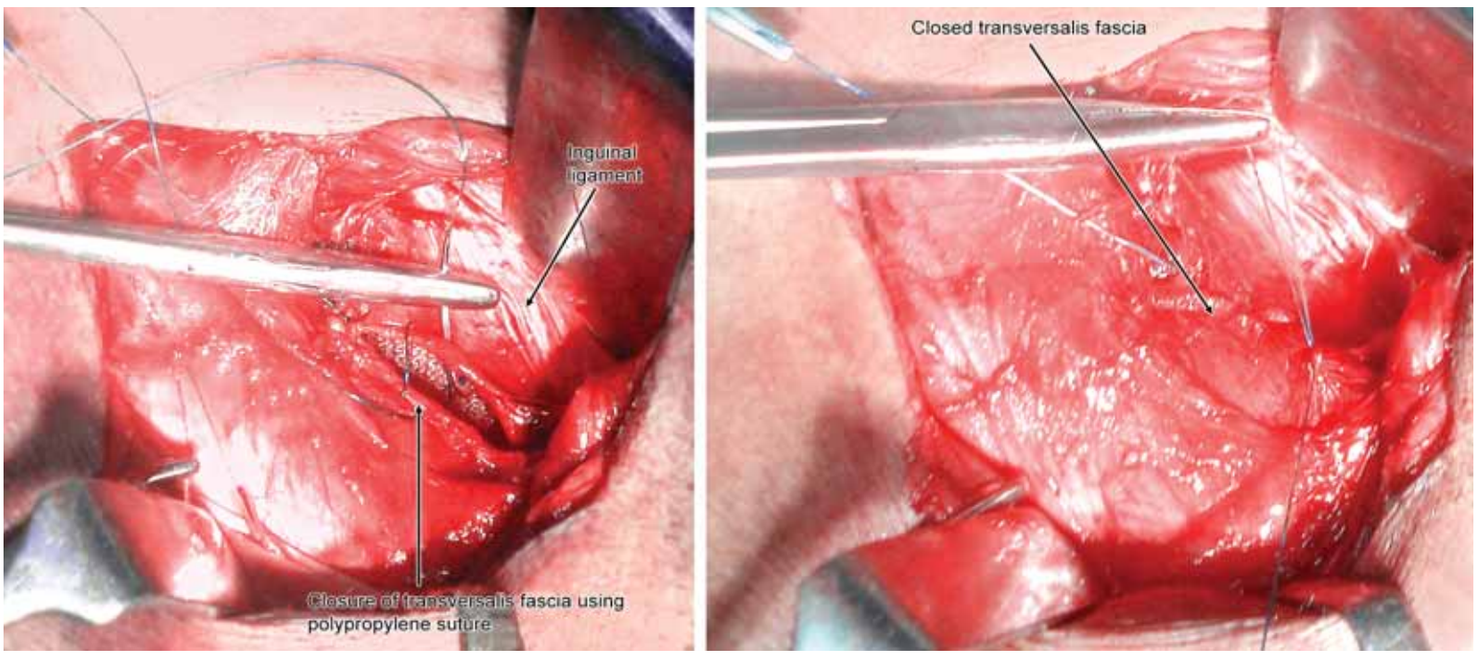
Figs 30-50A to C: Lichtenstein mesh repair—polypropylene is used; often mesh is trimmed.


External oblique aponeurosis
External oblique aponeurosis is incised in the line of incision
External ring is cut
Ilioinguinal nerve
Careful dissection of the cord structures
Iliopubic tract
Inguinal ligament
Cord
Transversalis fascia
Opening of the transversalis fascia
Reaching the preperitoneal space
Opening of the transversalis fascia

Figs 30-51(1)


Preperitoneal space dissection alround using finger and gauze
Identification of inferior epigastric vessels
Space dissection deep to pubic bone and Cooper's ligament
Polypropylene mesh of 15 x 15 cm size
Mesh is held in folding position like an umbrella to push deep into the preperitoneal space
Placing mesh underneath the pubic bone
Pubic bone
Mesh in place
Transversalis fascia
Fixing mesh to Cooper's ligament below using polypropylene suture
Suture knot between mesh and Cooper's ligament
Pubic bone
Cord
Transversalis fascia
Mesh
Mesh fixation

Figs 30-51(2)



Figs 30-51(3)

Figs 30-51(1 to 3): Rives trans inguinal preperitoneal mesh repair.

which stretches in the lower abdomen and pelvis. It is contraindicated in sepsis, iliac vein thrombosis, when GA or spinal anaesthesia cannot be given to the patient. It is done through lower midline subumbilical incision as a posterior preperitoneal approach across space of Retzius medially and space of Bogros laterally. Procedure is done under GA/spinal/epidural anaesthesia. Local anaesthesia is not used. Patient is placed in supine head down position. Subumbilical midline incision is placed across skin, subcutaneous fascia rectus sheath. Peritoneum is not opened. Space of Retzius in front of the bladder is dissected using finger and peanut swab. Dissection is continued towards *opposite side* of the surgeon first along the space of Bogros. Hernial sac/sacs whether indirect/direct or femoral sac are dissected off from their place. Indirect sac when large can be cut and proximal part is ligated and distal end is left open. Dissection is done further using finger along external iliac vessels, iliopsoas muscle. Funicular elements of sac along the vas deferens and testicular vessels are released so as to make complete parietalisation of the cord. Usual size of the mesh is 26 × 15 cm. Polyester mesh is preferred. Prosthesis mesh is made chevron shaped. It is placed and spread along the myopectineal orifice, on lateral part and towards midline. Mesh should be placed unfolded. Surgeon changes his position by moving on to opposite side to carry on with similar dissection on side where he was standing earlier. Usually such large mesh is placed without any anchorage. Often one vicryl stitch is placed between upper medial end of mesh and lower margin of midline of *umbilical fascia (Richet's*). Suction drains are placed. Mesh envelops the endoabdominal fascia widely preventing the recurrence below at groin or at lower midline wound. Drains are removed in 2 days. *In Rignault's modification*, procedure is done through Pfannensteil incision (nerve injury and bleeding chances are high in this incision). Unilateral half cut GPRVS is called as *Wantz procedure,* done under local anaesthesia. Migration of mesh into the bladder is the only rare but severe complication which may occur.

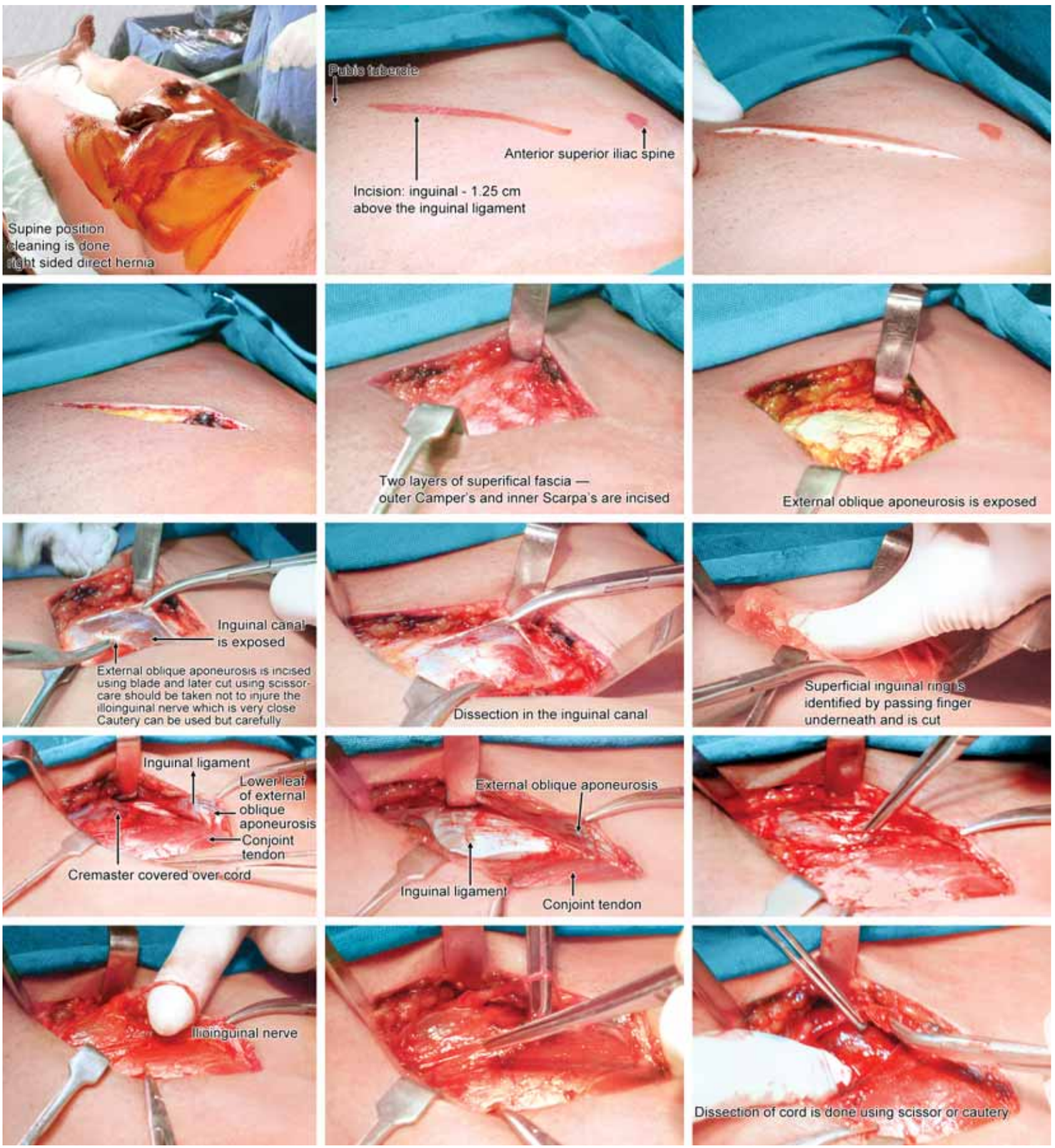
Gilbert mesh repair (patch and plug)

After herniotomy, internal ring is plugged by cone shaped (umbrella plug) piece of prolene mesh. Later onlay/inlay mesh repair of posterior wall of the inguinal canal is done.

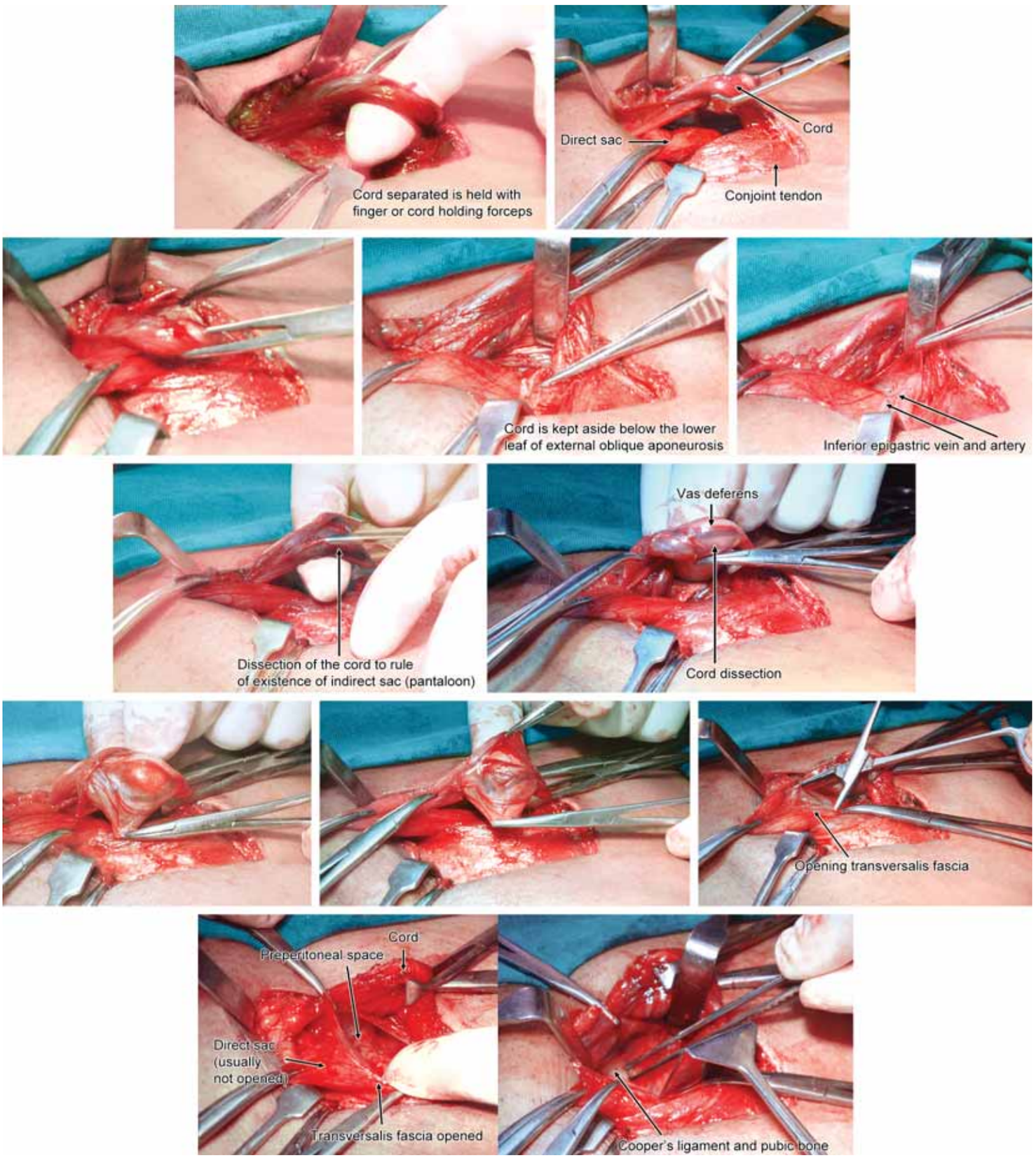
Gilbert's PHS (Prolene Hernia System) repair (onlay and sublay)

It is an open *transinguinal approach* to place a specially devised mesh in both preperitoneal as inlay and in front as onlay mesh repair. This mesh has got a rounded deeper part which is placed in preperitoneal space and a modified quadrangular part which is placed as onlay. Both parts are connected through a connecting stiff rounded part in between which steadies the mesh in place preventing the displacement. Procedure is usually done under local anaesthesia. Direct sac when present is opened. Transversalis fascia over the sac is cut circumferentially and extra part of the fascia is excised. Preperitoneal space is reached using gauze and finger dissection to place the round part of the mesh; lower part of this rounded mesh should be below and deep to the pubic bone to cover entire myopectineal orifice. Outer part is folded perpendicularly using a sponge holding/flat forceps to visualize the inner part and gently pushed into the preperitoneal space using finger. Using index finger it is spread gently in the preperitoneal space. On either side of connector of the mesh, transversalis fascia is sutured using one each polypropylene sutures to fix the connector. Outer quadrangular part is placed in front horizontally. Medially it should cover 2 cm beyond pubic tubercle like onlay mesh repair **(Fig. 30-53)**.

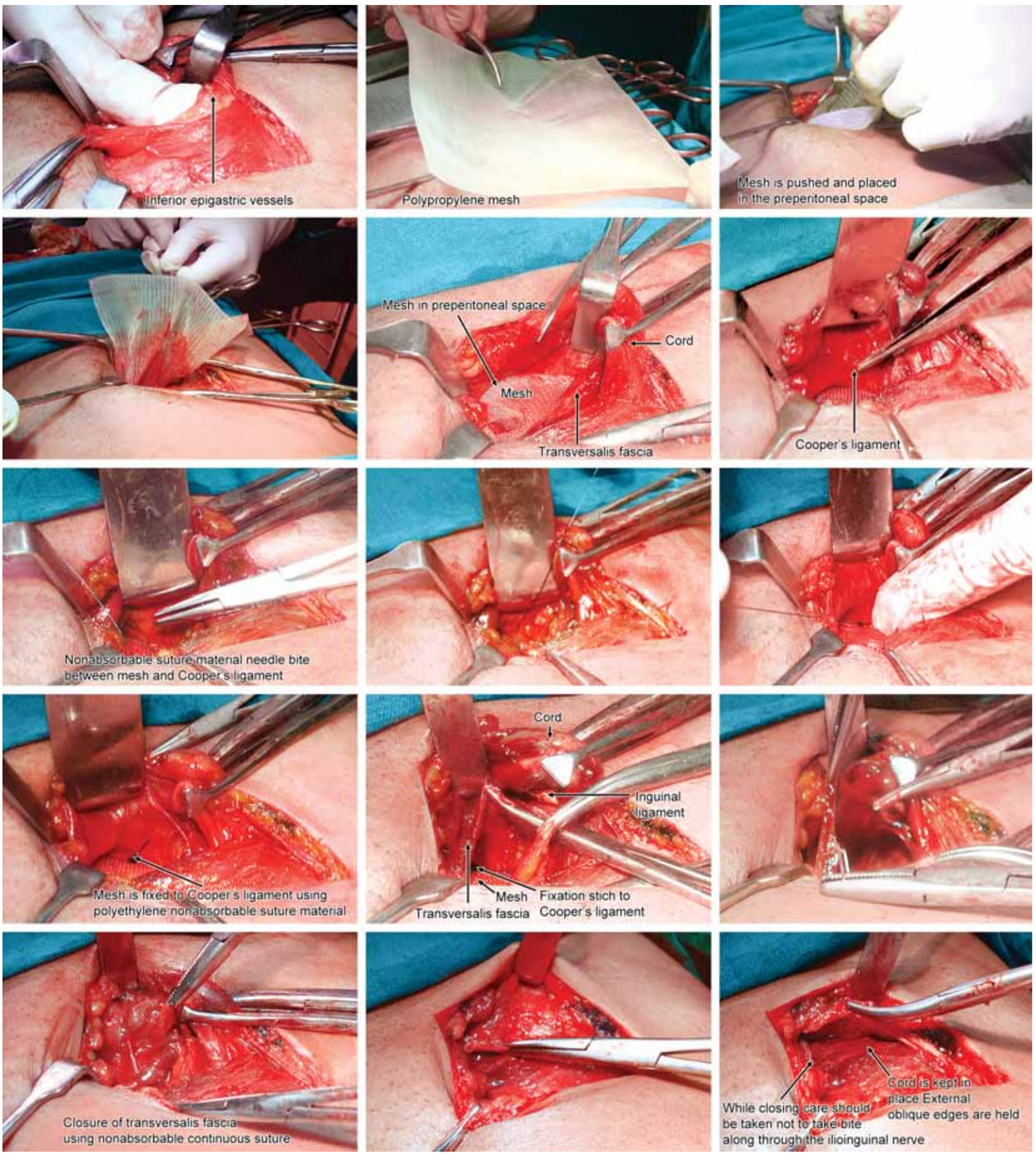
Using polypropylene interrupted suture below it is sutured to inguinal ligament, above to conjoined tendon by one suture, medially to soft tissue adjacent to pubic tubercle. Cord structure with ilioinguinal nerve is passed through the mesh by making a vertical cut on the wide portion of the anterior part of the mesh near its upper margin adjacent to internal ring and once cord is encircled, mesh is secured around the cord by single suture with crossing over the leaves


Supine position
cleaning is done
right sided direct hernia
Pubis tubercle
Anterior superior iliac spine
Incision: inguinal - 1.25 cm
above the inguinal ligament
Two layers of superifical fascia —
outer Camper's and inner Scarpa's are incised
External oblique aponeurosis is exposed
Inguinal canal
is exposed
External oblique aponeurosis is incised
using blade and later cut using scissor-
care should be taken not to injure the
illoinguinal nerve which is very close
Cautery can be used but carefully
Dissection in the inguinal canal
Superficial inguinal ring is
identified by passing finger
underneath and is cut
Inguinal ligament
Lower leaf
of external
oblique
aponeurosis
Conjoint
tendon
Cremaster covered over cord
External oblique aponeurosis
Inguinal ligament
Conjoint tendon
Ilioinguinal nerve
Dissection of cord is done using scissor or cautery

Figs 30-52(1)


Cord separated is held with finger or cord holding forceps
Direct sac
Cord
Conjoint tendon
Cord is kept aside below the lower leaf of external oblique aponeurosis
Inferior epigastric vein and artery
Dissection of the cord to rule of existence of indirect sac (pantaloon)
Vas deferens
Cord dissection
Opening transversalis fascia
Cord
Preperitoneal space
Direct sac (usually not opened)
Transversalis fascia opened
Cooper's ligament and pubic bone

Figs 30-52(2)


Inferior epigastric vessels
Polypropylene mesh
Mesh is pushed and placed in the preperitoneal space
Mesh in preperitoneal space
Cord
Mesh
Transversalis fascia
Cooper's ligament
Nonabsorbable suture material needle bite between mesh and Cooper's ligament
Cord
Inguinal ligament
Mesh is fixed to Cooper's ligament using polyethylene nonabsorbable suture material
Mesh
Fixation stich to Cooper's ligament
Transversalis fascia
Closure of transversalis fascia using nonabsorbable continuous suture
While closing care should be taken not to take bite along through the ilioinguinal nerve
Cord is kept in place External oblique edges are held

Figs 30-52(3)

Figs 30-52(4)

Figs 30-52(1 to 4): Rives preperitoneal mesh repair—trans inguinal approach.

of the cut part of the mesh. Slit can also be made on the lateral margin to accommodate the cord structure. Connecting cord (connector) or rounded part should not be cut or cord should not be passed through this. In indirect sac preperitoneal space can also be created through posterior wall of the inguinal canal like in direct sac or through the internal ring space is created by blunt dissection by passing index finger. Pulsation of iliac artery can be felt lateral to the index finger. This dissection can be achieved using a sponge held in an instrument or by index finger. Dissection is between preperitoneal space and transversalis fascia. Inferior epigastric vessels are usually left in place between the two lamina of fascia transversalis but can be securely ligated if difficulty arises. Space of 6 cm radius is created all around centering deep ring. Connector is made to remain either on internal ring or on the direct defect of the posterior wall of inguinal canal. Wound is closed in layers. Skin is closed with subcuticular absorbable suture or N butyl cyanacrylate bond. Patient can be discharged within 24 hours. Wound inspection is done in 7 days. Mild discolouration and oedema may last as long as for 6 weeks. Complications are haematoma, swelling, seroma, infection.

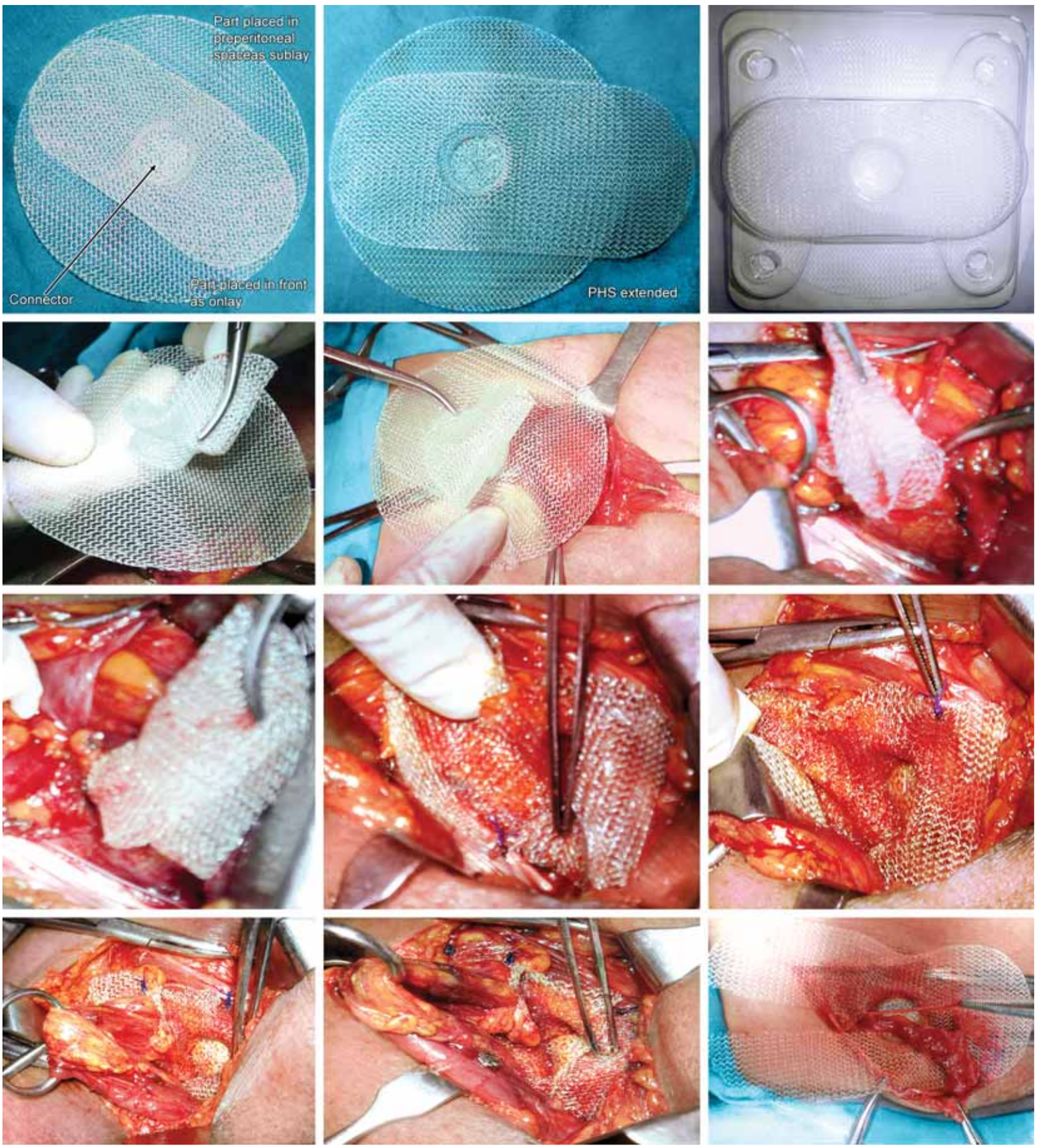
Kugel (Rober D Kugel) groin hernia mesh repair (sublay)

It is done through *posterior preperitoneal* approach with tension free less invasive sutureless repair. *Indications* are indirect, direct or femoral hernias; recurrent hernias after anterior approach (onlay); in young individuals. It can be done in bilateral hernias also. It can be done in post radiation patient with hernia or recurrence after TEP or TAPP. Kugel patch contains two overlapping layers of knitted polypropylene mesh which are attached to each other ultrasonically. Near the outer edge of the mesh it has got a polyester spring which stiffens the mesh to unfold. 1 cm of mesh extends outer to the spring which also has radial slits to have easy maneuverability. Anterior layer of the mesh has got single transverse slit to facilitate the insertion. Multiple 3 mm holes through both layers of the mesh are present that allow tissue contact in better way to prevent mesh displacement. Small V shaped triangular cuts on the anterior layer adjacent to these multiple holes act as sutureless anchors. Small 8 × 12 cm and large 11 × 14 cm sizes are available, former is used in indirect sac, latter in direct sac. Incision is above the deep ring and lateral to inferior epigastric vessels. Midpoint of the inguinal ligament is marked. *Oblique incision* line just superior to this point; with 1/3rd lateral and 2/3rd medial to this point is made **(Figs 30-54A and B)**.

Skin, subcutaneous tissue, external oblique aponeurosis is cut; internal oblique and transversus abdominis muscles are split to reach deeper space. Ilioinguinal and iliohypogastric nerves will not come into the field. Transversalis fascia often which is two layered is split vertically to avoid injury to inferior epigastric vessels. Inferior epigastric vessels are retracted medially. Preperitoneal space is created first superiorly then laterally. Indirect sac is dissected off the deep ring from above; if dissection is difficult, sac can be cut with distal part left open and proximal part being ligated using absorbable 3 zero vicryl. Direct sac is dissected off the defect without opening; its pseudosac which is modified transversalis fascia is dissected off entirely from the peritoneum behind. Often it is needed to make a small incision on the pseudosac to prevent seroma formation as this cut allows dissipation of fluid or blood into the tissue in the inguinal canal in front. As approach is small, proper malleable retractors are necessary. Dissection is carried out down under the pubic bone across Cooper's ligament. Care should be taken not to injure vessels at this place either small veins or aberrant obturator artery. Kugel's mesh patch is placed properly without allowing any tissue bands folding it. Transversalis fascia is sutured with one absorbable suture. Transversus abdominis and internal oblique muscles are not sutured. External oblique aponeurosis is sutured; then subcutaneous tissue and skin. Bilateral hernias are dealt with two separate incisions.

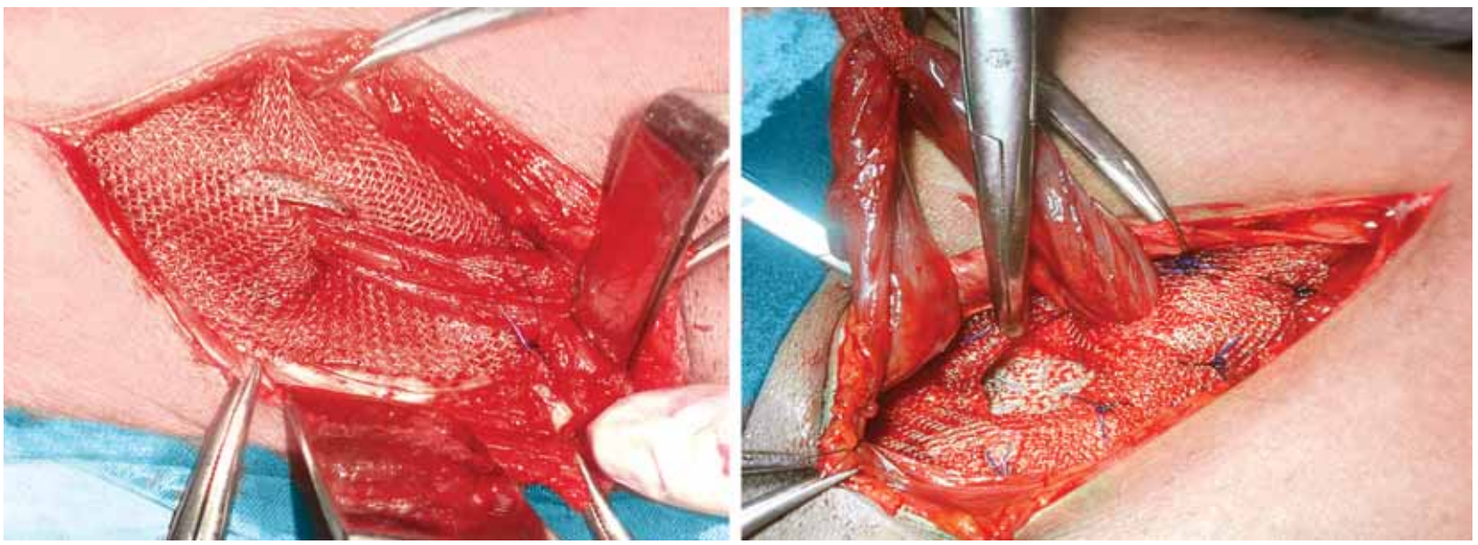
Transabdominal preperitoneal mesh repair (TAPP-sublay) using laparoscope (Arregui – 1991)

This is used in large indirect hernia or irreducible inguinal hernia. 10 mm umbilical port is used for laparoscope. 5 mm ports on pararectal point at the or above the level of the umbilicus one on each side are used so as to achieve adequate triangulation. Contents of the hernia are reduced. Hernial sac is dissected in preperitoneal plane after



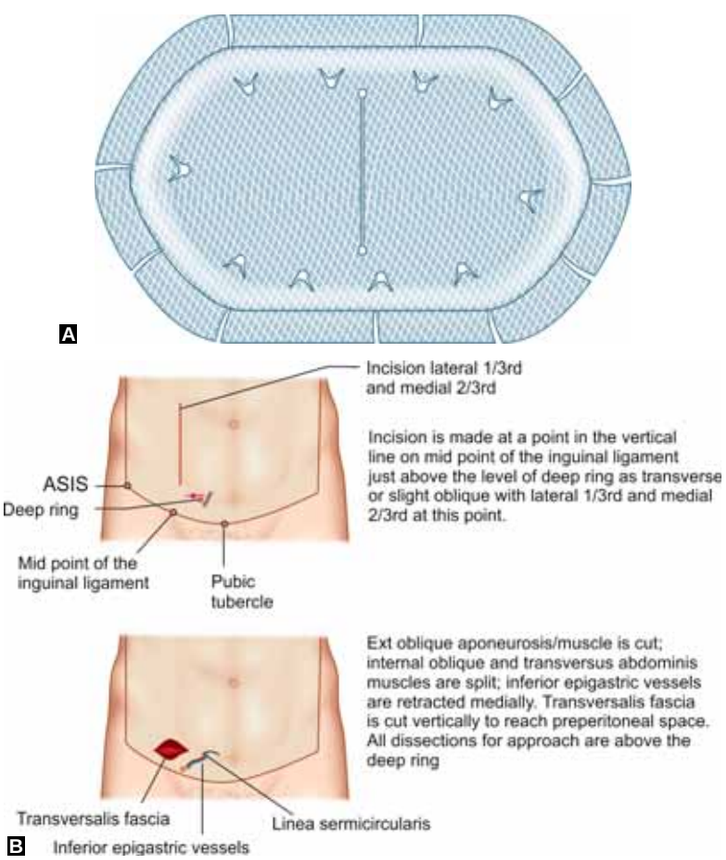
Figs 30-53(1)

making curved horizontal incision at the upper part of the opening of sac. Incision over the peritoneum is made from lateral to medial. From a point around 3-4 cm lateral to lateral umbilical ligament (inferior epigastric vessels) horizontal incision is made across internal ring on its upper part medially up to medial umbilical ligament. Preperitoneal space is dissected to identify pubic bone, Cooper's ligament, vas, gonadal vessels, and inferior epigastric vessels. Once sac is dissected and excised, a prolene/vipro/ultrapro mesh of 15 × 10 cm sized is placed in preperitoneal pace. It is fixed to pubic bone/Cooper's ligament using tacks. Peritoneum is closed with continuous



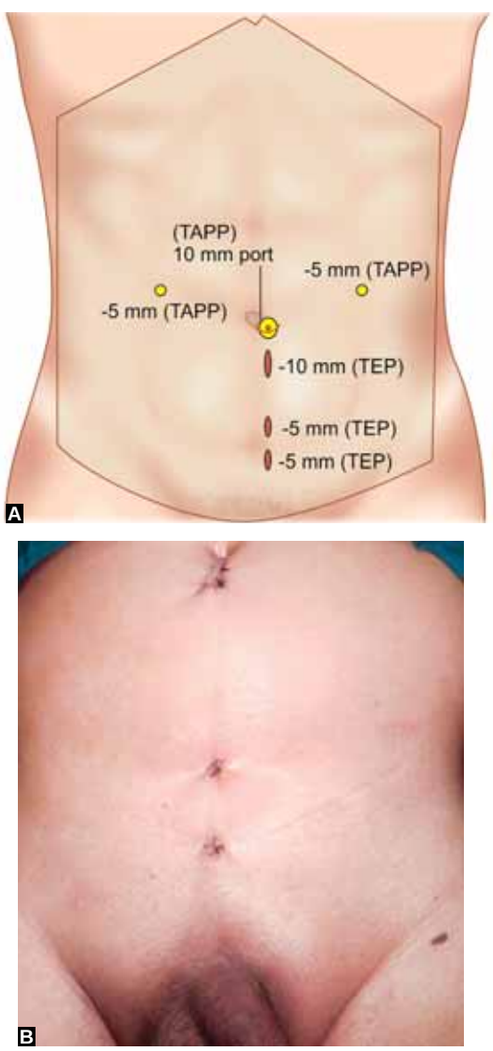
Figs 30-53(2)

Figs 30-53(1 and 2): Prolene hernia system—surgical technique (PHS).


A
Incision lateral 1/3rd and medial 2/3rd
Incision is made at a point in the vertical line on mid point of the inguinal ligament just above the level of deep ring as transverse or slight oblique with lateral 1/3rd and medial 2/3rd at this point.
ASIS
Deep ring
Mid point of the inguinal ligament
Pubic tubercle
Ext oblique aponeurosis/muscle is cut; internal oblique and transversus abdominis muscles are split; inferior epigastric vessels are retracted medially. Transversalis fascia is cut vertically to reach preperitoneal space. All dissections for approach are above the deep ring
Transversalis fascia
Linea sermicircularis
B
Inferior epigastric vessels

Figs 30-54A and B: Kugel's procedure for inguinal hernia. It is suprainguinal posterior approach.

prolene sutures from lateral to medial. It is mainly used in irreducible and large hernias. Thus reperitonealisation should be done properly. TAPP without reperitonealisation **(TAPPWR)** can be done if dual mesh with ePTFE on inner visceral side can be placed after complete dissection in retroperitoneal space without suturing/apposing the peritoneum. ePTFE prevents viscera from getting adherent and eroded by mesh. Neoperitoneum develops on the ePTFE mesh in 10 days. Complications of TAPP are similar to TEP. Additional problems of



Figs 30-55A and B: Ports used for TEP (red color) and for TAPP (yellow color).

bowel injury by trocars, problems of pneumoperitoneum can occur. Advantage of TAPP is larger working space **(Figs 30-55 to 30-58)**.

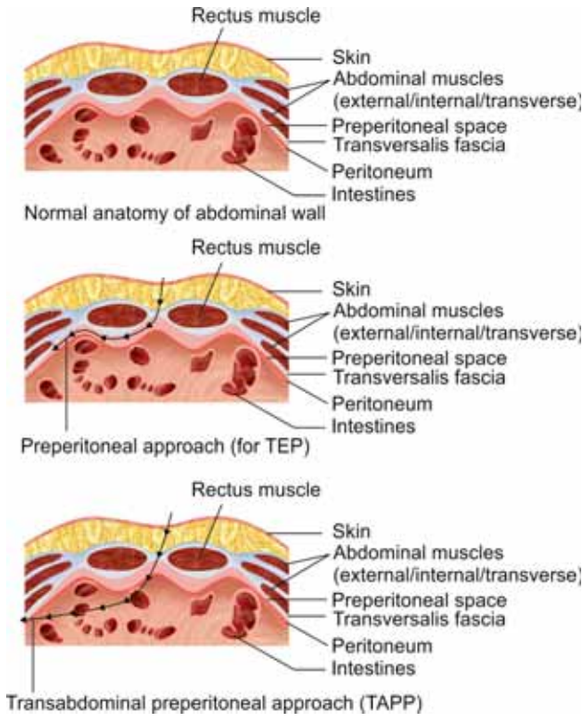


Fig. 30-56: Diagrammatic representations of TEP and TAPP.

Fig. 30-57: Indirect hernia sac as seen in TAPP.

Totally Extra Peritoneal Repair (TEP Repair) Using Laparoscope (First done by McKernon, EH Phillips and Laws 1990, 1993)

This technique is gaining more popularity than TAPP. It does not breach the peritoneal cavity. It is useful for bilateral and recurrent hernias. It is contraindicated in previous midline surgical scar, previous caesarean, previous pelvic surgery or pelvic radiation.

Patient is ideally *catheterized*. Surgeon should stand opposite to the side of the hernia. Camera man stands on the same side proximal to the surgeon. Scrub nurse stands on the opposite side. Monitor is kept near the foot end side on the side of the hernia. Through sub umbilical vertical/horizontal incision (10 mm) extra peritoneal space

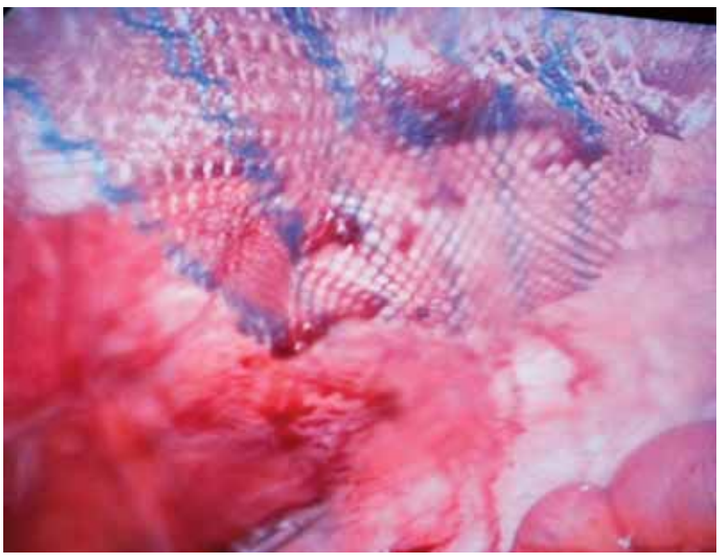


Fig. 30-58: Mesh placement in TAPP procedure.

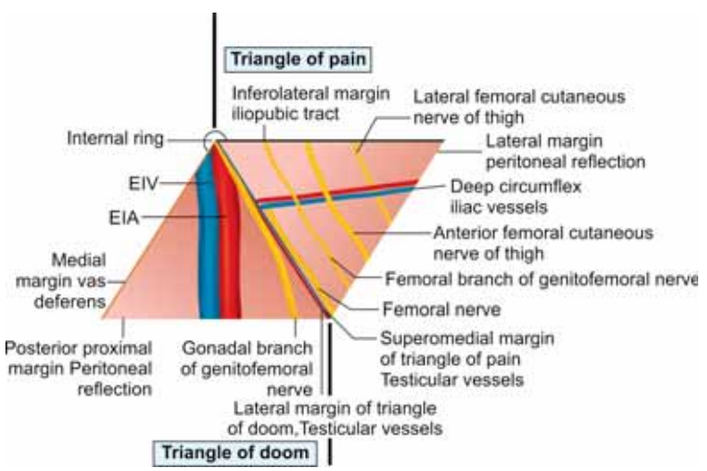
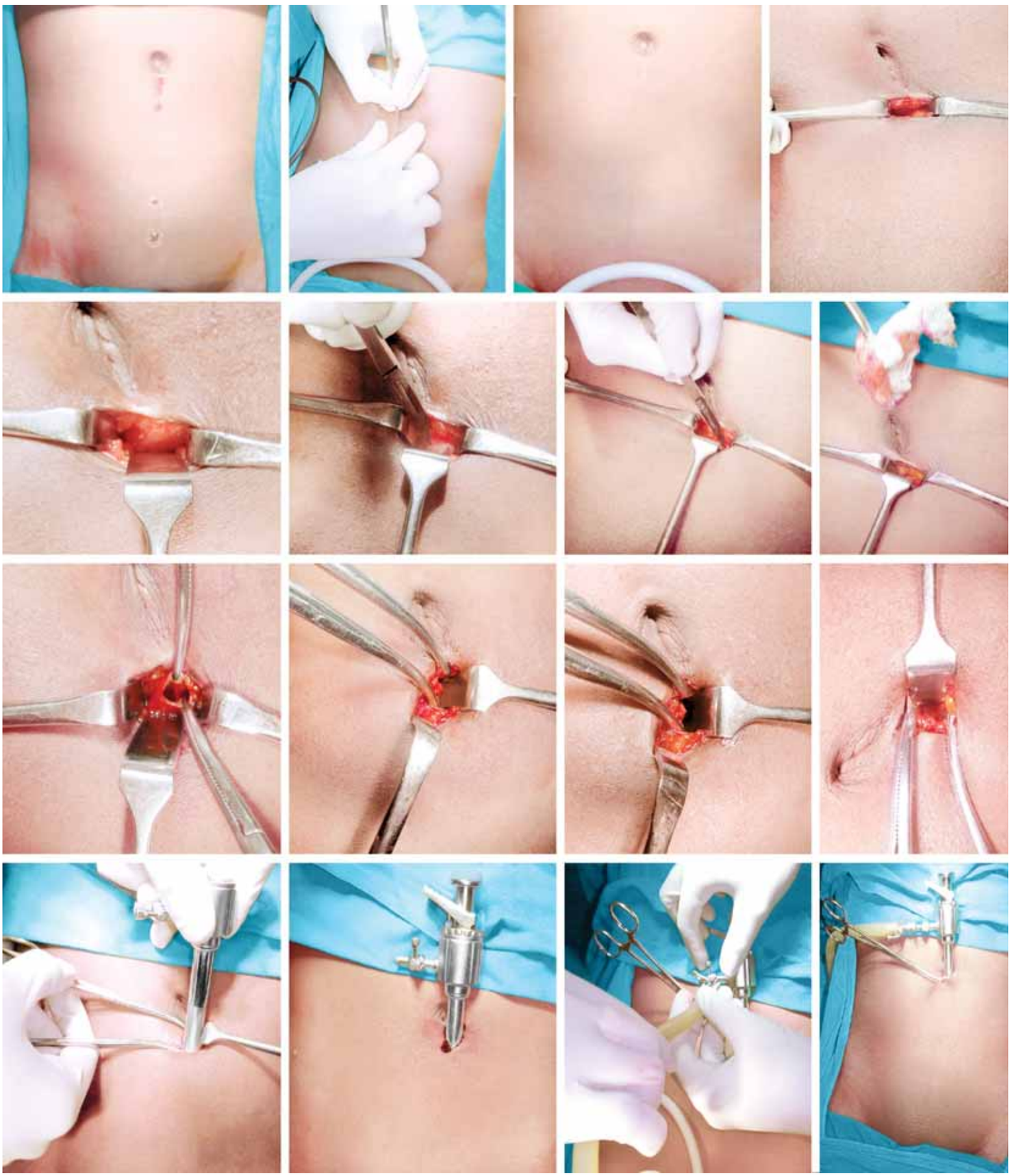


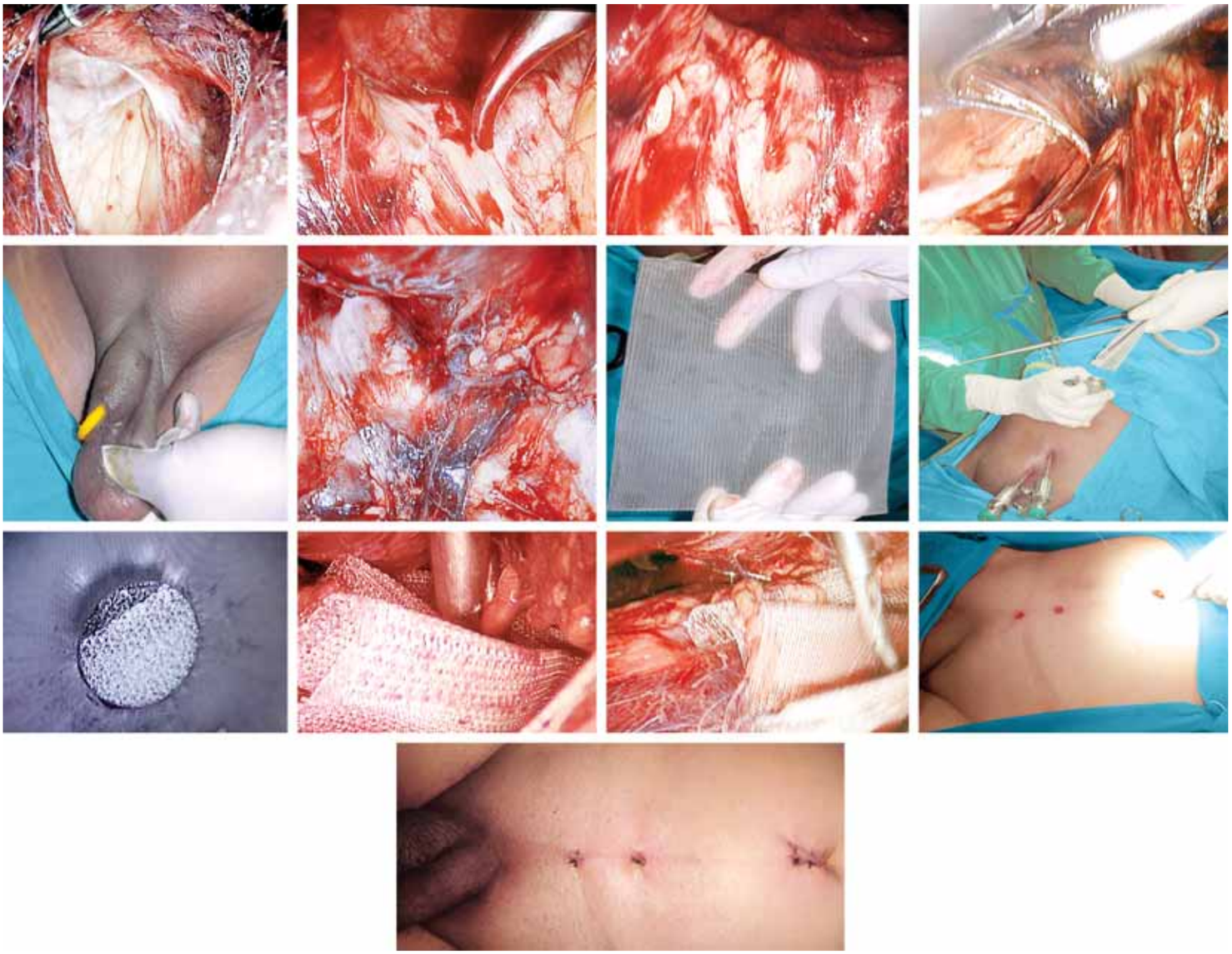
Fig. 30-59: Triangle of doom and triangle of pain.

is reached. Often special type of balloon is used to create the same. *Cobweb space* is avascular and easily identifiable. It is better to use zero degree telescopes initially to reach the pubic bone. Touching of the telescope over the hard pubic bone can be felt during dissection. Further dissection allows visualization of the bone as *light house sign*. Immediate laterally Cooper's ligament can be identified. After CO_2 insufflation, another 5 mm port is inserted 4 cm below the first port in the midline. It is often better to put a hypodermic needle (needle of a syringe) into the space from midline to identify the site of the further ports. Third 5 mm port is inserted in the same line 4 cm below or in the right iliac fossa. Dissection is carried out downwards carefully, then medially up to the pubic tubercle, ilio-pectineal ligament, laterally to iliac vessels, and inferior epigastric vessels. At this stage 30° telescope is used. Direct sac when present is immediately visualised. It is dissected proximally by traction and countertraction over the white pseudosac (attenuated transversalis fascia) in front. After complete separation many practice to pull this pseudosac proximally to fix it to anterior abdominal wall to prevent the formation of seroma. Entire sac should be dissected down and behind to visualize wide direct defect medial to inferior epigastric vessels. One should remember that inferior epigastric vessels are properly seen only after dissection



Figs 30-60(1)

Figs 30-60(2)



Figs 30-60(3)

Figs 30-60(1 to 3): Technical aspects of TEP

of the sac in case of direct one. Whereas in indirect sac, first inferior epigastric vessels are seen; then peritoneal sac is seen lateral to it running upwards, medially and proximally in the anterior abdominal wall. Hernial sac descends downwards into the internal ring. Sac is dissected from the deep ring. Usually entire sac can be dissected proximally. It is usual to place an endoloop into the sac but not always necessary. Large complete sac is transected at internal ring with placing an endoloop on proximal part of the sac; distal part of cut sac is left open without ligation.

Triangle of doom should be identified and care should be taken while dissecting in this area. Laterally dissection is done up to anterior superior iliac spine adequately along the iliopsoas to create needed space to place large mesh. *Triangle of pain* should be kept in mind as not to injure lateral femoral cutaneous nerve and femoral branch of genitofemoral nerve **(Fig. 30-59)**.

One should avoid opening peritoneum as it reduces the extraperitoneal space to undertake further part of the procedure. If it happens, then it is better to place a Verres needle into the peritoneal cavity to deflate it and to increase the CO_2 flow rate. If bleeding occurs through injury of inferior epigastric vessels, it is tackled by placing clips or using bipolar cautery. Iliac vessels injury is catastrophic which needs immediate conversion to open procedure for proper vascular repair.

Mesh is passed through 10 mm port using a reducer after removing the telescope. If difficulty arises in passing mesh then port knob is removed and mesh is directly pushed into the space through the port. Once adequate space is dissected 15 × 15 cm sized mesh is placed and spread. Care should be taken not to have any folding in the mesh. Mesh may be sutured to ilio-pectineal ligament. Tackers should not be placed laterally and adjacent to vessels. Displacement of mesh is not common. Other side also can be done together. Deflation of gas is done at the end to keep the mesh in place. Port sites are sutured. 10 mm port site needs deeper vicryl suture **(Fig. 30-60)**.

Different port approaches and port placements are used for TEP

1. *Duluq approach:* Veress needle is passed just above the midline across the linea alba into the *space of Retzius* in preperitoneal area. CO_2 is insufflated into the preperitoneal space at a rate of 1 litre/

minute with needle tip manipulating at various directions to inflate preperitoneal space adequately. Through a vertical subumbilical incision, 10 mm trocar is passed into the space directing obliquely towards the pubis initially, later at 60° angle. Zero degree telescope is passed to visualize the space and for further dissection using telescope along the cobweb areolar tissue. Further 5 mm trocars are passed as usual.

2. *McKernan's method:* Anterior rectus sheath is exposed through infraumbilical 2 cm vertical incision which is incised vertically to expose the rectus muscle; rectus muscle is retracted laterally to reach posterior rectus sheath; through this route Hassan's cannula is passed to proceed with creation of space and further two 5 mm ports below midline are inserted. 12.5 × 7.5 cm mesh with slit for passage of cord is used.
3. *Phillips TEP using initial peritoneoscopy:* After creating pneumoperitoneum through subumbilical 1 cm incision 10 mm trocars and port is passed into the peritoneal cavity. Under laparoscopic vision additional two 10 mm ports are passed on either side after making skin incision into the preperitoneal space without entering the peritoneal cavity along the lateral borders of the both rectus muscles. Laparoscope with the trocars is slowly withdrawn until preperitoneal space is reached where it is advanced into the preperitoneal space to proceed with the further dissection as usual.

Anatomical Considerations

Preperitoneal space is a potential space in front of the peritoneum, behind the transversalis fascia and anterior rectus muscle. Below in front of the urinary bladder, it is called as *space of Retzius* (medially), laterally it is called as *space of Bogros*. Median umbilical fold is formed by urachus in the midline. Medial umbilical ligament is formed by obliterated umbilical arteries, lateral umbilical fold by inferior epigastric vessels. Three fossae are lying in relation to these folds—supravesical and medial fossae are medial to lateral umbilical fold which are sites of direct hernia whereas lateral fossa is lateral to lateral umbilical fold and is site of indirect hernia.

In 1956 *Fruchaud* described his *myopectineal orifice* bounded medially by the lateral border of rectus abdominis, laterally by iliopsoas, superiorly by conjoined tendon and inferiorly by pectin pubis. This area is the site of groin hernia which should be covered by mesh of adequate size to strengthen the defect and to prevent the recurrence. Iliopubic tract is analogue of the inguinal ligament, extends from Cooper's ligament to anterior superior iliac spine which divides endoscopic view of preperitoneal space into *superior compartment* (contains inferior epigastric artery, Hesselbach's triangle, cord structures and is site of inguinal hernia) and *inferior compartment* (contains femoral canal, iliac vessels (vein medially; artery laterally), iliopsoas muscle, genitofemoral nerve, lateral femoral cutaneous nerve). External iliac vessels lie in a triangle formed by gonadal vessels laterally, vas deferens medially and peritoneal reflection inferiorly (*triangle of doom*).

Aberrant obturator artery which is an occasional branch of inferior epigastric artery replacing its pubic branch travels across Cooper's ligament, which during fixation of mesh can cause torrential haemorrhage—*circle of death*. *Triangle of pain* is formed by gonadal vessels medially, iliopubic tract laterally and peritoneal reflection below. Genitofemoral nerve and lateral cutaneous nerve of thigh traverse this triangle. Injury to these nerves either by dissection or by tacks cause post-operative pain. Tacks/staplers should not be placed in this triangle **(Figs 30-61 to 30-66)**.

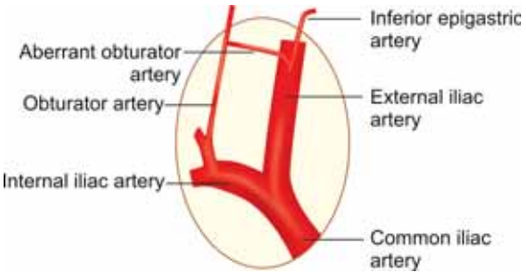


Fig. 30-61: Circle of death.

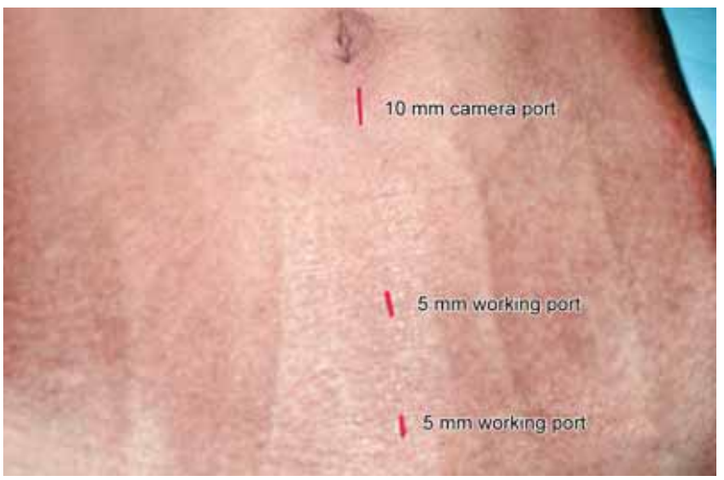


Fig. 30-62: Port incisions in TEP.

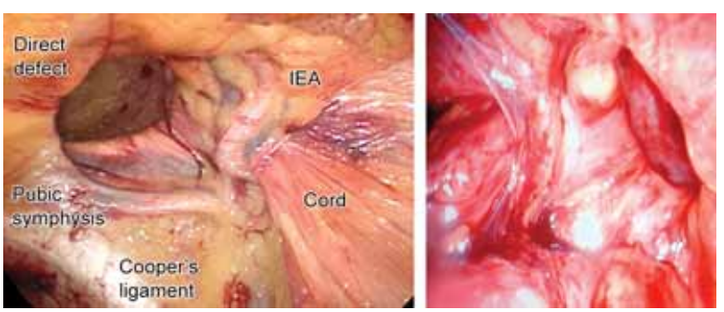


Fig. 30-63: TEP after dissection prior to placement of mesh. Direct defect, inferior epigastric artery, pubic symphysis and Cooper's ligament are clearly seen.

Fig. 30-64: TEP after dissection showing indirect sac, inferior epigastric vessels, Cooper's ligament.

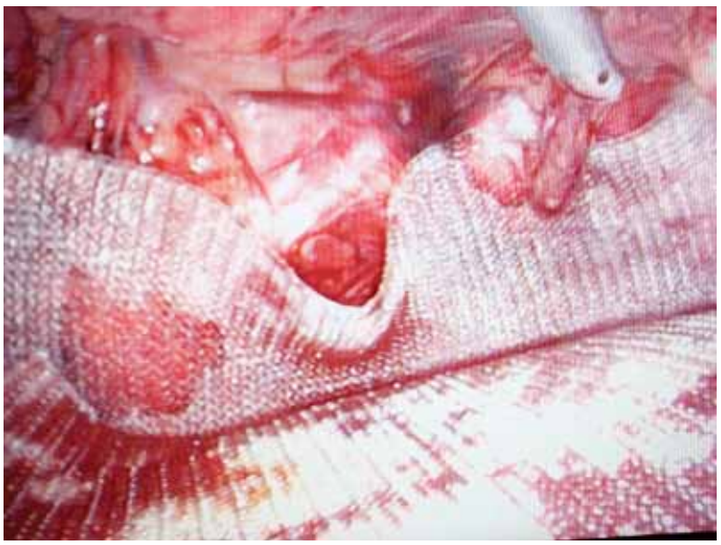


Fig. 30-65: TEP mesh placement in preperitoneal space.

Fig. 30-66: Seroma in groin is common after TEP which can be aspirated safely.

Indications for TEP	*Contraindications for TEP*
• Recurrent hernia • Bilateral hernia • Indirect/direct/femoral hernia	• Obstructed/strangulated inguinal hernias • Ascites • Bleeding disorders
Landmarks to be identified in TEP	*Principles in TEP*
• Pubic bone midline • Inferior epigastric artery • Cooper's ligament • Iliopubic tract • Cord and vas deferens • Psoas muscle and nerves in relation	• Supine or head-down supine position • Surgeon standing opposite side of hernia • Camera person placed on opposite side of hernia • Monitor at foot end • Catheterize/empty the bladder properly prior to TEP • Adequate wide space creation • Careful dissection of cord and sac • Ligate indirect sac • Mesh should not be fixed laterally • Size of mesh is 15 × 15 cm • Two point fixation—one at pubic bone other at Cooper's ligament by tacks/staplers

Difficulties and complications in TEP repair

Difficulty in dissecting indirect sac. Cord/vas injury
Inadvertent opening of the sac/peritoneum and creation of pneumoperitoneum.
Injuries to major structures like iliac vessels: 0.5-1.0%
Displacement of mesh or erosion into the structures like urinary bladder—rarely may occur.
Nerve injury: lateral cutaneous nerve of thigh and femoral branch of genitofemoral nerve
Formation of seroma/haematoma
Infection
Recurrence
Prolapsed of the mesh into the direct hernial defect

Advantages of TEP repair

Approach is totally extraperitoneal
Small incision
Proper placement of mesh in right space that is preperitoneal space
Peritoneal cavity is intact and not opened

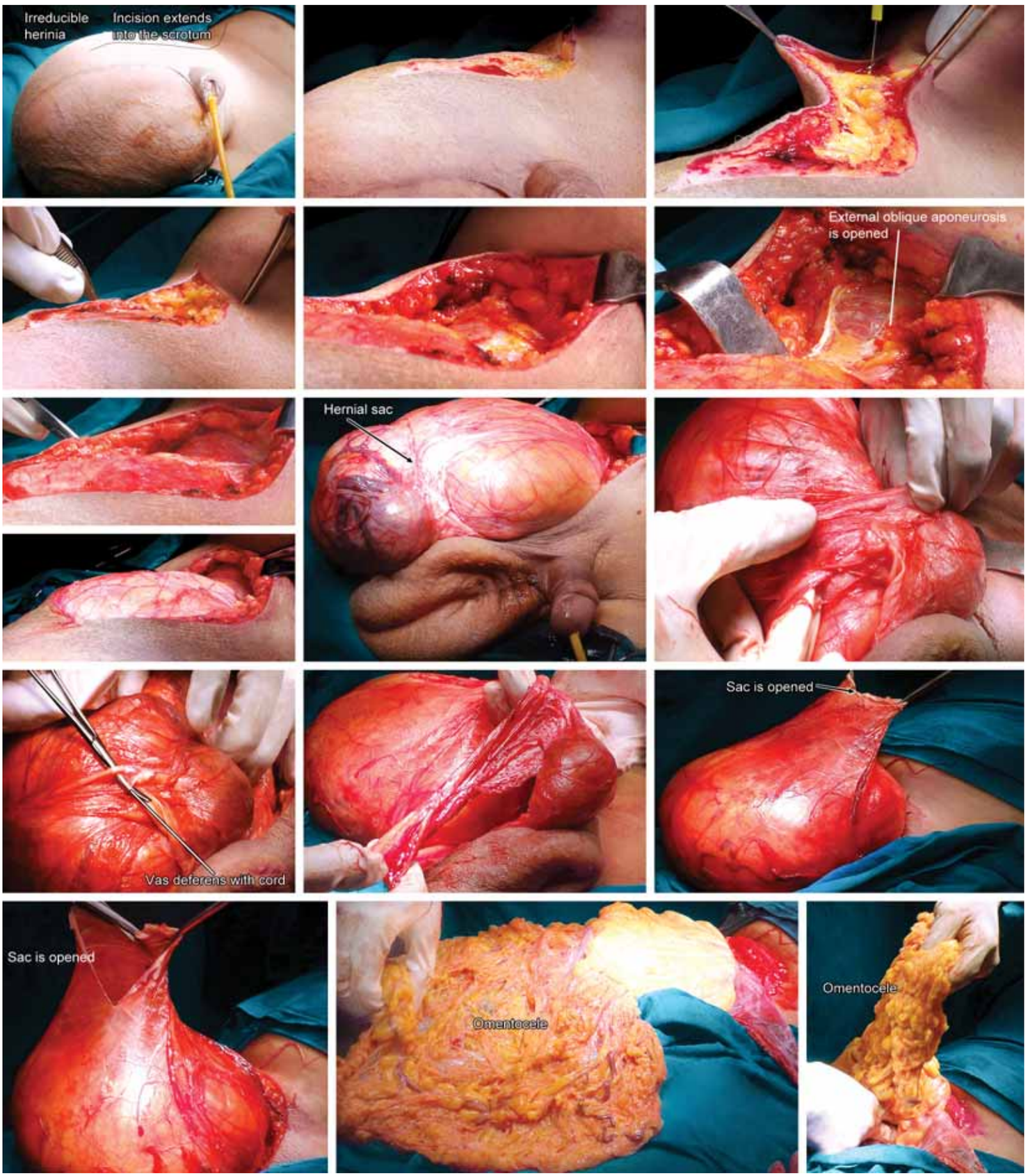
STRANGULATED INGUINAL HERNIA

Irreducibility, obstruction and strangulation are the complications of the inguinal hernia. First irreducibility occurs which leads into obstruction and strangulation **(Figs 30-67 to 30-71)**.

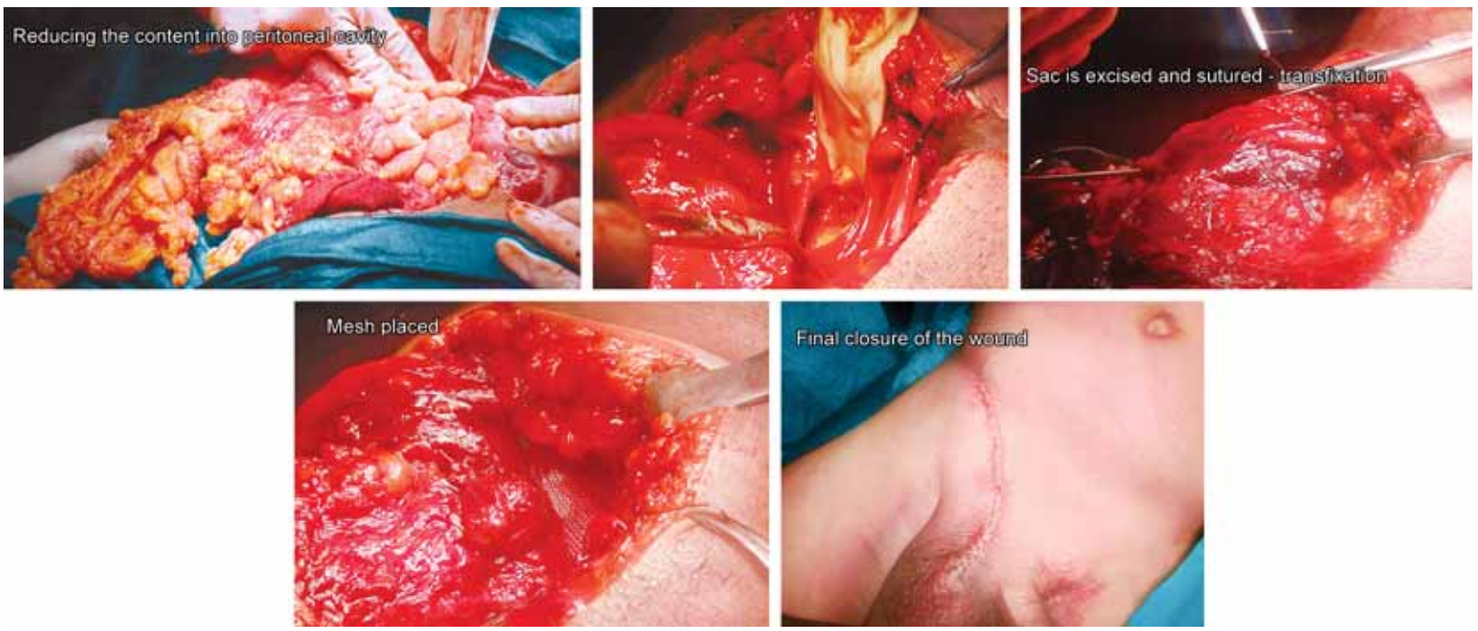
Features of strangulated hernia	*Causes of strangulation*
• Tense, tender, irreducible	• Narrow neck
• No impulse on coughing	• Adhesions
• Shock, toxicity	• Irreducibility
• Features of obstruction when there is enterocele	• Long-time, large hernia with adhesions
• Abdominal distension, vomiting	
• Rebound tenderness	

Patient with strangulated inguinal hernia presents with irreducibility, pain and tenderness, distension of abdomen, vomiting, and toxic features. Initial resuscitation is done with nasogastric aspiration, fluid and electrolyte therapy, antibiotics, urinary catheterization. Erect X ray abdomen may show multiple air fluid levels. *Emergency surgery* is needed under general anaesthesia. Inguinal incision extending into the groin is placed. Incision is deepened to reach the external oblique aponeurosis which is cut across the superficial inguinal ring **(Fig. 30-72)**.

Incision is extended and deepened downwards along the root of the scrotum. Sac is identified and held. One should also hold the contents in the sac so has to prevent contents getting reduced and also toxic fluid spilling into the peritoneal cavity. Sac is opened carefully; all toxic fluid in the sac is sucked out thoroughly. Content, either bowel or omentum is held with Babcock's forceps. Viability of the bowel is checked by its colour, texture, peristalsis, mesenteric pulsation or when in doubt by giving 100% oxygen to the patient or after covering the bowel wall using hot mops. If bowel is not viable resection and anastomosis is done. For this, incision may be adequately extended laterally along the lateral abdominal wall. Closing this wound and separate laparotomy incision is not mandatory. Anastomosis is done using interrupted single layer silk or vicryl sutures. *Strangulated omentum* is not uncommon which is treated by omentectomy. *Drains* are placed into the peritoneal cavity as well as into the inguinal wound **(Fig. 30-73)**.


Irreducible herinia
Incision extends into the scrotum
External oblique aponeurosis is opened
Hernial sac
Vas deferens with cord
Sac is opened
Sac is opened
Omentocele
Omentocele

Figs 30-67(1)


Reducing the content into peritoneal cavity
Sac is excised and sutured - transfixation
Mesh placed
Final closure of the wound

Figs 30-67(2)

Figs 30-67(1 and 2): Large irreducible omentocele in a hernia.

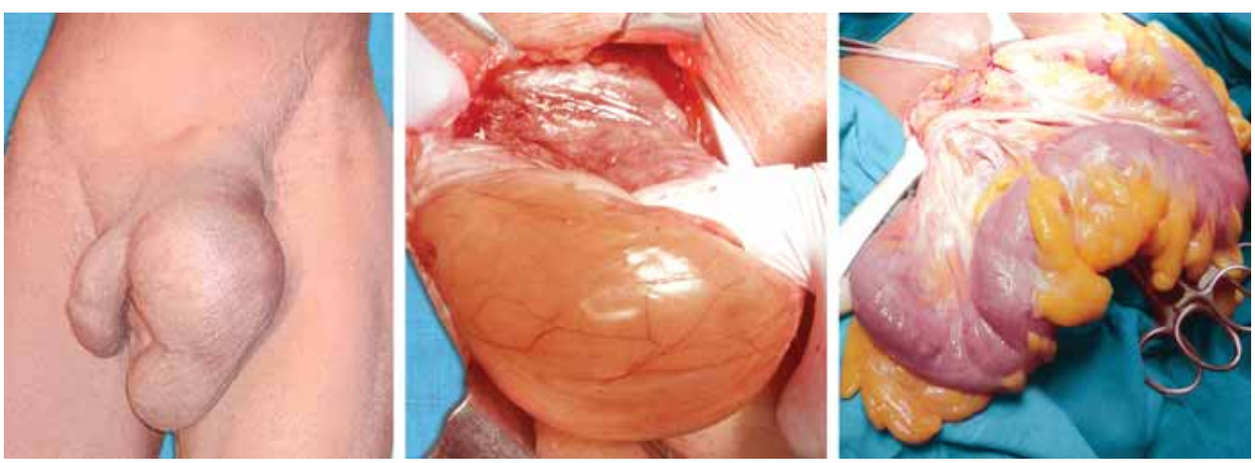


Fig. 30-67(A): Irreducible hernia-typical look.

Inguinal canal is strengthened by *modified Bassini's repair* using interrupted monofilament polypropylene sutures. Prosthetic mesh is not used as field is contaminated. In later period if hernia recurs then prosthetic mesh is used for repair. Biological mesh can be used during the surgery for strangulated hernia **(Fig. 30-74)**.

Problems in strangulated hernia are: sepsis, leak and fistula formation, ileus, wound infection, peritonitis, intraabdominal abscess formation like pelvic or subphrenic, electrolyte imbalance, respiratory complications like pneumonia and ARDS, DIC.

INGUINAL HERNIA IN FEMALES

Commonest groin hernia in females is inguinal hernia. Often it may contain Fallopian tube or ovary. Round ligament is attached to labia. Sac is in close relation with round ligament. Sac is adherent and is often difficult to dissect. It is invariably indirect sac. Direct hernia is rare in females. Surgery is the treatment. Laparoscopic or open approach can be used. Round ligament is excised and inguinal canal is entirely closed. Mesh is placed in preperitoneal plane. That also prevents femoral hernia to develop. Incision and technique are same. Bilateral inguinal hernia can be treated surgically in same sitting **(Fig. 30-75)**.

VENTRAL HERNIA

Any protrusion through abdominal wall with the exception of hernia through the inguinofemoral region is defined as *ventral hernia*. Incisional hernia (80%) and primary defects in abdominal fascia which can cause umbilical hernia, epigastric hernia, paraumbilical hernia or Spigelian hernia are grouped under ventral hernia. *Ventral hernia can be*—reducible, irreducible, obstructed, strangulated, single, multiple small defects (*Swiss cheese hernia*) **(Figs 30-76 to 30-83)**.

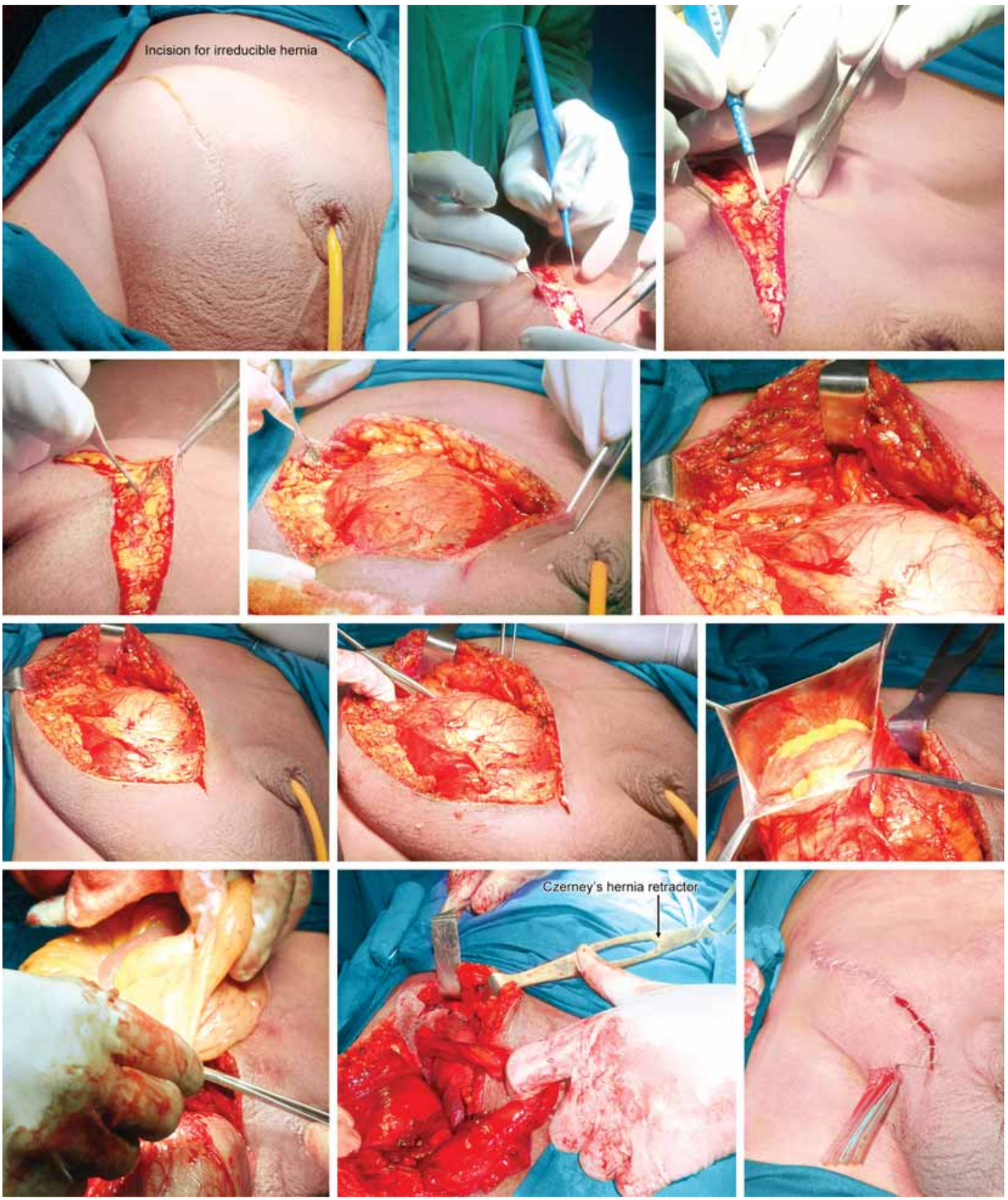


Fig. 30-68: Irreducible enterocele.

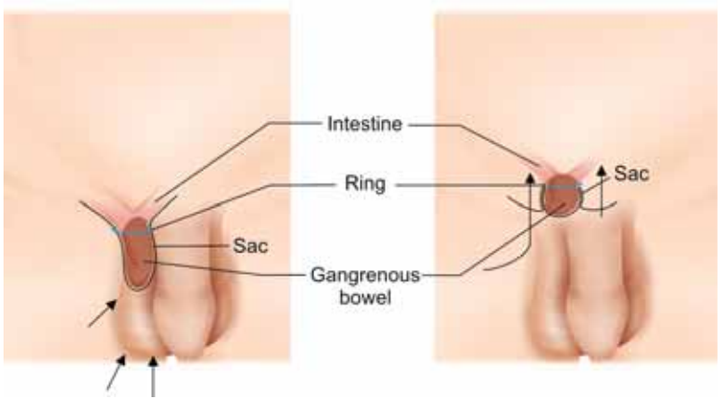


Fig. 30-69: Forced reduction of inguinal hernia will get reduced with the sac with persistent obstruction and strangulation within the peritoneal cavity.

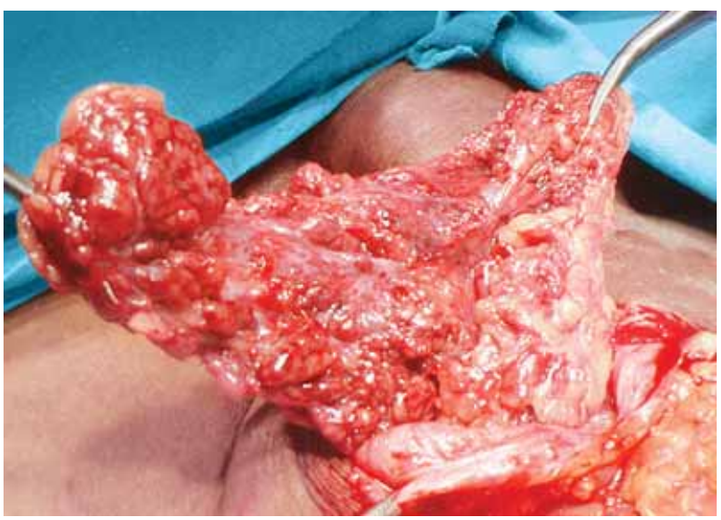


Fig. 30-70: Gangrenous omentum.

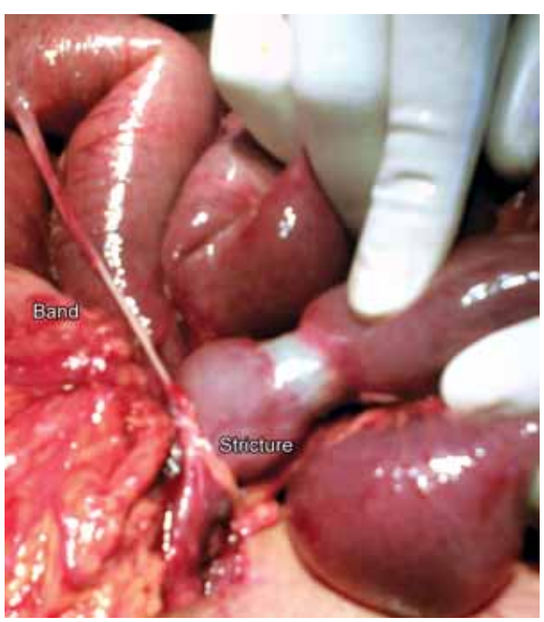


Fig. 30-71: Garry's stricture occurs in long standing obstructed hernia. Stricture develops where bowel developed obstruction at the ring.

Factors responsible for development of incisional hernia

- Vertical incision has got higher chances of incisional hernia than horizontal incision
- Layered closure of the abdomen has got higher chance than single layer
- Continuous closure has got higher chances than interrupted closure
- Using absorbable suture material has got higher chances of hernia than nonabsorbable sutures
- Emergency surgical wound has higher chances than elective surgical wound
- Laparotomy for peritonitis, acute abdomen, and trauma can commonly cause incisional hernia
- Drainage through the main laparotomy wound may precipitate formation of incisional hernia
- Chronic cough, smoking, obstructive uropathy, constipation can precipitate incisional hernia
- Diabetes, old age, malnutrition, malignancy, anaemia, hypoproteinaemia, jaundice, ascites, liver disease, uraemia, steroid therapy, immunosuppressive diseases are other precipitating factors

Type of defects in incisional hernia

- Small defect
- Large and wide defect
- Very large defect
- Massive/diffuse
- Multiple defects

Incisional hernia may be vertical midline above or below the umbilicus; vertical midline including umbilicus; vertical paramedian; transverse above or below the umbilicus; transverse which crosses the midline; oblique above or below the umbilicus or combined.

It may be less than 5 cm defect; between 5-10 cm; more than 10 cm.

Note: Size of the defect is important to decide the type of surgical closure in incisional hernia.

Pre-operative Preparations for Incisional Hernia Surgery

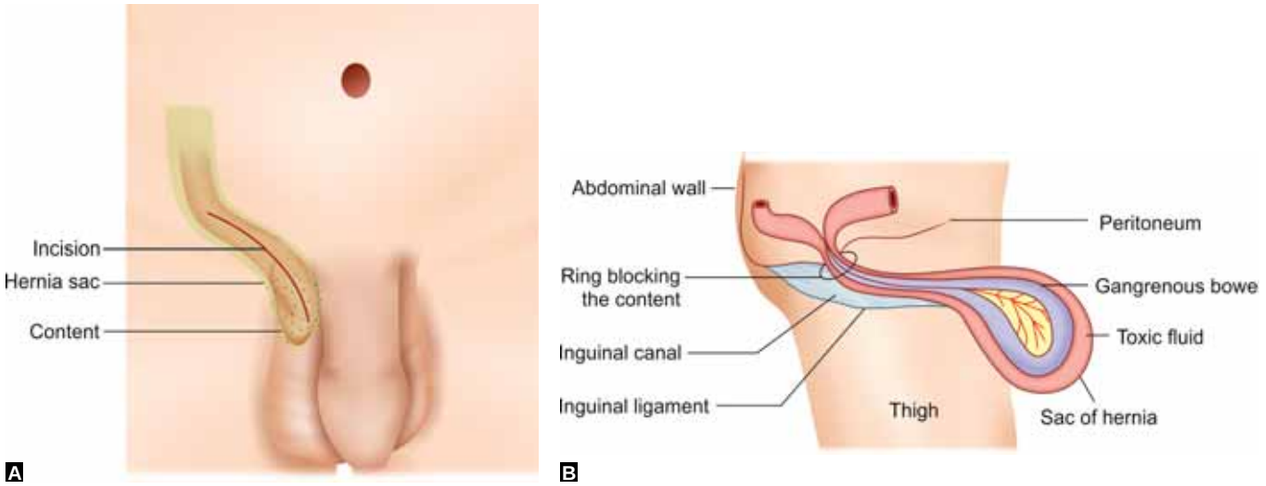
- Reduction in weight and control of obesity; nutrition, control of anaemia; treatment for diabetes, hypertension, cardiac diseases, respiratory problems; treating the precipitating causes; chest X-ray, U/S abdomen to be done. Cessation of smoking, respiratory physiotherapy is important.
- Massive incisional hernia after reduction may cause IVC compression, paralytic ileus and diaphragmatic elevation with respiratory embarrassment (*abdominal compartment syndrome*). It is prevented by prior increasing the capacity of peritoneal cavity by creating pneumoperitoneum using CO_2 so as to increase the intraperitoneal pressure by 12-15 cm of H_2O, daily for 3-6 weeks. Later definitive surgery is done.

Treatment Strategy for Incisional Hernia

It can be non prosthetic tissue repair or prosthetic repair. *Non prosthetic repair has become a surgical legacy.* ***Prosthetic repair is the present standard.***

Non Prosthetic Repair

Non prosthetic repair has got only historical value as recurrence rate is very high (as high as 55%).



Figs 30-72A and B: Incision for strangulated inguinal hernia.

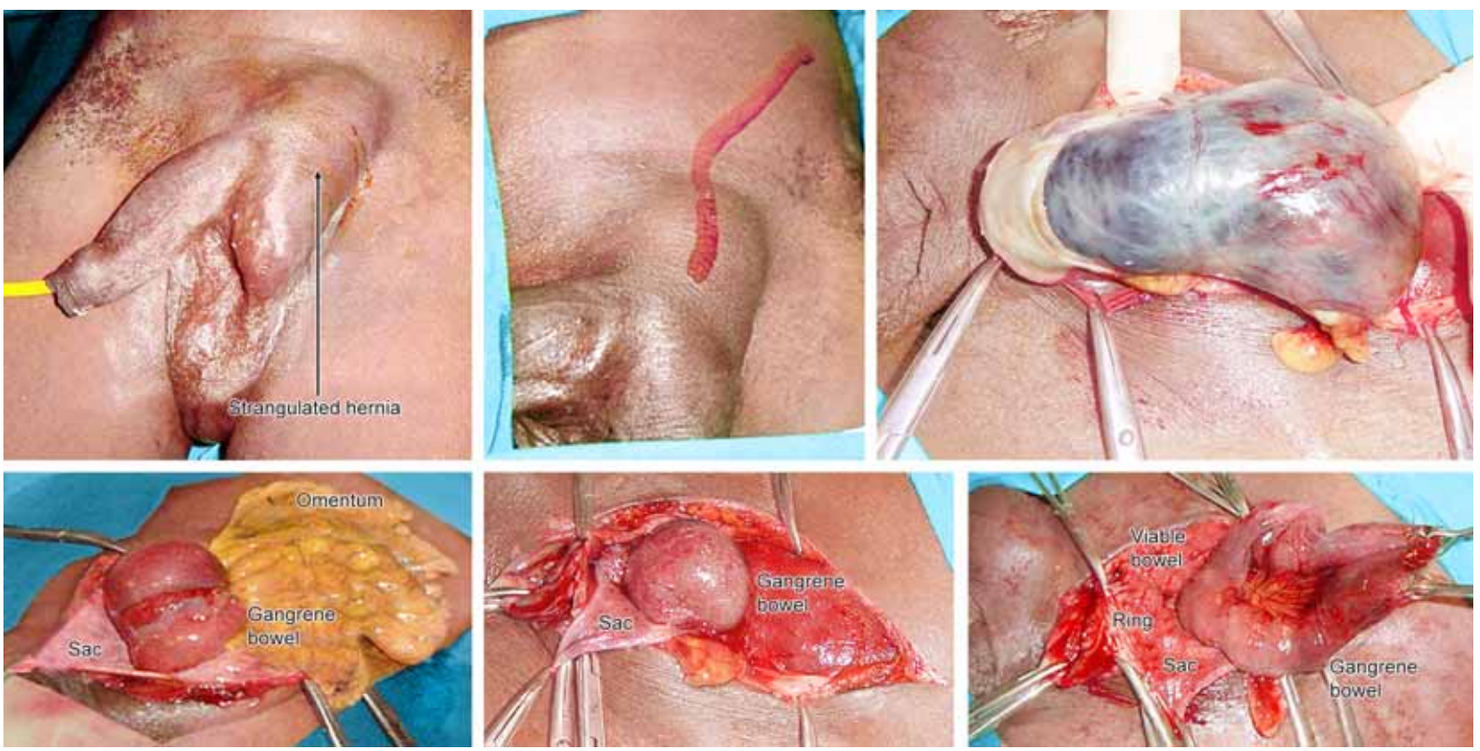


Fig. 30-73: Strangulated hernia—approach. Note the incision placed for strangulated hernia. Only tissue is done Modified Bassini's. Mesh is not used.

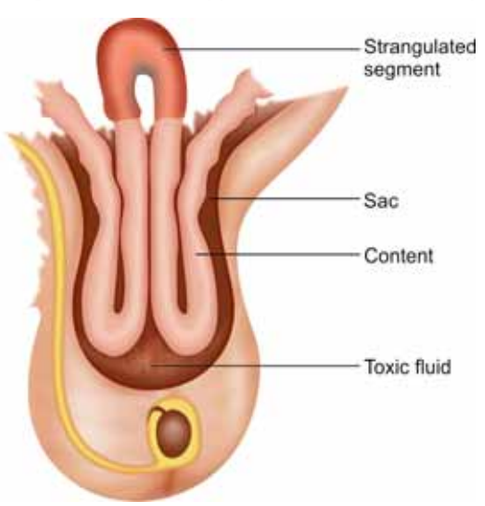
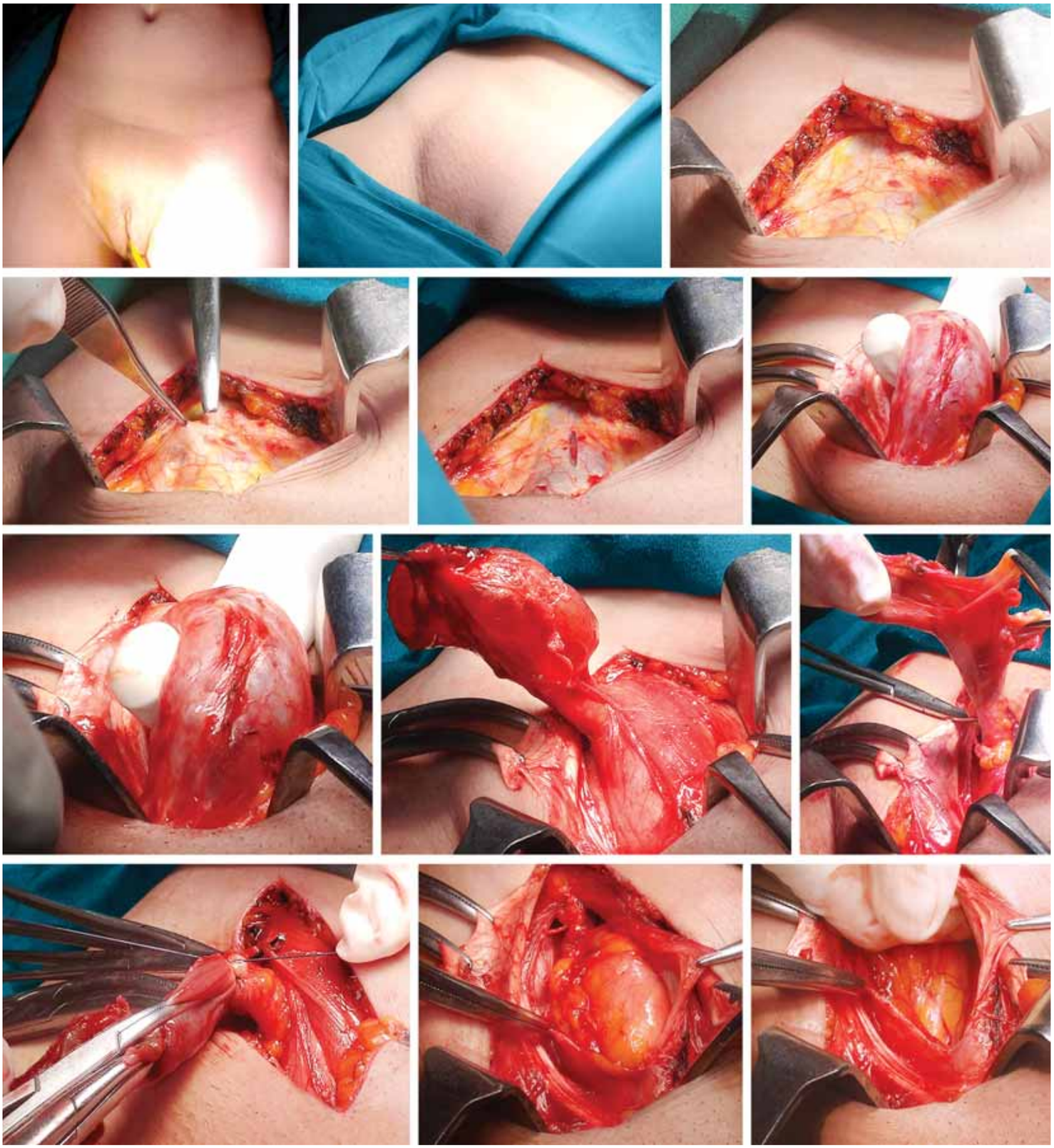


Fig. 30-74: Strangulated hernia with 'W' type bowel content (Maydl's hernia). Inner loop gets strangulated.

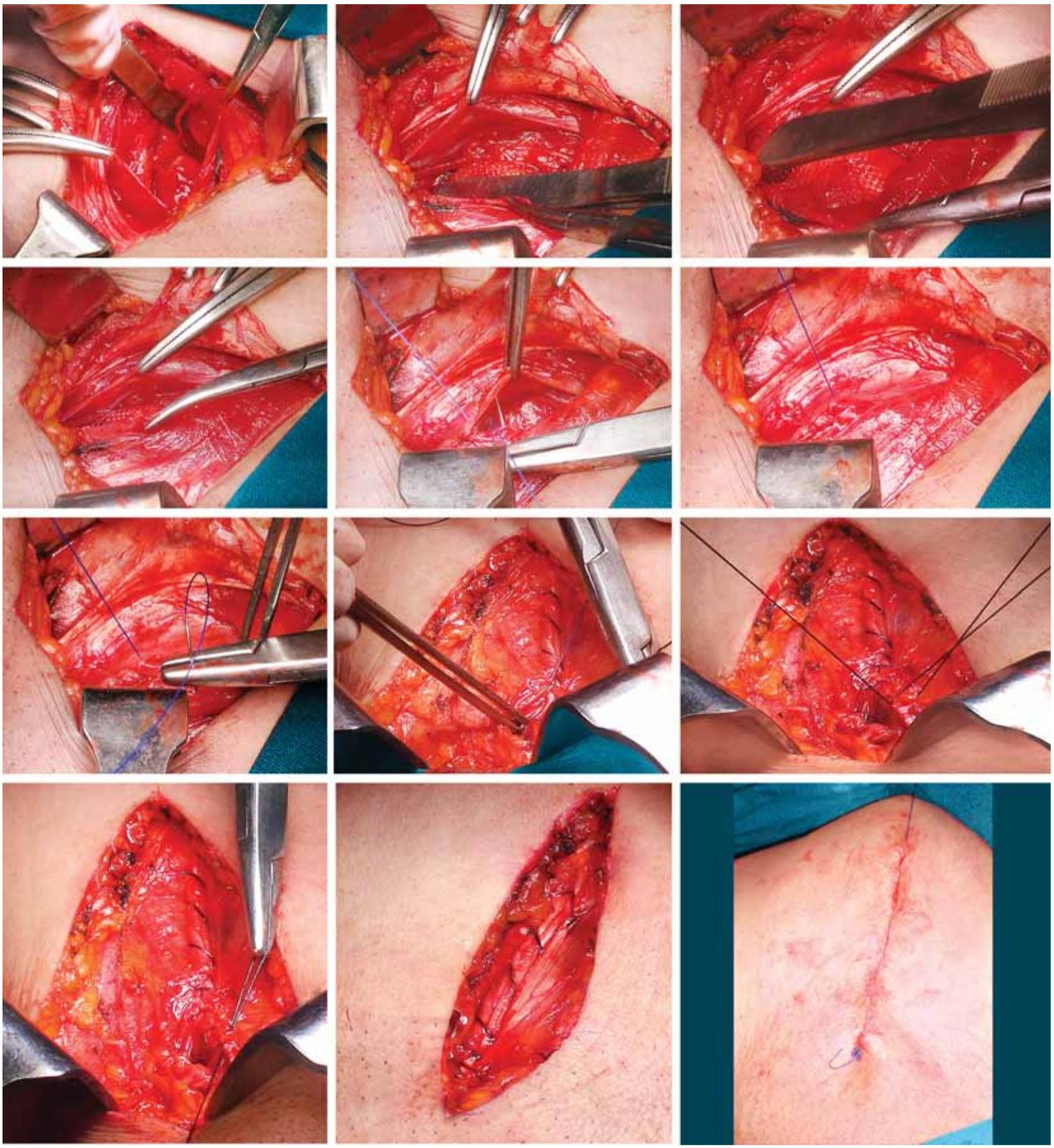
Cattell's operation: When the defect is less than 3 cm, and if the patient is having adequate abdominal muscle tone, *layer-by-layer anatomical repair* is done using monofilament non-absorbable suture material like *polypropylene/polyethylene,* ideally with interrupted sutures. Sac should be dissected, ligated and excised prior to repair. Peritoneum and posterior rectus sheath is apposed as first layer and anterior rectus sheath as second layer.

Double breasting of the rectus sheath using interrupted nonabsorbable sutures using monofilament suture material. It is overlapping the rectus sheath in two layers with two rows of sutures.

Keel operation is done in large defect. Scar is excised and sac is dissected beyond the margin of the defect. Sac is never opened unless there is obstruction of the content. Sac in inverted using continuous/interrupted inverting nonabsorbable sutures, layer by layer until the defect margins are apposed together which is then again sutured with interrupted sutures. (*Keel is inverted beam of the ship running along its bottom*).



Figs 30-75(1)



Figs 30-75(2)

Figs 30-75(1 and 2): Inguinal hernia repair in female.

Fig. 30-76: Large ventral hernias. It needs proper mesh repair. Causes—Congenital defect, obesity, smoking, chronic cough.

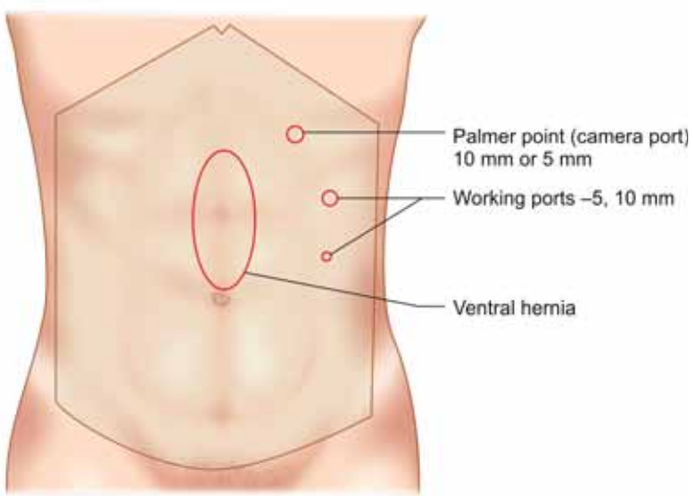


Fig. 30-77: Port placement for laparoscopic ventral hernia repair. Left subcostal point is Palmer point.

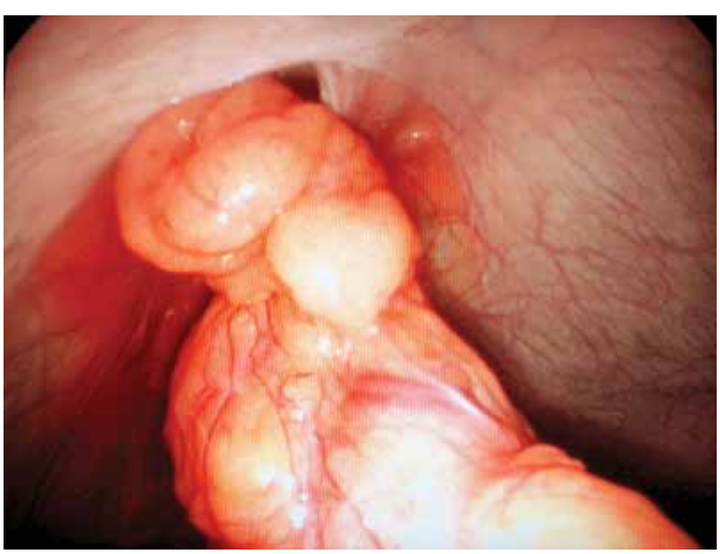


Fig. 30-78: Laparoscopic view of ventral hernia with omentum as irreducible content. Content is released and dual or four layered mesh is fixed with tackers or sutures.

Nuttall's operation is done for lower midline incisional hernia. Recti attachments are detached from the pubic bones and are crossed over to fix to opposite pubic bones so as to create a firm abdominal wall support by crossed recti muscles **(Fig. 30-84)**.

Prosthetic Repair of Incisional Hernia

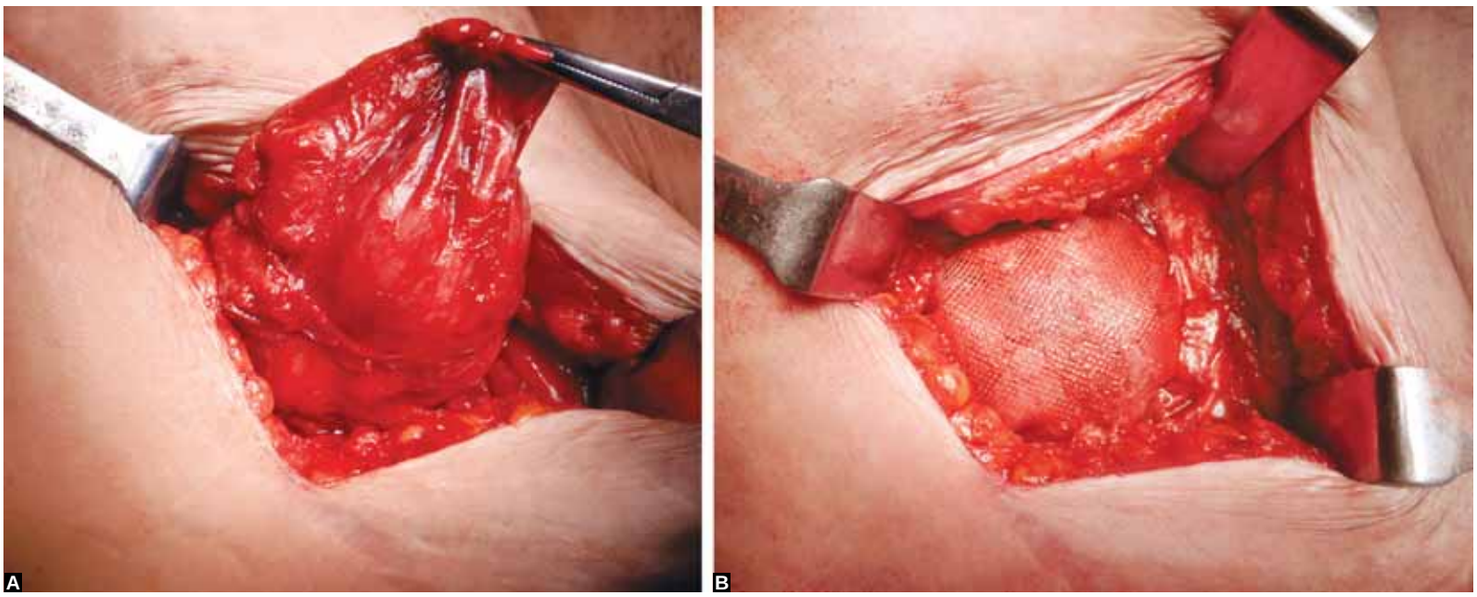
It is the Present Standard

It is now universally accepted that prosthetic repair is gold standard for all incisional hernia. Prosthesis used are polypropylene mesh, e-PTFE, Dacron, dual intraperitoneal mesh, biologic grafts.

Open Mesh Repair of the Incisional Hernia

It is always better and ideal with less chances of recurrence. Adequate sized mesh is placed at different planes onlay/overlay or inlay or retrorectus or preperitoneal. Mesh onlay is placing mesh in front of the defect and muscle layer usually after doing simple repair. It has got high recurrence rate (25%) with wound infection. So it is not practiced commonly. Inlay is bridging the defect using prosthetic mesh by suturing mesh to the surrounding myoaponeurotic defect. Repeated contractions of abdominal wall muscles, mesh shrinkage, separation forces of recti lead into high recurrence rate in this (20%). So again it is not commonly accepted method. *Rive's Stoppa's mesh placement* for incisional hernia is placing mesh between posterior rectus sheath and rectus muscle. It is *sublay retrorectus mesh* placement. Midline or transverse incision is done. If needed panniculectomy incision may also be used. Hernial sac is dissected using fine scissor and cautery. Bowel may be adherent to sac and so care should be taken not to injure the bowel. Usually peritoneal sac is opened; all adhesions are released. Retrorectal plane is entered by incising the posterior rectus sheath; 5 cm area beyond the defect is dissected. Usually it will be within the rectus muscle area; if dissection is needed beyond that then it is done through intermuscular plane between internal oblique and transverse abdominis or through preperitoneal plane up to the plane of psoas major muscle. Dissection is done using blunt, sharp scissor and cautery. Peritoneum, posterior rectus sheath and transversalis fascia are sutured. Polyester or lightweight polypropylene mesh is ideal **(Fig. 30-85)**.

Mesh is fixed using polypropylene interrupted sutures to the abdominal wall muscles in its full thickness. 'U' stitches are placed using Reverdin needle. Sutures are placed on one side of the wound from mesh to abdominal wall; once all sutures are placed on one side of the wound, they are tied. Then mesh is fixed similarly on the other side of the wound. Usually around 10 sutures are needed on one side. Absorbable sutures may be used to reduce the chances of chronic abdominal pain. Sutures keep the mesh in place and prevent bulging of the mesh. Often these sutures are brought out through separate stab incisions in the abdominal wall and knots are tied which are buried in the subcutaneous plane. Deeper blind bites on to the peritoneum should not be taken. Linea alba or anterior rectus sheath should be closed to keep the abdominal contour and function normal and also to prevent infection. Commonly polypropylene mesh is used. Other materials used are polyester, Dacron, polytetrafluroethylene (PTFE) mesh, polyglycolic acid mesh (vicryl mesh) or combined polypropylene and polyglycolic acid mesh (vypro mesh). Suction drain should be placed in front of the mesh and in subcutaneous plane as



Figs 30-79A and B: On table look of ventral hernia sac and its mesh repair (in retrorectus plane).

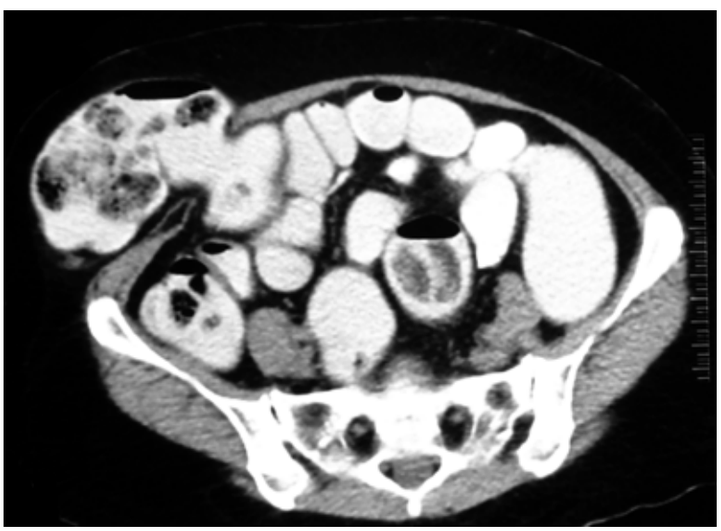


Fig. 30-80: CT scan finding of the ventral hernia.

Fig. 30-81: Incisional hernia through right subcostal incision scar.

Fig. 30-82: Incisional hernia—large.

well. Subcutaneous tissue and skin are closed with interrupted sutures. When subcutaneous drain is placed, suturing of subcutaneous fat is not done as strangulation/necrosis of fat can occur by suturing. Mesh repair is ideal approach for incisional hernia. Prevention of infection/haemostasis and drainage are important. Recurrence rate in this type is less than 5% **(Fig. 30-86)**.

Open Intraperitoneal Mesh Repair for Incisional Hernia

It is done whenever peritoneum is not enough to close. Dissection is done similarly. ePTFE mesh is used to place the mesh directly outer to viscera intraperitoneally. Mesh is first fixed to abdominal wall at 12 and 6 O'clock positions to prevent displacement. Continuous mesh fixation suture is placed from 12 o'clock position to 6 o'clock position; later from 6 o'clock to 12 o'clock position. Rectus sheath is sutured in front after placing a suction drain.

Fig. 30-83: Incisional hernia while coughing; while relaxing it is getting reduced showing thin lax skin.

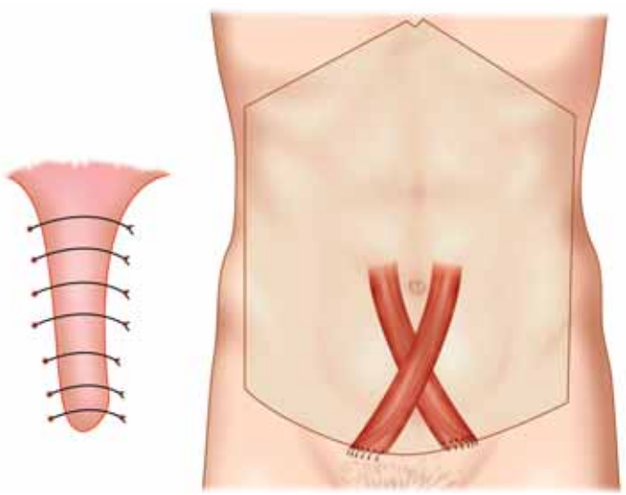


Fig. 30-84: (A) Keel and (B) Nuttall's operation for incisional hernia. It is not used nowadays.

Component Separation Technique with Mesh Placement (Autologenous Repair by Vascularised Innervated Muscle Flaps) (Ramirez, 1990)

It is release of the external oblique aponeurosis and separation of the lateral abdominal wall muscles to achieve advancement of the abdominal wall to cause medialisation of the rectus muscle up to 10 cm to achieve reformation of dynamic abdominal wall with midline linea alba closure. Originally it was designed as a nonprosthetic repair but eventually it became popular with additional mesh placement in retrorectus or intraperitoneal area. Vertical incision is made along the hernial sac usually in midline. Sac is identified, dissected, opened and ligated. Flap in front of anterior rectus sheath is raised to identify the external oblique aponeurosis 2-5 cm lateral to the lateral margin of the rectus sheath. Longitudinal incision is made in the external oblique aponeurosis below and beyond the hernial defect usually up to the inguinal ligament; above up to 5 cm above the costal margin. External oblique muscle is then dissected off from the internal oblique in an avascular plane between these two muscles up to posterior axillary line to medialise the rectus muscle along its full length. Additional 4 cm of medialisation can be achieved if needed by incising the posterior rectus sheath longitudinally on its medial aspect. Large prosthetic mesh is now placed after creating plane in retrorectus area or intraperitoneal dual mesh can also be placed. Biologic graft can be used in infected contaminated area. Drain is placed over the mesh. Linea alba is closed. Multiple drains are placed in subcutaneous plane. By this separation technique rectus is advanced for 5 cm in upper abdomen; 7-10 cm in middle and 3 cm in lower abdomen.

It is often of practice that skin fat is first dissected off the anterior rectus sheath for 5 cm beyond the rectus; incision is made in posterior rectus sheath and muscle is separated from the posterior rectus sheath; lastly aponeurosis is incised to separate external oblique from internal oblique to achieve adequate medialisation to close the defect and linea alba.

Separation of component can also be achieved *endoscopically*. 10 mm incision is made adjacent to the tip of 11th rib. External oblique aponeurosis is identified and incised along the line of incision 1 cm to reach an avascular plane between external oblique aponeurosis and internal oblique muscle. Inguinal hernia balloon dissector is placed, directed towards pubic tubercle and is inflated to create adequate space to place a 10 mm port to achieve up to 12 mm Hg pressure with CO_2 insufflation. One 5 mm port is placed in posterior axillary line through which aponeurosis is cut caudally using scissor or cautery. Another 5 mm port is placed medially through which cranial part of the aponeurosis is cut. *Complications of component separation technique are*—seroma/haematoma formation; lateral bulging of the muscle if internal oblique muscle is cut; mesh related complications; paralytic ileus; wound infection; abdominal wall nerve injury and its consequences. Recurrence rate is less than 5%.

Laparoscopic Mesh Repair for Incisional/ Ventral Hernia (1992—LeBlanch and Booth)

It is placing a mesh under the defect laparoscopically in intraperitoneal plane. The only problem of this underlay placement is chances of adhesion and GI fistula formation but it is found to be safer. Laparoscopic preperitoneal mesh placement is also done for smaller defects. Now dual mesh (PTFE) or four layered mesh are available. Presently only these meshes are recommended for use. Here mesh is placed under the peritoneum deep to the defect after reducing the contents. Mesh is fixed with sutures and tacks. In four layer mesh, deepest 1st layer is absorbable cellulose which allows new peritoneum to creep underneath. 2nd layer is PDS/PTFE mesh 3rd layer is polypropylene mesh last 4th layer is again PDS/PTFE mesh. It is ideal but costly.

Exact defect is marked using skin marking pen after cleaning and draping under general anaesthesia. Catheterization is always better done especially in lower abdominal hernias. After creating pneumoperitoneum ports are placed. Table can be tilted accordingly depending on location of the hernial site. Procedure is done in supine position. Surgeon and cameraman are standing on left side of the patient. Monitor is placed on right side towards leg end. Left Palmar point below the left subcostal margin is used for 10 mm port for 10 mm end or side viewing telescope. 5 mm port with 5 mm telescope can be used if available. Usually open method is used. Hasson cannula is better in this situation. Visiport usage makes creation of this first port site better. Further two 5 mm ports are placed also in the left side along the anterior axillary line. If needed additional port may be used on the opposite side. Hernial contents are reduced with careful dissection.

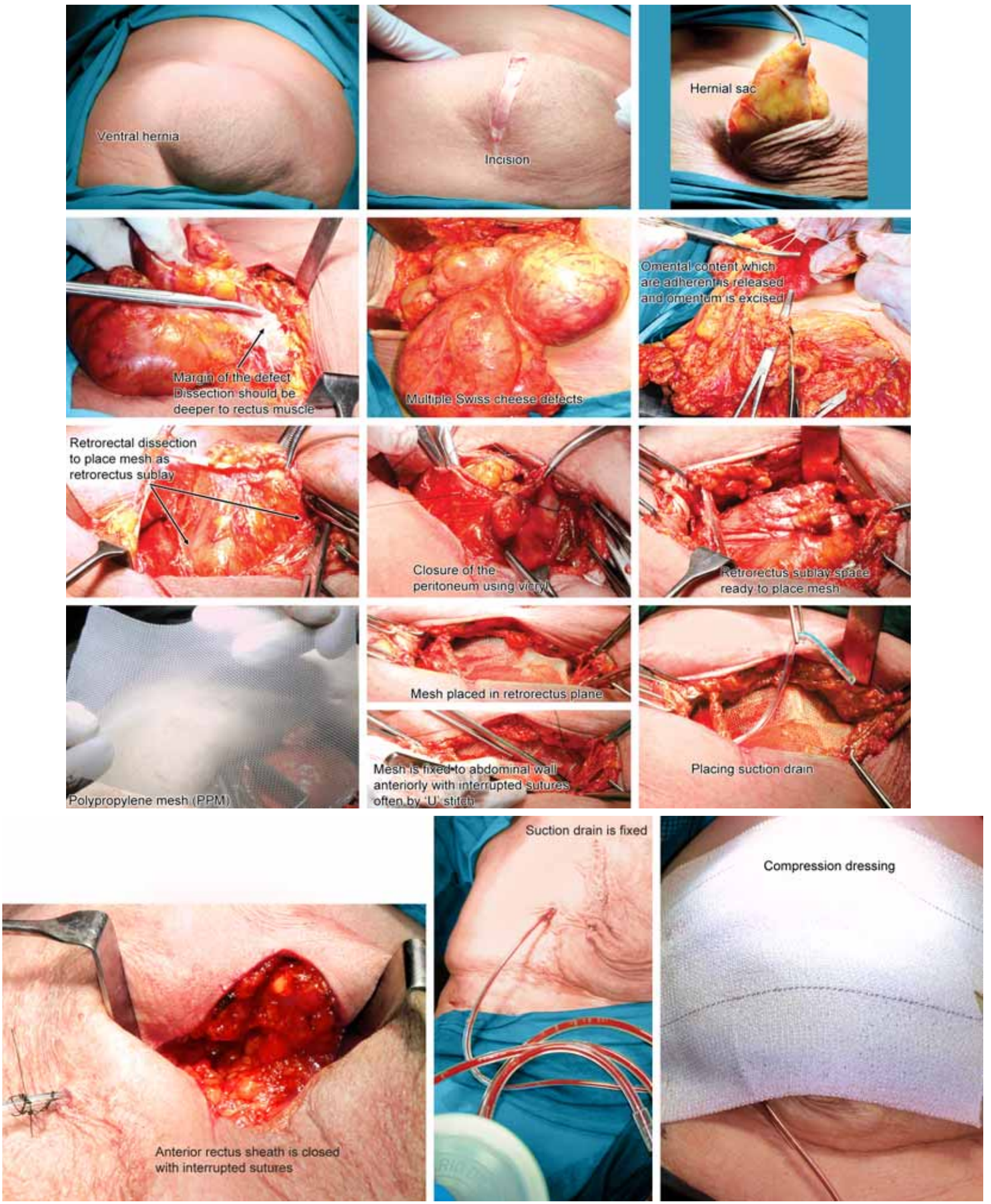
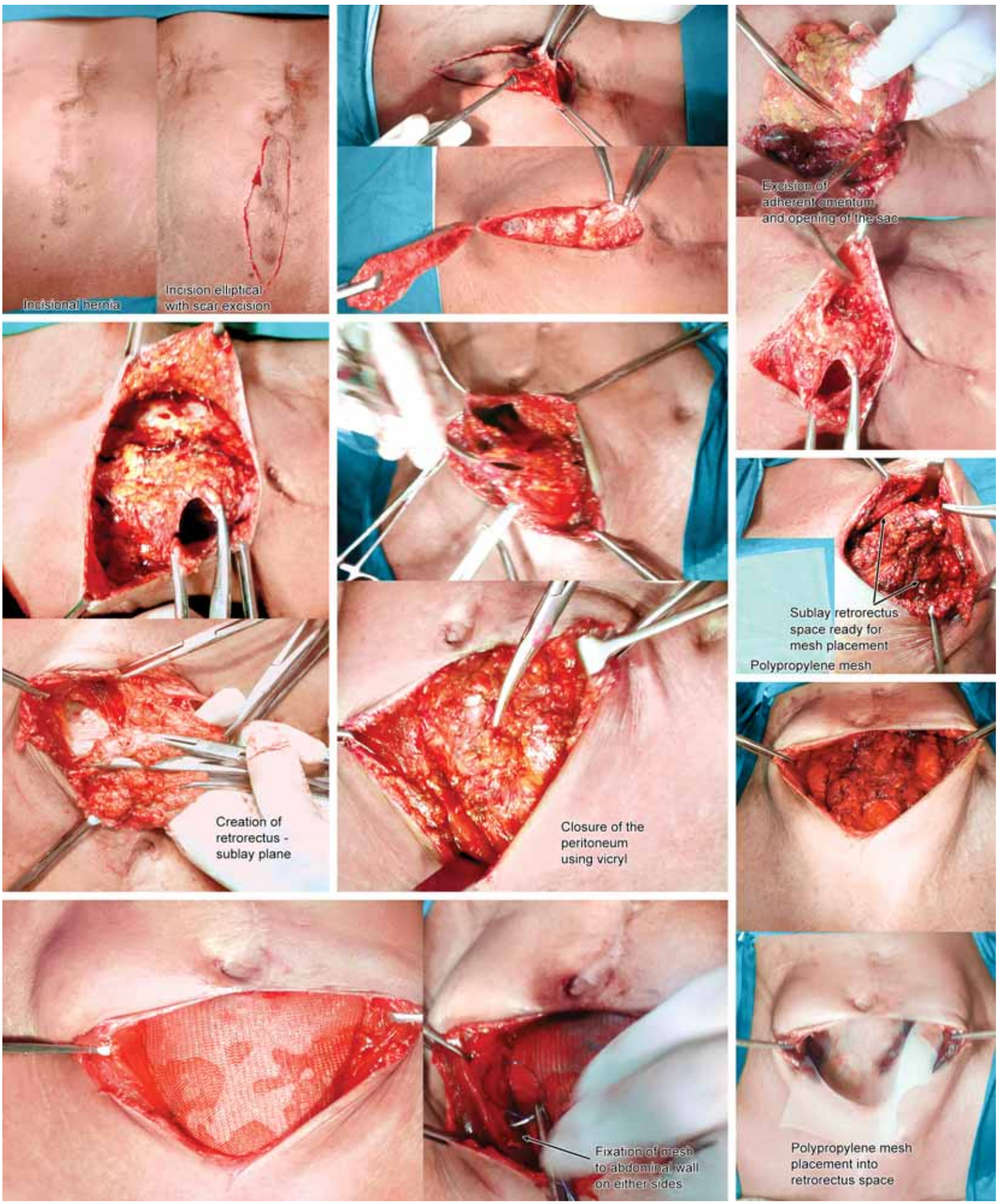
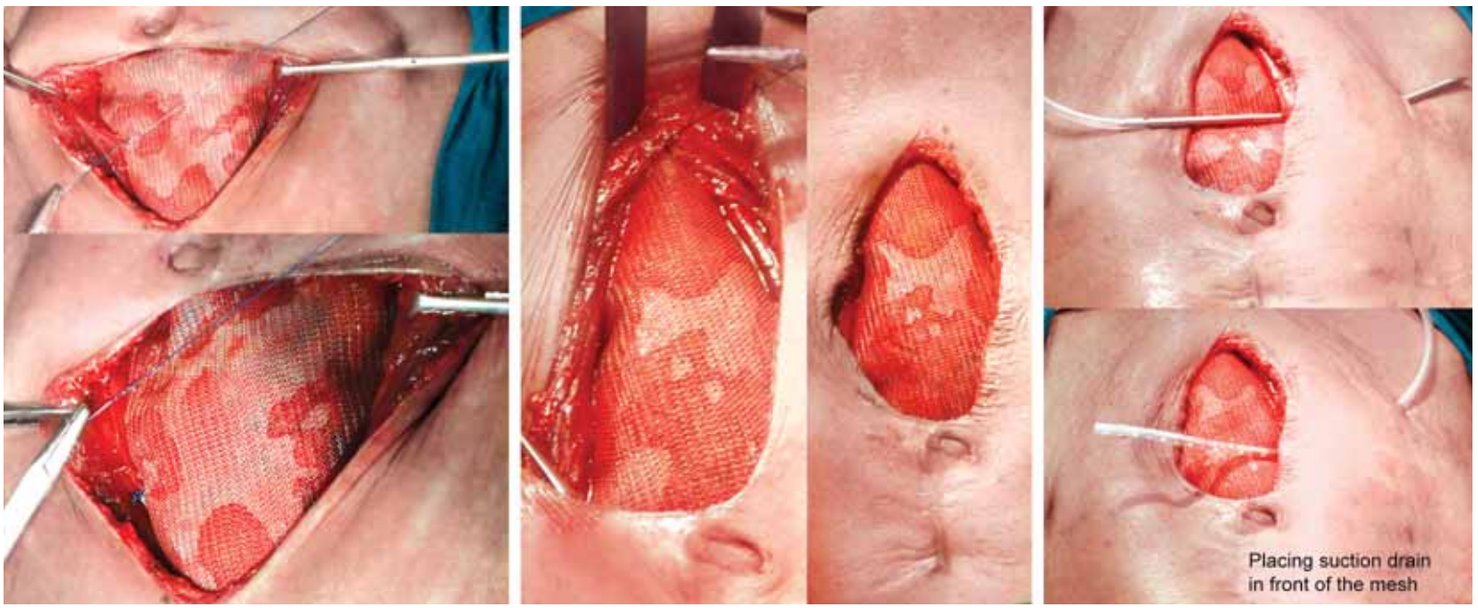


Fig. 30-85: Technique of open ventral hernia repair by placing mesh in retrorectus plane.


Incisional hernia
Incision elliptical with scar excision
Excision of adherent omentum and opening of the sac
Creation of retrorectus - sublay plane
Closure of the peritoneum using vicryl
Sublay retrorectus space ready for mesh placement
Polypropylene mesh
Fixation of mesh to abdominal wall on either sides
Polypropylene mesh placement into retrorectus space

Figs 30-86(1)



Figs 30-86(2)

Figs 30-86(1 and 2): Incisional hernia repair and retrorectus mesh placement. This is the standard technique in open repair. Suction drain should be placed always.

Dissection is done either with bipolar cautery or ideally sharp scissor. Adhesiolysis is done by keeping scissor close to abdominal wall to reduce the chances of bowel perforation. Entire abdominal contents are inspected. Hernial defect is assessed by placing a flexible ruler intraabdominally through a port under standard insufflation pressure of 12 mm Hg. Dual or four layer mesh with nonadhesive surface facing towards abdominal contents is placed. It is folded carefully and passed inside through 10 mm port. All four corners are sutured using transfascial fixation sutures. It is fixed properly using tackers (helical tacks) or sutures. It is better to place sutures using specialized needle or by intracorporeal suturing and knotting technique. Helical tacks are placed all round at every 5 mm gap. Patient is discharged in 24 hours with abdominal binder for 6 weeks advicing not to lift weight for 6 weeks. *Advantages of laparoscopic ventral hernia repair* are—proper visualization of entire abdomen; avoidance of unnecessary dissection; identification of multiple/Swiss cheese defects; less recurrence rate; short hospital stay; less morbid surgery; faster recovery; better in obese patients. *Disadvantages, problems and complications* are—seroma formation (20%), cautery or dissection injury to bowel (5%), costly mesh, need for general anaesthesia, mesh folding, displacement, bowel interposition between mesh and peritoneum if mesh is not properly placed, mesh infection, wound infection, recurrence, port site bleeding, port site hernia, inadvertent fall of tackers into the peritoneal cavity and its possible complications like erosion into major vessels and vital structures, paralytic ileus, retention of urine postoperatively after removal of the catheter, abdominal wall neuralgia due to injury to abdominal wall nerves by sutures or tackers, conversion into open method. Complications are classified as intraoperative, early, late.

Different types of Mesh Repair for Incisional Hernia

- *Rive's Stoppa's method* of placing mesh between posterior rectus sheath and rectus muscle widely—retrorectus approach is better.
- *Under the peritoneum, directly over the content (intraperitoneal):* Now it is accepted but there are chances of adhesions/fistula formation. It is used in laparoscopic repair. Dual mesh/four layered mesh is used.
- *Overlay* mesh placed outer to musculoaponeurotic layer *is not ideal* due to high recurrence rate.
- *Combined inlay and overlay* with two layers of mesh—practiced in few centers.
- *Bridging at myoaponeurotic level outer to peritoneum (inlay):* Adequate sized mesh is placed in the defect level bridging the gap to cover preperitoneum. It is better by principle but still shows high recurrence **(Fig. 30-87)**.

Postoperative Care

Postoperative management is crucial in these patients. Prevention of sepsis, DVT, ileus, mobilisation are important. Heparin should be started to prevent DVT. Early ambulation, fluid and electrolyte management, catheterization, care of drain (drain should be kept until drainage becomes minimal), abdominal binder is used to support abdominal wall during recovery period.

Additional Problems in Large Incisional Hernia

- While reducing the bulky contents like bowel and omentum, inadequate intraabdominal capacity leads to increased intra-abdominal pressure causing IVC compression, mesenteric oedema following stasis of splanchnic bed, paralytic ileus, diaphragmatic elevation and respiratory distress (*abdominal compartment syndrome*), urinary and bowel disturbances. Abdominal capacity can be raised by creating regular pneumoperitoneum over the period of 3-6 weeks.
- Lordosis and back pain may be presenting feature.
- Sac and contents may get adherent to the thin skin over the summit of the hernia leading to skin ulceration and occasionally fistula formation.
- Often might need resection of the adherent bowel segment. In such a situation only biologic grafts may be possible. Otherwise primary tissue has to be done which has got high recurrence rate.

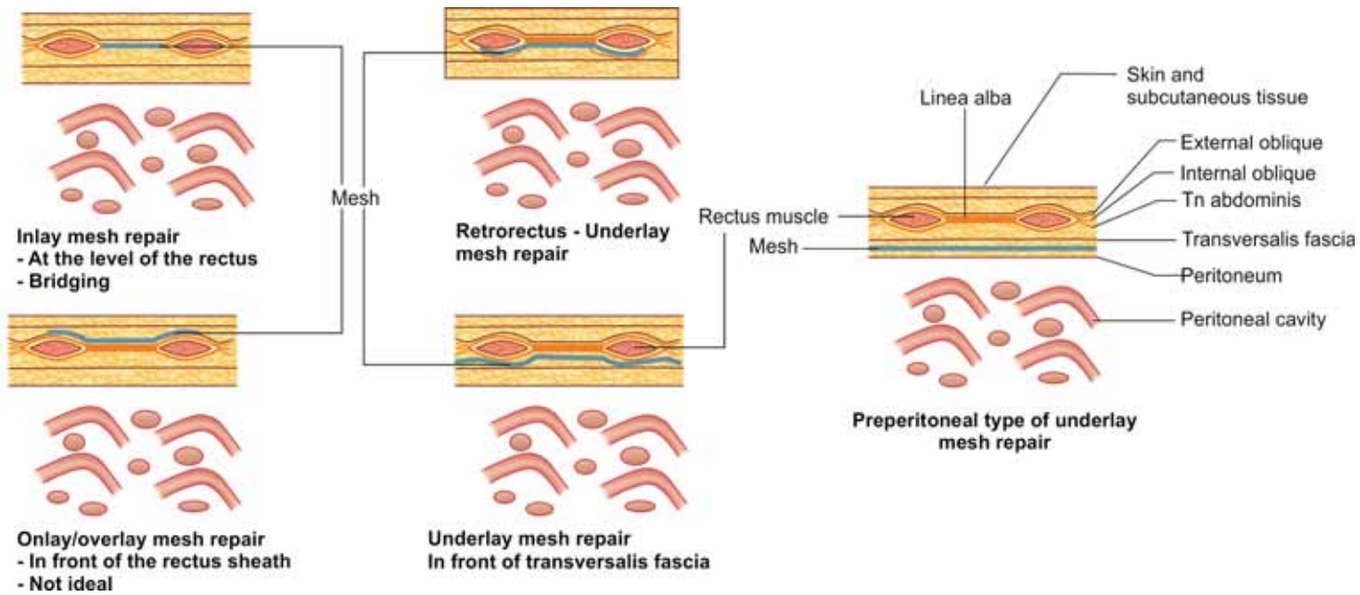


Fig. 30-87: Different levels where mesh can be placed in ventral/incisional hernia—sublay/retrorectus is ideal anatomical plane.

- Large mesh placement is required.
- Additional lipectomy (panniculectomy) may be done in case of pendulous abdomen.

UMBILICAL HERNIA REPAIR

Anatomy of Umbilical Region

Umbilical ring is a complex structure which is related to linea alba, falciform ligament, obliterated urachus (median umbilical ligament) and umbilical fascia (*Richet's fascia)*. It is located at the level of L4 and L5 vertebral disc. It is lower position in infants. It is water shed area for venous and lymphatic drainage—above umbilicus it drains to axillary vein or lymphatics; below to inguinal area. Umbilical skin is supplied by T10 spinal cord. It is the meeting point of four folds of embryonic plate and three systems—GI (vitellointestinal), urinary (urachus), and vascular (umbilical vessels). Umbilical hernia develops due to either absence of umbilical fascia or incomplete closure of umbilical defect. Weakest part in the umbilical cicatrix is upper part where hernia begins **(Figs 30-88A and B)**.

Figs 30-88A and B: Umbilical hernia in a child and in an adult. Both need surgical intervention. In children primary repair or Mayo's repair is done; in adult mesh repair is done placing mesh retrorectus plane.

Primary Closure of the Defect

An infraumbilical incision is made encircling its lower half. Sac is dissected circumferentially and is released off from the umbilicus and subcutaneous tissue. Sac is opened; contents are reduced; excess part is excised up to the umbilical ring. Defect is closed with interrupted nonabsorbable polypropylene sutures. Often layer by layer closure of the layers of the peritoneum is also advocated. Anterior rectus sheath can be sutured either horizontally (ideally) or vertically. Umbilicoplasty is done by creating umbilical dimpling. Center of the umbilical flap is inverted by using finger or instrument; from the summit of the inverted umbilical skin absorbable vicryl – 3 zero suture bite is taken which is sutured firmly to the sutured rectus sheath defect. Skin is closed often with a suction drain underneath **(Fig. 30-89)**.

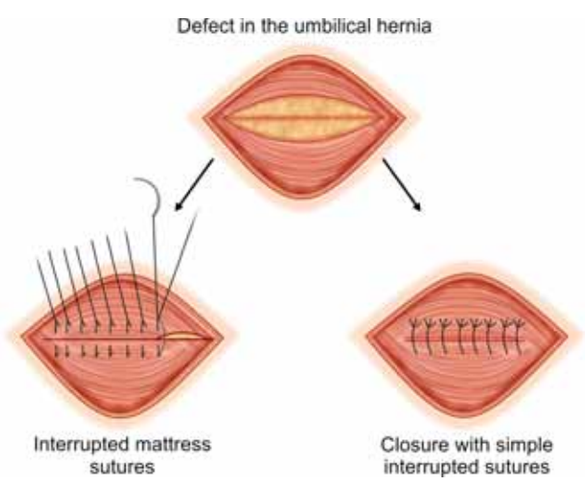


Fig. 30-89: Primary closure of umbilical hernia is done when defect is small. Mayo's repair or mesh repair is better.

Mayo's Operation

Here horizontally opened rectus sheath is approximated as double breasting with upper flap overlapping lower flap in front. Interrupted

nonabsorbable polypropylene 2 zero sutures are used. Suture bite begins from outer surface of upper flap about 2 cm from cut margin; passes deeper to upper flap reaches the outer surface of the lower flap about 1 cm from the cut margin of the lower flap where the horizontal bite of 5-8 mm width is taken; again bite comes out of the outer surface of the lower flap which later pierces upper flap from deeper aspect to outer aspect to complete the suture. Similar sutures are taken at 5 mm distance. All suture ends are held using small haemostats which are tied together after completion of taking all suture bites. Cut margin of the upper flap which is overhanging on to the lower surface of the lower flap is sutured to the lower flap with continuous or interrupted sutures using polypropylene. It is ideal to place a suction drain underneath the main suture line before tying all knots. Skin is closed using interrupted sutures. Pressure dressing is placed. Procedure is also done for paraumbilical hernia. It is '*vest over pant*' autogenous repair **(Fig. 30-90)**.

Sublay Mesh Repair

In a large umbilical hernia with a degenerated skin on its surface it is often difficult to retain the umbilicus. When umbilicus is tried to be saved, infraumbilical incision should extend laterally about 2 cm on each side at 3 and 9 o'clock positions. Sac is dissected similarly. Sac is excised after excision of redundant sac. Presently it is standard to use polypropylene mesh as sublay or in retrorectus position and then rectus sheath is closed. Mesh placement is better to prevent recurrence in large umbilical hernia. Keeping a suction drain is the usual practice. Umbilical dimpling can be created by placing single vicryl/polypropylene interrupted suture under the center of skin flap to sutured rectus defect. Skin is closed ideally with interrupted sutures even though many practice absorbable subcuticular suture **(Fig. 30-91)**.

Umbilectomy

Unhealthy thin skin over the large umbilical hernia is a real problem. It is better to do umbilectomy in these patients (excision of umbilical cicatrix). A horizontal elliptical incision is made to encircle the umbilicus. Undermining of skin should not be done. Incision is deepened up to aponeurosis. Umbilical margin is dissected using cautery or scissor; sac is opened and excised. Often content is adherent to sac. Sac is carefully dissected off the contents. Adherent omentum needs omentectomy. Often defect may require to be widened to replace the content into the peritoneal cavity. It is achieved by incising the defect laterally (horizontally). Falciform ligament attached to umbilicus is ligated and divided to complete the excision of the umbilicus. Sac is closed using vicryl. Preperitoneal space is created deep to rectus muscle. A polypropylene mesh of adequate size is placed in preperitoneal/retrorectus plane. It is sutured at the margin at different places to abdominal wall in front. It should never be sutured to peritoneum posteriorly. Suction drain is placed in front of the mesh. Rectus sheath is closed using interrupted polypropylene sutures. Subcutaneous drain is often helpful. Skin is closed with interrupted sutures **(Fig. 30-92)**.

Open dual PTFE and polypropylene mesh placement: Umbilical hernia is dissected similarly through subumbilical incision. Redundant sac is excised. Peritoneum is not closed. A special composite mesh containing wider PTFE on the inner side with little smaller polypropylene mesh on the outer aspect is used. It has also got two additional straps of the mesh attached to the outer part of the main composite mesh which are used to hold and later to fix into the defect anteriorly. 4.3 cm and 6.4 cm diameter sized meshes are available. Holding straps folded mesh with PTFE part facing the visceral surface is placed intraperitoneally abutting into the peritoneal surface. Care

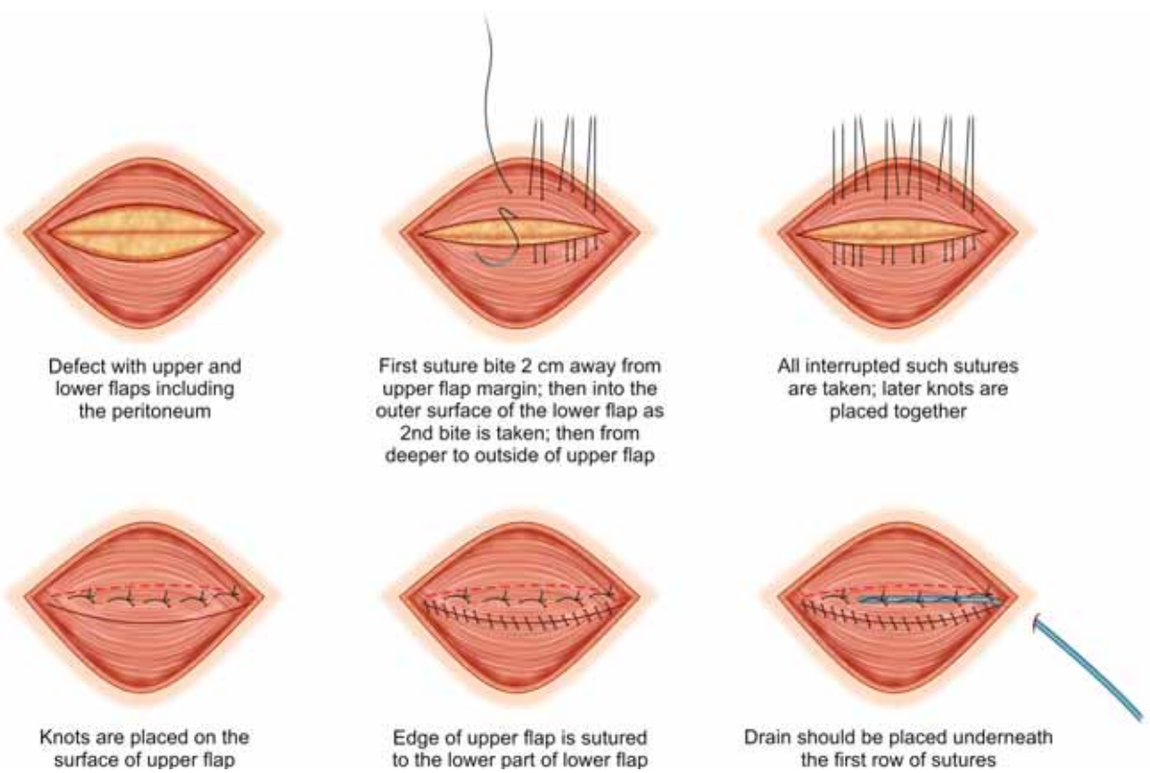
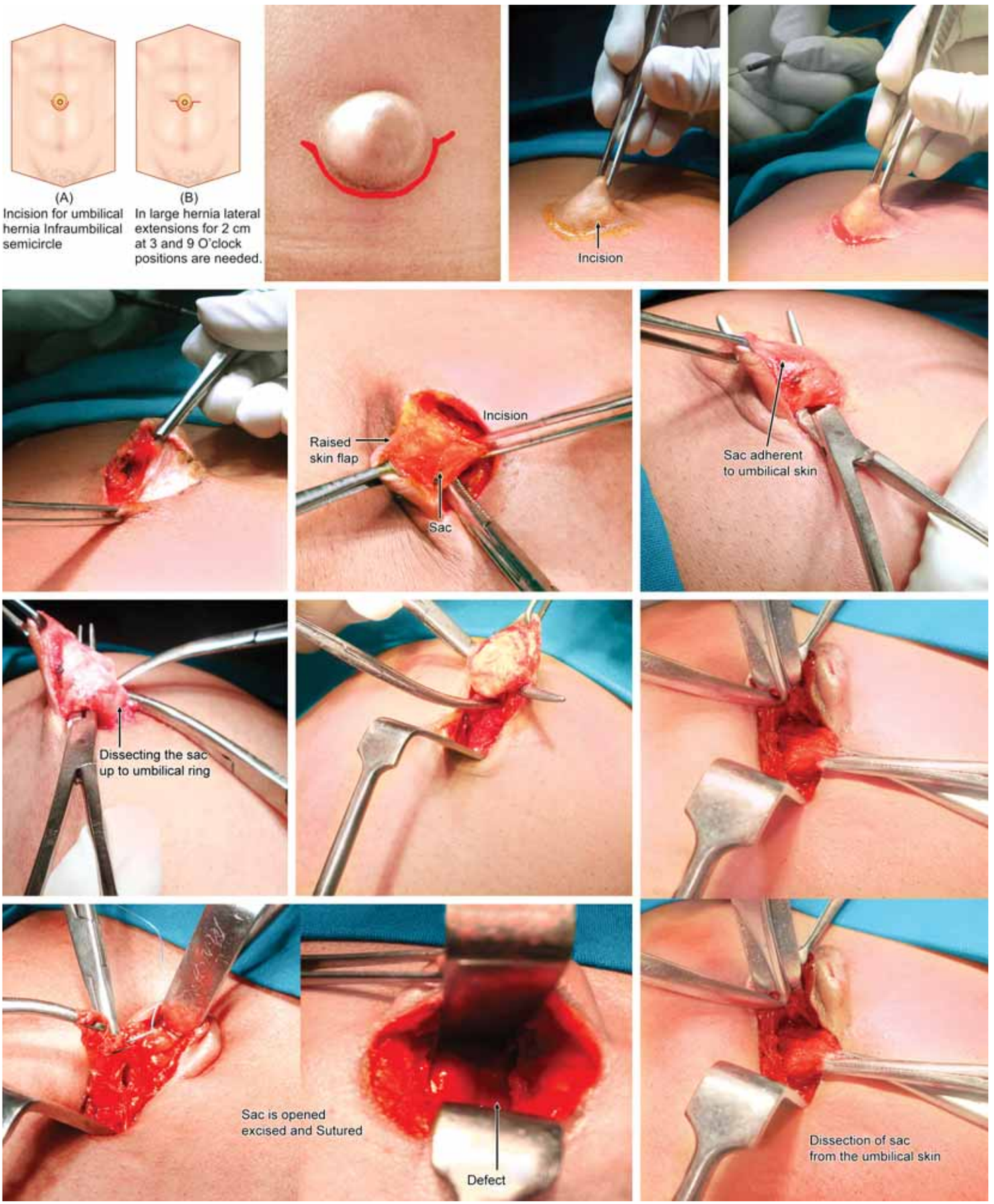
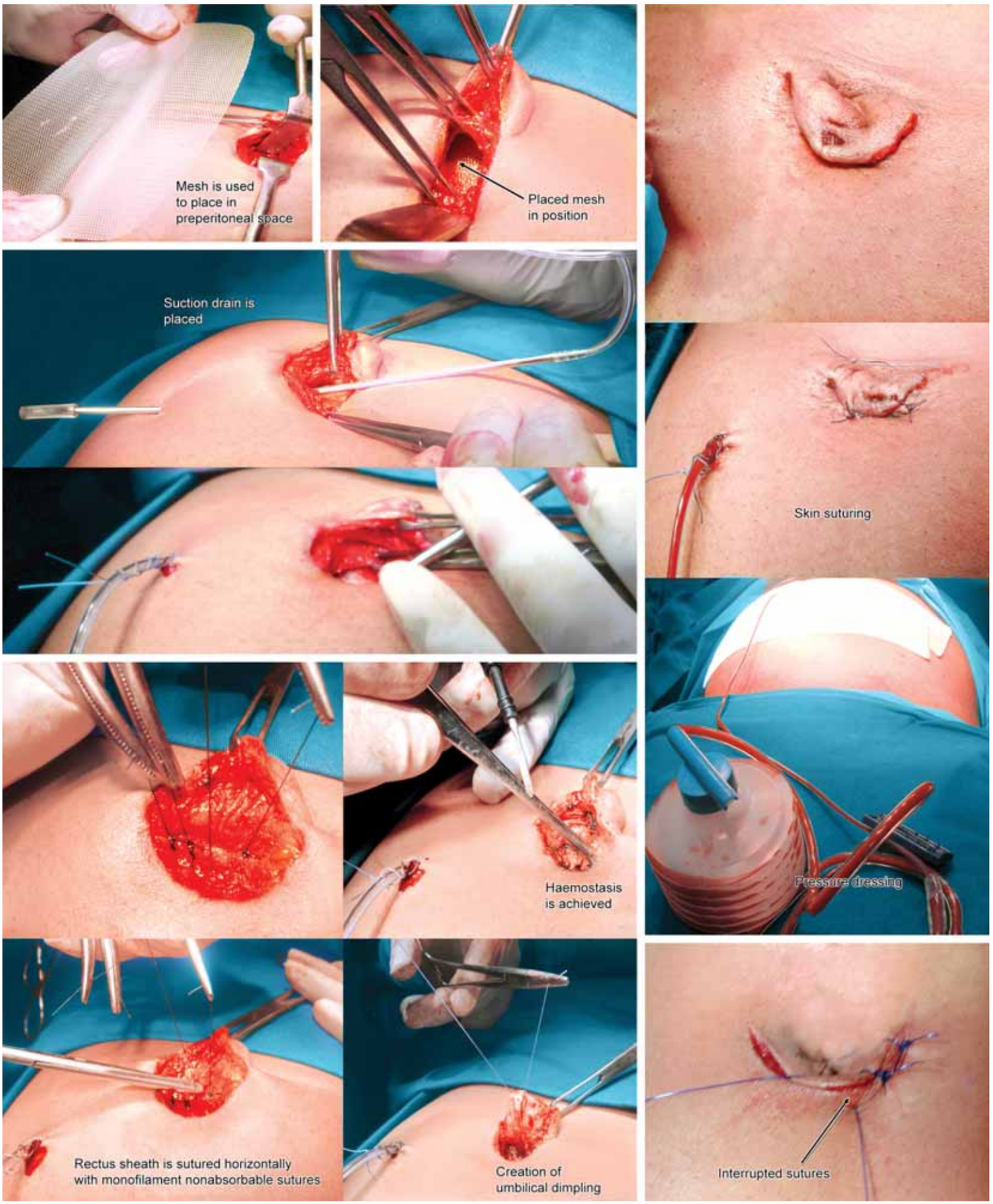

Defect with upper and lower flaps including the peritoneum
First suture bite 2 cm away from upper flap margin; then into the outer surface of the lower flap as 2nd bite is taken; then from deeper to outside of upper flap
All interrupted such sutures are taken; later knots are placed together
Knots are placed on the surface of upper flap
Edge of upper flap is sutured to the lower part of lower flap
Drain should be placed underneath the first row of sutures

Fig. 30-90: Mayo repair (vest over pant) for umbilical hernia—steps.

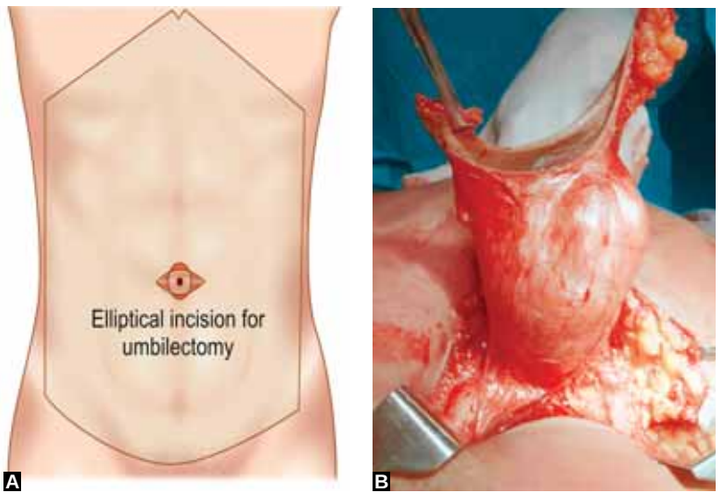

(A)
Incision for umbilical hernia Infraumbilical semicircle
(B)
In large hernia lateral extensions for 2 cm at 3 and 9 O'clock positions are needed.
Incision
Incision
Raised skin flap
Sac
Sac adherent to umbilical skin
Dissecting the sac up to umbilical ring
Sac is opened excised and Sutured
Defect
Dissection of sac from the umbilical skin

Figs 30-91(1)


Mesh is used to place in preperitoneal space
Placed mesh in position
Suction drain is placed
Skin suturing
Haemostasis is achieved
Pressure dressing
Rectus sheath is sutured horizontally with monofilament nonabsorbable sutures
Creation of umbilical dimpling
Interrupted sutures

Figs 30-91(2)

Figs 30-91(1 and 2): Technique of umbilical hernia repair with sublay mesh placement.



Figs 30-92A and B: Umbilectomy is needed for large hernia through elliptical incision.

should be taken to avoid interposition of the bowel between mesh and peritoneal surface. Outer polypropylene part of the mesh is fixed to anterior myoaponeurosis 4 cm away from the margin of the defect using 'U' stitch with knot on the outer surface. First at 3 and 9 o'clock positions sutures are placed; then straps are tugged under the defect in front of the round polypropylene part of the mesh and these straps are fixed using similar 'U' stitches at 6 and 12 o'clock positions. Anterior rectus sheath is approximated horizontally using interrupted sutures. Skin is closed with interrupted sutures after absolute haemostasis. This has got excellent results with low recurrence rate.

Laparoscopic umbilical hernia repair: It is similar like any ventral hernia repair through laparoscopy which is done under general anaesthesia.

Complications

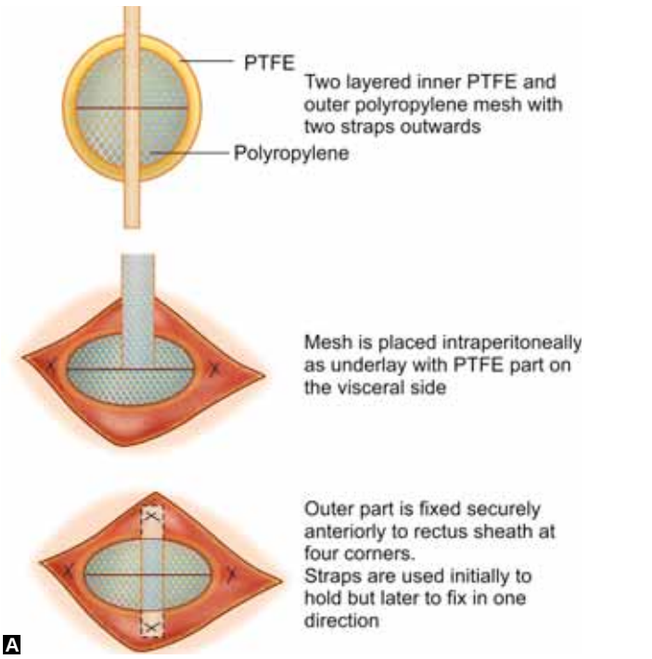
infection, haematoma/seroma formation, ileus, recurrence. Recurrence rate with primary repairs is very high—40% if defect is more than 1 cm. So mesh repair is ideal in adult umbilical hernia repair.

EPIGASTRIC HERNIA (FATTY HERNIA OF LINEA ALBA)

It is common (10%); common in males; 20% of epigastric hernias are multiple—Swiss *cheese like*. It occurs usually through a defect in the decussation of the fibres of linea alba, anywhere between xiphoid process and umbilicus. Extraperitoneal fat protrudes through the defect as fatty hernia of the linea alba presenting like a swelling in the upper midline with an impulse on coughing. *It is sacless hernia*. Later protrusion enlarges and drags a pouch of peritoneum, presenting as a *true epigastric hernia*. If the defect is less than 1.5 cm, lateral margin of the defect is formed by only anterior and posterior lamina of the rectus sheath; if the defect is > 1.5 cm, then lateral margin is also formed by rectus muscle. Content of true epigastric hernia is usually omentum, sometimes it may be small bowel. It is common in muscular men; manual labourers **(Figs 30-94 and 30-95)**.

Treatment

Through a vertical incision, sac is dealt with. Defect is closed with nonabsorbable interrupted sutures. Large defect is supported with


PTFE
Two layered inner PTFE and outer polyropylene mesh with two straps outwards
Polyropylene
Mesh is placed intraperitoneally as underlay with PTFE part on the visceral side
Outer part is fixed securely anteriorly to rectus sheath at four corners.
Straps are used initially to hold but later to fix in one direction
A

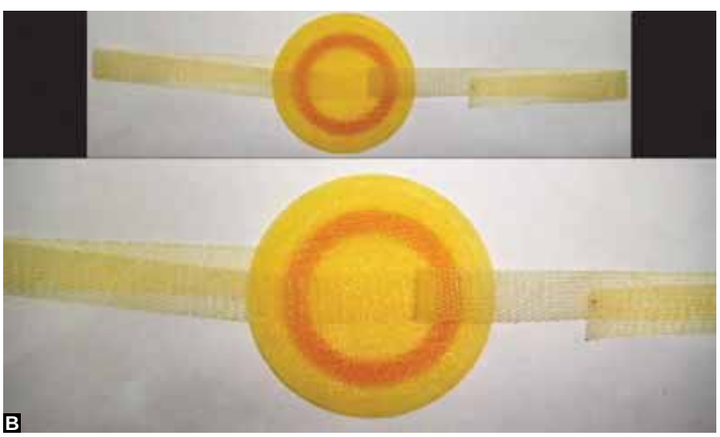


Fig. 30-93A and B: Umbilical hernia repair using open dual PTFE and polypropylene mesh placement.

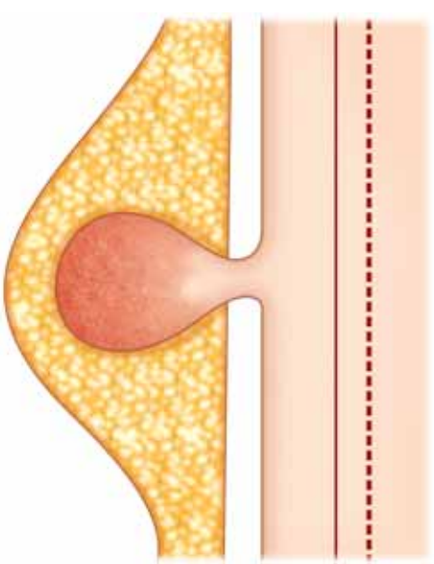


Fig. 30-94: Epigastric hernia.

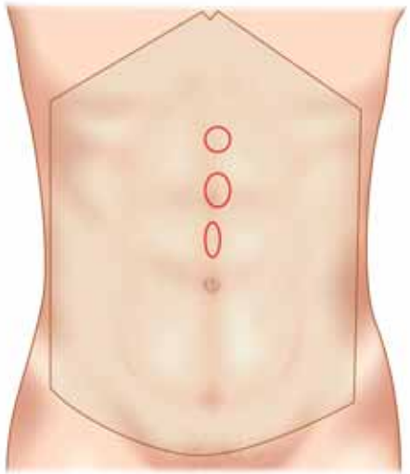
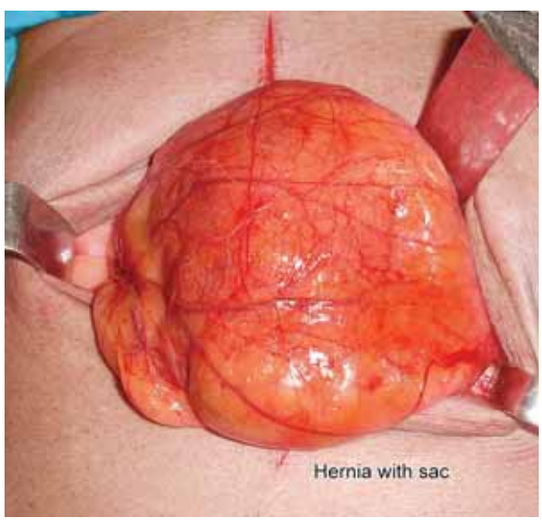


Fig. 30-95: Epigastric hernia with Swiss cheese defects.



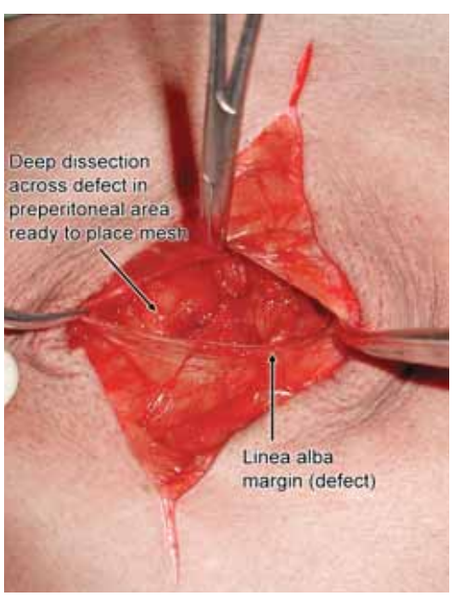


Fig. 30-95A: Epigastric hernia on table look.

preperitoneal mesh—ideal and better. Complete reconstruction of linea alba is needed from xiphisternum to umbilicus especially in *Swiss cheese* type using different methods like—interrupted primary closure using polypropylene sutures; *modified shoelace technique* is used after removing strip of medial margins of the linea alba; double breasting of the linea alba **(Figs 30-96 and 30-97)**.

FEMORAL HERNIA REPAIR

Surgical Anatomy of Femoral Canal Fig. 30-98 and 30-99

It is the medial most compartment of the femoral sheath which extends from femoral ring above to saphenous opening below. It contains fat, lymphatics, lymph node of Cloquet. It is 1.25 cm long and 1.25 cm wide at the base. Below it is closed by cribriform fascia.

Femoral ring is bounded anteriorly by inguinal ligament and iliopubic tract; posteriorly by ilio pectineal ligament of Cooper, pubic bone and pectineal fascia covering the pectineus muscle; medially by concave, sharp lacunar (Gimbernat's) ligament; laterally by a thin septum separating from femoral vein **(Fig. 30-100 and 30-101).**

Pathology in Femoral Hernia

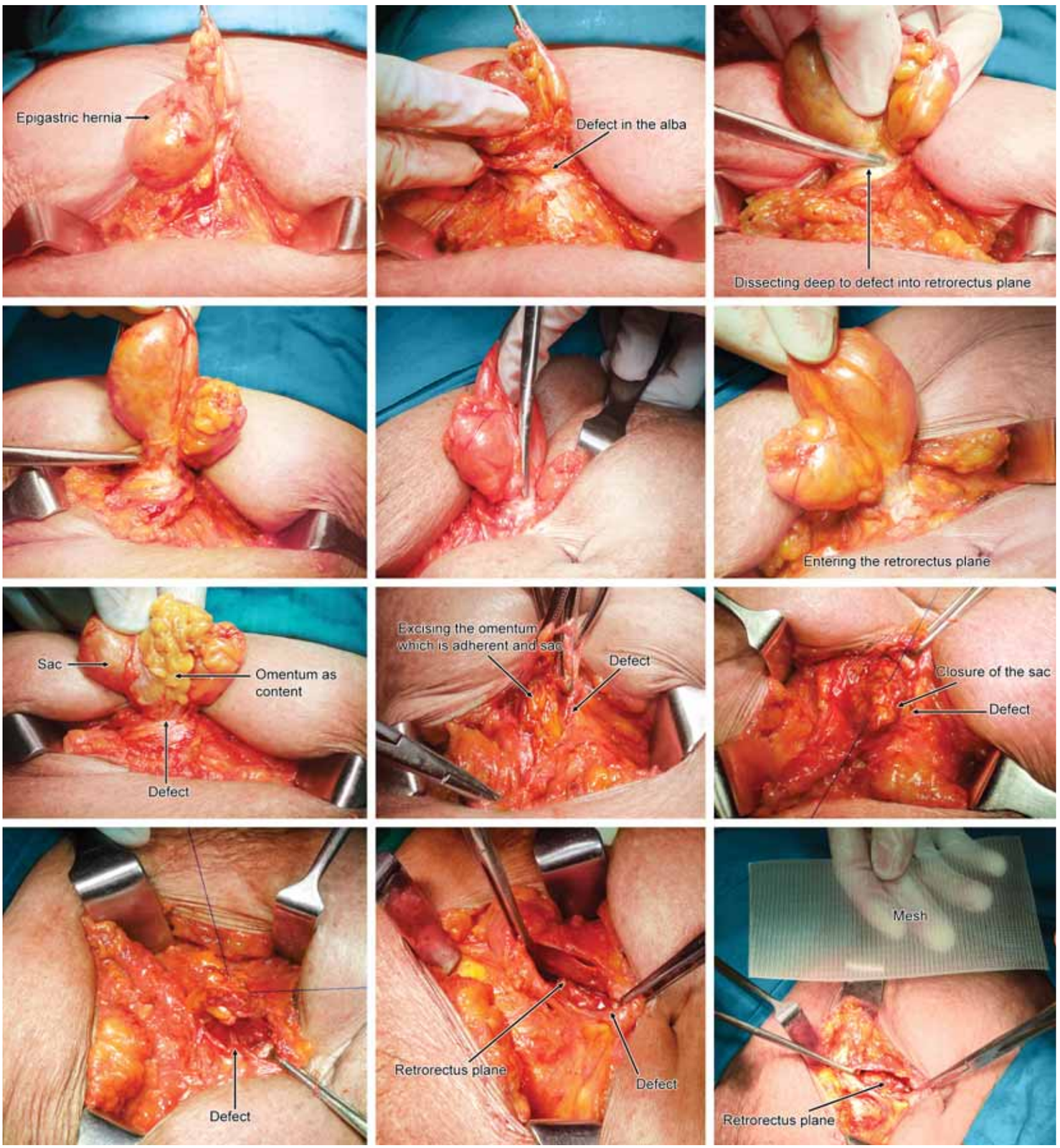
Through femoral canal, hernial sac descends down vertically up to saphenous opening and then escapes out into the loose areolar tissue to expand out like a ***retort***. Because of its irregular pathway and narrow neck, it is more prone for obstruction and strangulation. During surgery, precaution should be taken about the femoral vein and pubic branch of obturator artery (or abnormal obturator artery) which often may get injured leading to torrential haemorrhage.

Hydrocele of femoral hernia occurs when adherent omentum is the content which secretes fluid into the sac. *Herniation* through a gap in the lacunar ligament (medial) is always strangulated and is called as *Laugier`s femoral hernia*. In congenital dislocation of hip, femoral hernia occurs *behind* the femoral vessels—*Narath`s femoral hernia*. If sac lies under the pectineal fascia, it is called as *Cloquet`s hernia*. *Strangulation and Richter`s hernia are common in femoral hernia*. Often on medial side, a portion of bladder forms the wall of the femoral hernial sac— *sliding femoral hernia*.

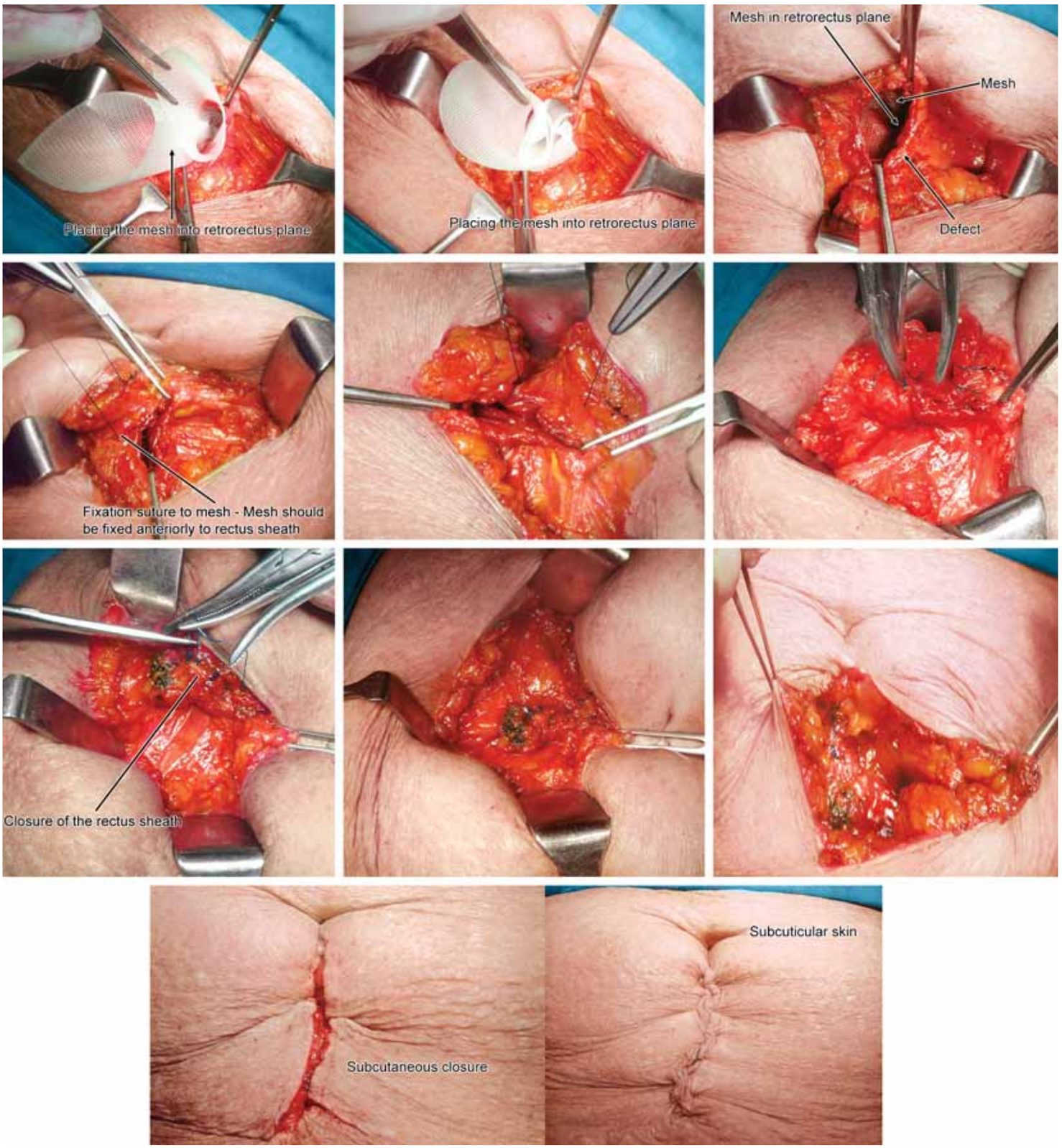
Surgical Approaches Fig. 30-102

Lockwood (London)—Low Operation

Here sac is approached below the inguinal ligament through groin crease incision so that fundus of sac is dissected by direct vision and repair is done from below. Incision is made 1 cm below the inguinal ligament on its medial portion. Skin and subcutaneous tissue is incised to visualize the swelling with sac. Blunt dissection will reveal the margin of the sac. Commonly sac content is irreducible. Sac is opened; fluid invariably present in the sac is collected for culture and sucked out. Bowel/omentum are held using Babcock's forceps. Viability of bowel or omentum is checked by colour, peristalsis, and blood supply. If content is viable, it is pushed into the peritoneal cavity. If reduction of the content is difficult then constriction at femoral ring should be released. It is done by cutting the inguinal ligament in front. One should not cut the lacunar ligament to release the ring while approaching from below as superior invisible part of the lacunar ligament may be closely related to aberrant obturator artery or pubic branch of obturator artery which communicates with pubic branch of inferior epigastric artery. If this artery is cut both

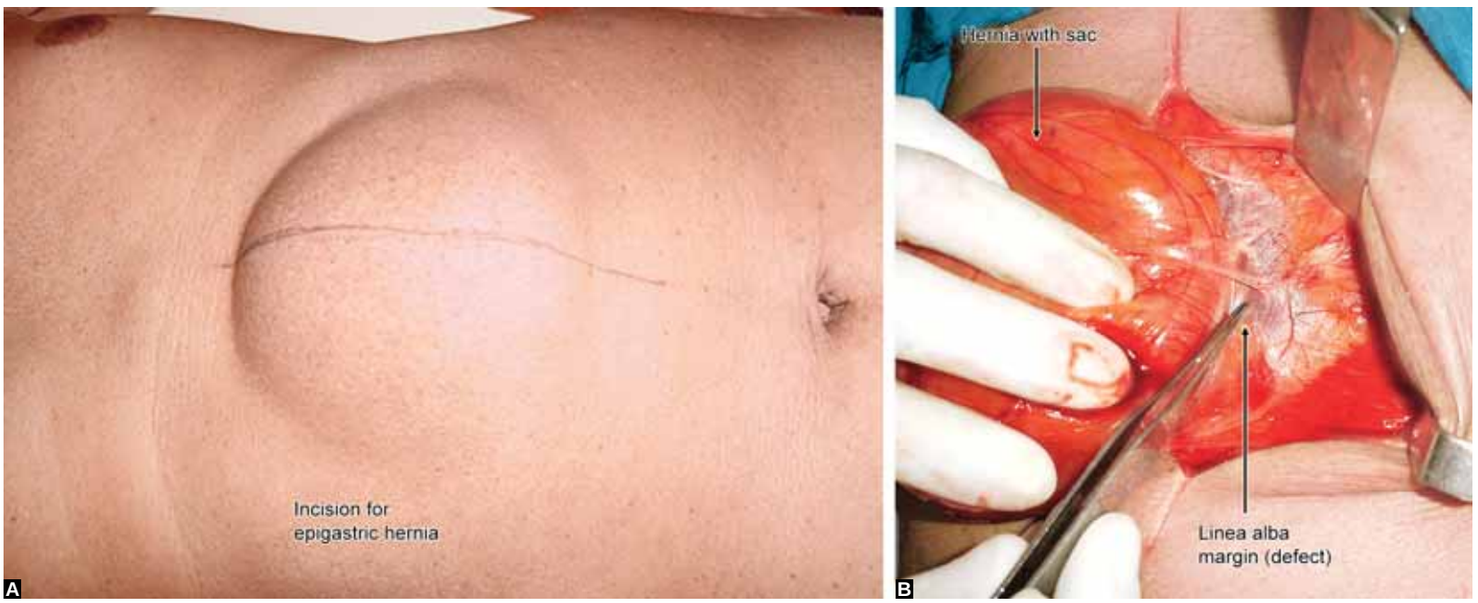

Epigastric hernia
Defect in the alba
Dissecting deep to defect into retrorectus plane
Entering the retrorectus plane
Sac
Omentum as content
Defect
Excising the omentum which is adherent and sac
Defect
Closure of the sac
Defect
Defect
Retrorectus plane
Defect
Mesh
Retrorectus plane

Figs 30-96(1)


Placing the mesh into retrorectus plane
Placing the mesh into retrorectus plane
Mesh in retrorectus plane
Mesh
Defect
Fixation suture to mesh - Mesh should be fixed anteriorly to rectus sheath
Closure of the rectus sheath
Subcutaneous closure
Subcuticular skin

Figs 30-96(2)

Figs 30-96(1 and 2): Epigastric hernia dissection, defect and retrorectus mesh repair.



Figs 30-97A and B: Surgical treatment of epigastric hernia and plane of placing the mesh.

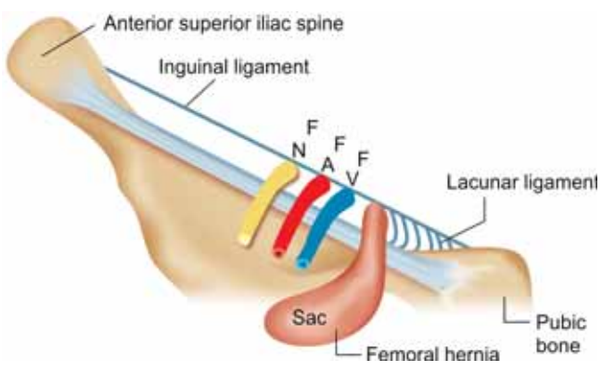


Fig. 30-98: Femoral hernia – surgical anatomy.

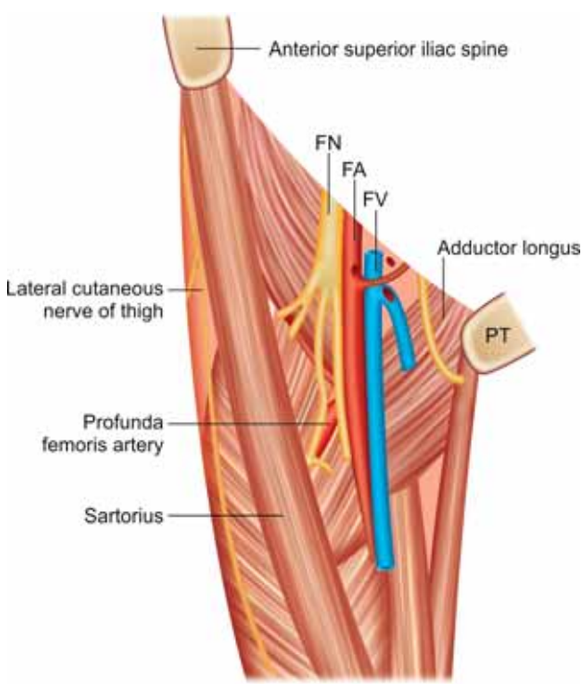


Fig. 30-99: Femoral triangle and its boundaries.

Figs 30-100A and B: Femoral hernia is common in females.

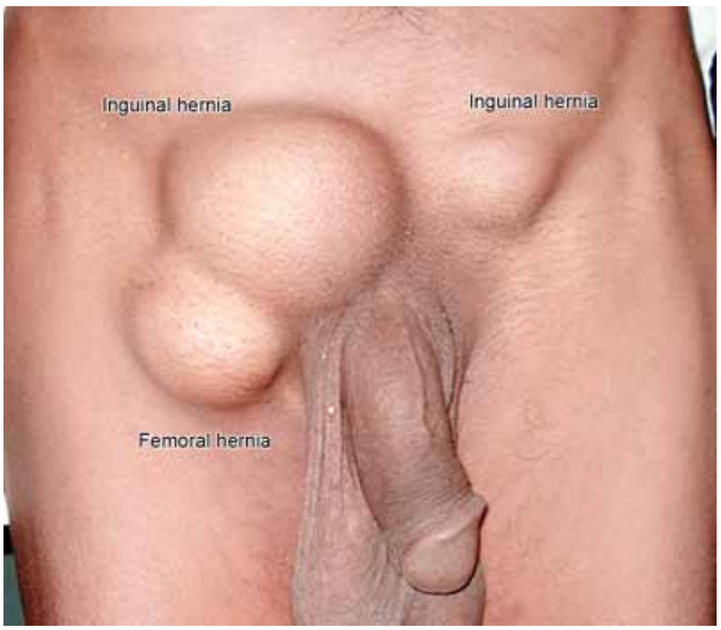


Fig. 30-101: Femoral and direct inguinal hernia in a male patient.

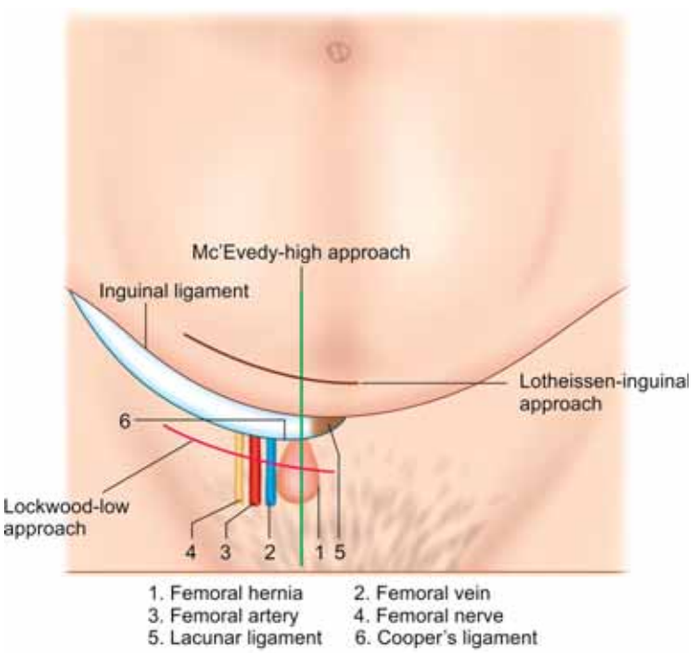


Fig. 30-102: Surgical approaches for femoral hernia repair.

cut ends of the artery will bleed profusely and also medial cut end may retract into obturator fossa which will be difficult to identify for secure ligation. Inguinal ligament is sutured to Cooper's ligament or pectineal fascia using interrupted polypropylene sutures. Femoral vein that is located laterally should be guarded using finger to prevent taking of inadvertent bite. Usually three sutures are sufficient. First all three sutures are placed and then tied together to prevent tearing of the inguinal ligament. One should ensure that constriction of the femoral vein will not occur. J shaped needle if available should be ideal to take suture bites.

If bowel is gangrenous it is better to do resection by formal laparotomy incision. Other option is extending the incision vertically across into the lower abdomen to complete the resection and anastomosis. In uncontaminated hernia mesh plug is placed which

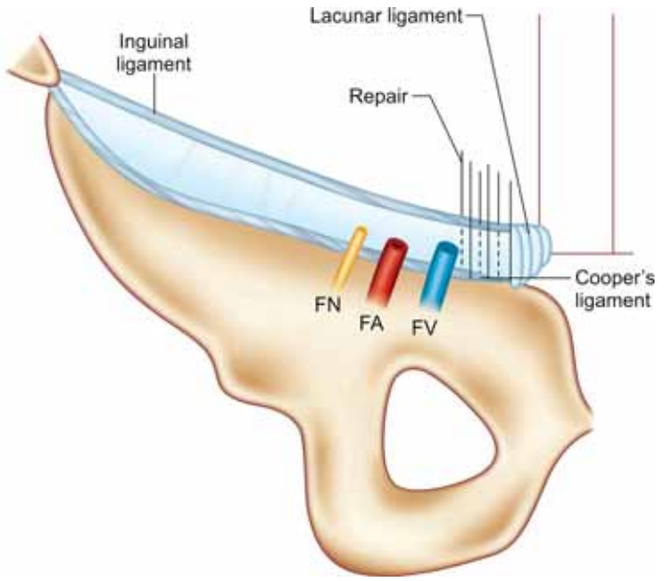
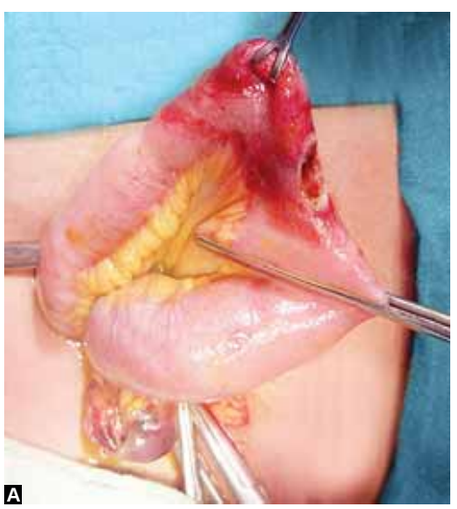
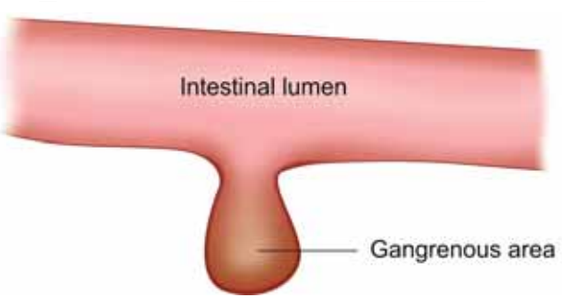


Fig. 30-103: Repair of femoral hernia.





Figs 30-104A and B: Femoral hernia Richter's type—perforated. Only part of circumference of the bowel is involved (gangrene or ischaemia) in Richter's hernia.

is often sutured into the inguinal ligament and Cooper's ligament **(Figs 30-103 and 30-104).**

Mc'Evedy (Manchester) High Operation

An incision is made over the femoral canal extending vertically above the inguinal ligament. Sac is dissected from below, neck from above and repair is done from above. It gives a very good exposure of neck, fundus of sac and repair is also easier. It is done in strangulated femoral hernia.

Lotheissen's (Vienna) Operation

It is through inguinal canal approach (like for inguinal hernia). Transversalis fascia is opened and neck of the sac is identified in the femoral ring. Sac is dissected from above, neck is ligated and repair is done. If release of constriction ring is necessary then cut can be given to lacunar ligament under direct visualization; one should not injure vessels which is (abnormal obturator artery or pubic branch of inferior epigastric artery) in close proximity to it. If difficulty arises then it is better to cut medial most part of the inguinal ligament to release the neck of the sac.

Lotheissen's repair: After herniotomy, conjoined tendon is sutured to ilio-pectineal line (ligament) by interrupted sutures (2 or 3), using nonabsorbable monofilament sutures. Care should be taken to avoid injury to femoral vein, pubic branch of obturator artery, bladder.

A.K.Henry's approach: Repair of bilateral femoral hernia through lower midline abdominal incision with extraperitoneal approach.

Laparoscopic approach: It is similar to inguinal hernia either through TEP or TAPP or with placement of mesh to cover the Fruchaud's myopectineal orifice.

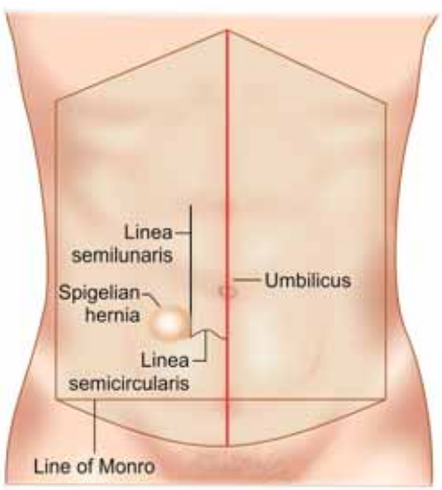


Fig. 30-105: Surgical anatomy of Spigelian hernia.

Fig. 30-106: Spigelian hernia and placing mesh after dissection.

Complications

Bleeding; haematoma, abscess formation.

SPIGELIAN HERNIA

It was first described by Flemish anatomist Adriaan van den Spiegel. It is lateral ventral hernia through *Spigelian fascia* at any point along its line. *Semilunar line of Spiegel* is a line from pubic tubercle to tip of 9th costal cartilage. It marks the lateral margin of the rectus sheath. Semicircular arcuate line (fold) of Douglas is lower end of posterior lamina of rectus sheath below the umbilicus and above the pubis. Spigelian fascia is area between lateral border of the rectus muscle and external and internal oblique and transversus abdominis muscle. Spigelian hernia belt extends from line Monro (interspinous line) for 6 cm above where spigelian hernia is very common **(Figs 30-105 and 30-106).**

Spigelian hernia can occur above (10%) or below (90%) the umbilicus. Below the umbilicus it occurs at the junction of the linea semilunaris and linea semicircularis. In Spigelian hernia, defect is formed by internal oblique and transversus abdominis muscle. External oblique is outer to the hernial sac. A vertical or transverse incision is made. External oblique is cut vertically or transversely. Sac can be visualized deep to it. Ring often requires a release by cutting the rectus muscle medially. Sac is opened; contents are reduced; sac is ligated using 3 zero vicryl. In earlier days, defect containing internal oblique and transversus abdominis was closed with interrupted monofilament polypropylene sutures. Now retrorectus mesh placement is done prior to closing the defect.

BIOMATERIALS USED IN SURGERIES OF HERNIA

There are many biomaterials used in hernia and vascular surgeries. Its efficacy is based on its tissue response.

Response to Prosthetic Material

Inflammatory response occurs in 4 phases. They are: (1) Acute inflammation that occurs within 2-3 days and climaxes after 14 to 21 days. (2) Chronic inflammatory response seals the foreign body. (3) Foreign body reaction with mediators like PDGF, TGF-β, ILGF, EGF recruiting more inflammatory cells, fibroblasts and smooth muscle cells to promote tissue ingrowths. (4) Fibrosis—collagen rich scar tissue forms and builds a three dimensional frame work around and through the mesh.

Prosthesis

Bursting and ultimate effective strength of the prosthetic material depends on: (1) Pore size, (2) Structural configuration and (3) Filament properties—diameter, type of polymer, monofilament or multi-filament.

Classification of pore size - Type I: Pore size >75 μm, e.g. Prolene lighter mesh which allows macrophages, fibroblasts, blood vessels and collagen to adhere significantly to the material thereby increases its tensile strength. Type II: Pore size less than 10 μm, e.g. ePTFE attract

more histiocytes than fibroblasts, causes formation of immature, loose granulation tissue around the mesh. Type III: Macroporous material with multifilamentous or microporous component, e.g. PTFE mesh, Dacron mesh, braided polypropylene mesh. Type IV: Submicronic pore size e.g. silastic sheeting.

Maximum tensile strength required to maintain abdominal closure is 16N/cm with normal intra abdominal pressure being 20kPa. Conventional prosthetic materials have greater than 32N/cm e.g. prolene may rupture at 131kPa. So, true failure of prosthesis is rare. Recurrence, usually at suture line is due to weakness of prosthesis-tissue interface. Mesh of small pore size causes rigid nonelastic scar plate in tissue. Mesh of large pore size causes elastic flexible soft scar mesh which is always better.

Earlier in olden days of surgical practice, prosthetic materials made of stainless steel and tantalums were used. Usher in 1958 first used inert strong polyethylene Marlex mesh; but it was difficult to sterilize. In 1962 polypropylene which can be sterilized by autoclave was introduced. Presently meshes made of—polypropylene, polyester and polytetrafluoroethylene (PTFE) with combinations of these as composite mesh are available. All these meshes are designed to bear 4 times more than the bursting pressure of the abdominal wall.

Meshes can be *heavyweight (80 g/m^2), medium weight or lightweight (<30 g/m^2)*. Compliance of abdominal wall (abdominal wall movement) is studied using stereography technique in all these different weight mesh groups to prove that restriction of movement of the abdominal wall is highest in heavyweight mesh and is less with lightweight mesh. Compliance, pain and abdominal wall discomfort depends on the formation of strong scar around the mesh with shrinkage of mesh, stiffness and discomfort. Heavyweight mesh shows shrinkage up to 40%. Lightweight mesh or combination of lightweight mesh with an absorbable component (vypro [LWM with vicryl], ultrapro [LWM with monocryl]) showed less shrinkage. These meshes cannot be placed over viscera directly as it may cause bowel ingrowth into the mesh and fistula formation. Interceed antiadhesive barrier dual mesh is used to place the mesh intraperitoneally. There is theoretical possibility of carcinogenicity of heavyweight mesh which is not identified in humans until now even though it is observed in experimental studies in rats.

Meshes can be: (1) *Nonabsorbable* like polypropylene or polyester or ePTFE; (2) *Absorbable* like polyglactin (vicryl); (3) *Composite* absorbable and nonabsorbable like vypro with polypropylene and vicryl, ultrapro with polypropylene and absorbable poliglecaprone 25 (glycolide + e-caprolactone). ePTFE (1972) is a common material used as vascular graft. It is now used as intraperitoneal prosthesis as visceral ingrowth into the mesh is not seen. Dual Goretex ePTFE mesh is also used. Polyester meshes (mersilene by Ethicon, Dacron by Bard) are commonly used for Rives and Stoppa procedures. Polyester is softer and supple and does not stiffen and harden as much as heavyweight polypropylene. Only absorbable vicryl mesh is used in splenic and renal trauma which has got 0.5 mm pore size with 0.17 mm thickness. It is inert, nonantigenic which supports well for 60 days. It is placed over the organs using sutures. Absorbable mesh cannot be used for hernia repair **(Fig. 30-107)**.

Lightweight mesh was started by professor Schumpelick, Germany to have strength enough to bear the abdominal wall pressure and stress but flexible and elastic to move with abdominal wall and also being thin with less mass to handle easily. Composite absorbable and nonabsorbable mesh is widely used now. *Vypro mesh* contains equal parts of absorbable polyglactin and nonabsorbable polypropylene components. Filaments of both are twisted together and knitted to form vypro mesh to make it more elastic with stretching capacity in all directions. Polyglactin component of the mesh loses its tensile strength gradually by hydrolysis in 70-90 days. Due to large pore size of 5 mm tissue ingrowth is better thus preventing non elastic rigid scar plate formation but to form an *elastic flexible stretchable* (30% stretchable as compared to only 8% stretch of polypropylene mesh) strong biophysical anatomical reinforcement of the defect and abdominal wall with less abdominal wall discomfort. It forms less foreign body mass. It cannot be used in contaminated field. A modified version of vypro mesh with rhombically placed violet polyglactin and polypropylene thread is often used for inguinal hernia repair. Rhomboid part keeps the mesh rigid making intraoperative manipulation easier. Similarly *Ultrapro mesh* contains equal parts of polypropylene and poliglecaprone 25 which like vypro mesh achieves flexible stable scar tissue. It is ideal for tension free repair, TAPP and TEP. Ultrapro mesh contains dyed and undyed parts **(Fig. 30-108)**.

Fig. 30-107: Poylopropylene synthetic mesh.

Fig. 30-108: Light weight mesh used in laparoscopic hernia surgery.

Multilayered mesh has developed to place intraperitoneally to prevent adhesion of bowel/viscera with fistula formation. Sterile multilayered thin flexible mesh contains oxidized regenerated cellulose (ORC) as 1st and innermost layer; polydioxanone (PDS) 2nd deeper layer; soft nonabsorbable polypropylene mesh as 3rd deeper layer; again a layer of PDS as deepest 4th layer. First ORC layer prevents adhesions and peritoneum develops on it in 4 weeks. PDS is nonantigenic and gets absorbed in 6 months. This mesh is easier to handle, unroll, less infective, stays intact, creates flexible scar, and incorporates strongly to tissues and abdominal wall. This mesh is used in intraperitoneal placement in all incisional and ventral hernias either through open or laparoscopic methods. It is contraindicated in contaminated areas. *Dual mesh* of different types with cellulose or ePTFE as inner layer and polypropylene part as outer layer is also available for same use. These meshes should be fixed properly to abdominal wall using sutures at regular intervals of 1 cm to prevent gap between mesh and abdominal wall which may be a site of dangerous visceral interposition. Sutures are ideal although tacks are practiced by many.

Biological meshes are available for use in contaminated fields. Cellular parts of the human or animal (porcine or bovine) tissue are removed to prevent allergic reactions and protein structure is stabilized to act like a collagen implant to scaffold the tissues by allowing natural fibroblast to proliferate. They act as extracellular matrix for ingrowth of new vessels and collagen to create bioscaffolding which controls the bacteria by presence of macrophages and antibiotics when needed in these tissues adequately. Many materials used are—porcine gut submucosa (*surgisis*), cadaver dermis, porcine dermis, bovine pericardium, fetal bovine pericardium. These disappear over the time from the host completely replacing natural collagen tissue.

Surgical technique of placing mesh are: Onlay on the myoaponeurotic fascia (like in Lichtenstein in inguinal hernia; not used in ventral hernia); Inlay is bridging of the myoaponeurotic fascia; Sublay/underlay is either preperitoneal (preferred placement) or intraperitoneal (only dual or similar mesh) placement of the mesh. Mesh should be fixed with permanent sutures preferably of the same material. It should be overlapped for 4-6 cm with normal fascia in order to obtain a solid prosthesis tissue interphase and also taking into account the shrinkage of tissue which occurs eg prolene mesh can shrink up to 40% in the body.

Complications of mesh are: infection, reaction, extrusion, nerve entrapment, abdominal wall discomfort, visceral erosion and fistula formation, inguinodynia in inguinal hernia repair, seroma formation (5% to 16%) may be due potential space, lymphatic disruption, reaction to mesh.

COMPLICATIONS OF HERNIA SURGERY

Complications of hernia surgery are important as often complications may become more problematic than hernia itself. 20 years back where tissue repair was popular recurrence was the most worried complication. Now since recurrence rates have come down due to standard usage of mesh, mesh related complications have become more common than recurrence. Inguinodynia, mesh extrusion, mesh infection, mesh erosion are the worried problems **(Fig. 30-109)**.

• Complications of open hernia surgery • Complications of TEP/TAPP • Complications of other hernia surgery—ventral/femoral	• Early • Delayed • Late • Life threatening

Complications of open hernia surgery	*Complications of TEP/TAPP*
• Infection • Neural: Groin pain; ostetitis pubis • Ischaemic orchitis—due thrombosis of pampiniform venous plexus (0.5%) • Injury to vas • Injury to viscera • Recurrence • Hydrocele formation • Seroma, haematoma • Inguinodynia • Dysejaculation: painful, burning sensation just before/during/after ejaculation due to cremaster dysfunction or vas stricture (0.25%)	• SC emphysema • Pneumothorax, hypercarbia • Vascular • Neural • Visceral • Infection, ileus • Conversion • Recurrence

Immediate	*Late/delayed*
• Vascular: Injury to iliac vessels/IE vessels • Visceral injury—bowel/bladder • Vas injury • Anaesthetic complications	• Seroma/haematoma • Neural complications • Intestinal obstruction • Bowel adhesion/fistula • Testicular atrophy • Mesh related complications • Recurrence

Inguinodynia

It is chronic inguinal pain seen in post hernia surgery patients (30%)—whether tissue or mesh repair. *Causes are*—traction, cautery, transection, entrapment. Even though it can occur in both tissue and mesh repair, it is more observed in mesh repair especially in onlay mesh repair. It is due to entrapment of nerve in the suture or in the mesh itself or nerve gets adherent to the mesh during fibrosis (perineural fibrosis) (*Mesh inguinodynia*). It may be transient or

Fig. 30-109: TEP causing haematoma in the groin which is aspirated.

persistent. Nerves involved are—Iliohypogastric, ilioinguinal, genital branch of genitofemoral nerve, paravasal nerves. *Features are*—Distressing pain in the groin which often radiates to thigh, scrotum and loin. Arch and twist mobility of pelvis reproduce the pain. Bupivacaine injection relieves the pain. Imaging/nerve conduction studies are of no use. Open method has higher (32-38%) incidence of inguinodynia than TAPP/TEP. In open hernia surgery inguinodynia has replaced recurrence as a primary complication. It is distressing discomfort to both patient and surgeon. Incidence is less in posterior or laparoscopic approach.

It is treated with analgesics/nerve block (Injection of steroid, local anaesthetic agents, phenol, and alcohol)/transcutaneous stimulation/cryotherapy/radiofrequency therapy/neurectomy. Neurectomy is done via groin or suprainguinal or laparoscopic or laparotomy approach. Commonly groin approach is used. Ilioinguinal, iliohypogastric and genitofemoral nerves are carefully dissected. Nerve which is causing the problem is transected at a point where it comes out of the internal oblique muscle and proximal end should be ligated, otherwise end neuroma may form to cause recurrence of the pain. This ligated stump is buried in the internal oblique muscle. Just neurolysis may be sufficient but chances of readhesion are higher with recurrence of symptoms. In difficult cases nerve may be transected through laparotomy/laparoscopy approach **(Fig. 30-110)**.

Ischaemic Orchitis

It is due to thrombosis of pampiniform plexus veins in the cord leading to venous congestion and eventual testicular atrophy (0.5%). It is commonly observed while managing the recurrent hernia through anterior approach. In such situation it is advisable to use posterior approach. It can occur in laparoscopic hernia repair also.

Wound Infection

It may be surface infection of skin or subcutaneous tissue. It may be deeper infection involving the mesh. Surface infection is controlled by using specific antibiotics. There is risk of mesh extrusion in deeper infection and may require surgical removal of the mesh. Parenteral antibiotics are needed. Prophylactic antibiotic is given at perioperative period 30 minutes prior to skin incision. Focus of infection especially in the skin should be identified prior to surgery and treated properly **(Fig. 30-111)**.

Recurrence

Recurrence after hernia surgery is reduced significantly in last 15 years. It is different for different procedures. Now overall incidence is 1-3%. Bassini's repair—10%; Shouldice repair—1%; hernioplasty—1 to 3%; other methods—1 to 5%.

Tissue repair has got higher recurrence than prosthetic repair. *Causes* may be—persisting precipitating etiologies, smoking, more tension in the wound, infection, mesh displacement, missed indirect sac, patulous internal ring **(Figs 30-112 to 30-114)**.

Recurrence may be *medial or lateral* recurrence. Medial recurrence is common and is due to the fact that greatest tension in hernia repair occurs adjacent to the pubic tubercle.

Recurrence also often may be classified as *true or false* recurrences. If hernia occurs in inguinal region after inguinal hernia repair it is called as true recurrence. If other groin hernia occurs after inguinal hernia repair like femoral hernia or obturator or other rare types, it is called as false recurrence. But presently hernia is classified grossly as groin hernias and so all recurrences are true recurrences.

Dysejaculation (0.25%)

It is burning or painful sensation just before, during or after ejaculation. It may be due to obstruction to the ejaculate flow caused by stricture in vas deferens or due to cremaster dysfunction.

Hydrocele

Post herniorrhaphy hydrocele occasionally can occur due to lymphatic obstruction. Deep and superficial rings should not be constrictive while suturing.

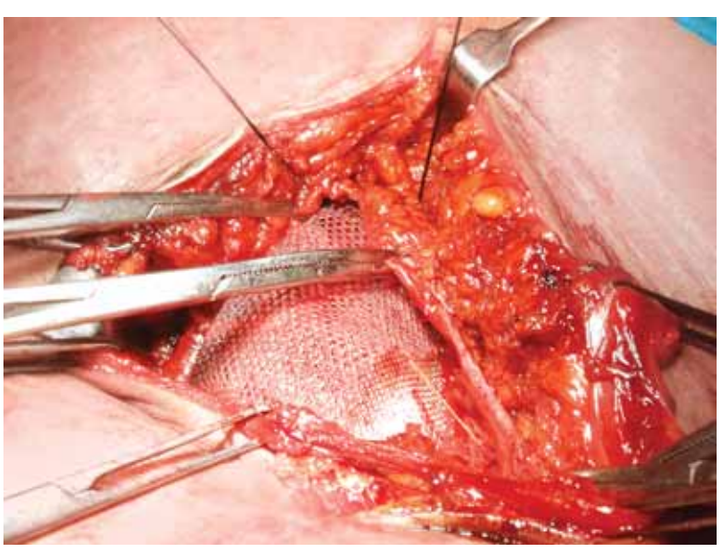


Fig. 30-110: Ilioinguinal nerve entrapment.

Fig. 30-111: Infection of the hernia surgery wound may increase the chance of recurrence.

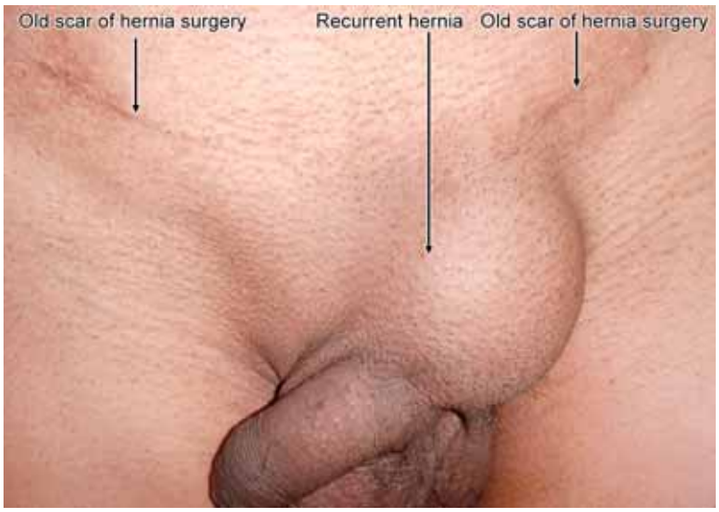


Fig. 30.112: Left sided recurrent hernia.

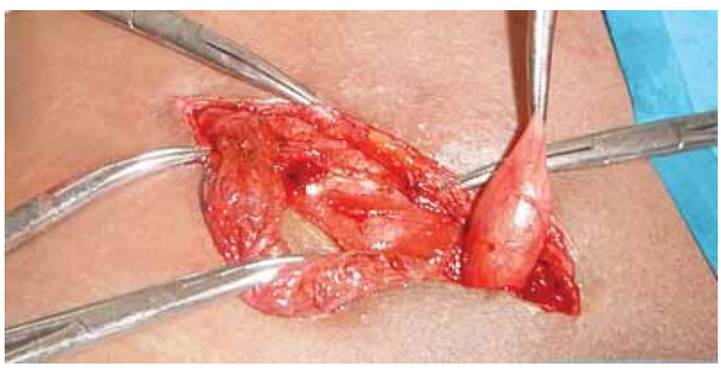


Fig. 30.113: Sac in a recurrent hernia.

Fig. 30.114: Large recurrent hernia.

Haematoma or Seroma Formation

It is common. It often requires needle aspiration. Open evacuation is usually not required unless haematoma is significantly large. Often haematocele can occur. In TEP bleeding can occur from small vessels, inferior epigastric vessels, or port site. It is dealt with bipolar cautery, clipping or ligaseal **(Fig. 30.115)**.

Infection

Minor infection on the subcutaneous tissue subsides with dressing and antibiotics. Deeper infection may cause trouble to the mesh. Infected mesh may get extruded or may form a sinus. Such mesh has to be removed under general anaesthesia. Defect may get fibrosed or later may require a repair **(Figs 30-116 and 30-117)**.

Major Complications

Injury to iliac vessels, inferior epigastric vessels, pubic branch of inferior epigastric artery or abnormal obturator artery can cause severe torrential haemorrhage. It needs surgical exploration and corrective procedures like repair of injured iliac vessel or ligation of inferior epigastric vessels. Bowel or urinary bladder injury can cause fistula formation. Bowel fistula needs proper evaluation with CT fistulogram and later surgical exploration and resection of the involved segment. Injury to urinary bladder causing urinary fistula can be treated by catheterization for 3-6 weeks. Once fistula subsides catheter can be removed safely without any problem later. If fistula persists then bladder exploration and excision of fistula tract with suturing and repair of bladder wall is done. Anaesthetic complications like pneumonia, ARDS can be occasionally life threatening.

GUIDELINES AND RECOMMENDATIONS FOR GROIN HERNIA

References—European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. Hernia 2009 Aug;13(4):343-403.

Fig. 30.115: Port site bleeding is a cumbersome problem in TEP surgery. It should be carefully controlled using bipolar cautery. If inferior epigastric vessel is the cause then it may require clipping after changing one of the 5 mm ports into 10 mm.

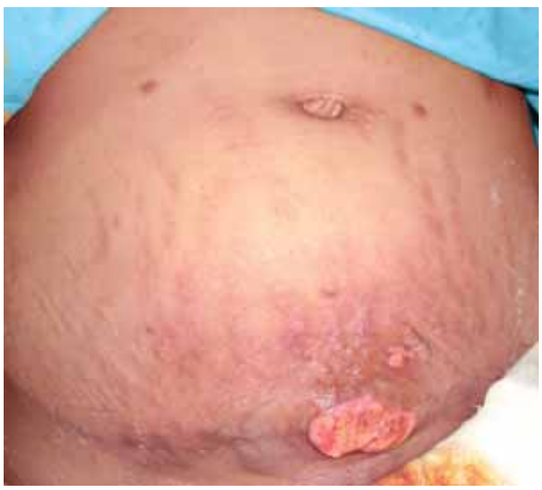


Fig. 30-116: Mesh infection forming fistula after laparoscopic ventral hernia repair.

Fig. 30-117: Infection of the mesh after open inguinal hernia surgery.

doi: 10.1007/s10029-009-0529-7. Epub 2009 Jul 28. Danish Hernia Database recommendations for the management of inguinal and femoral hernia in adults - This guideline has been approved by the Danish Surgical Society December 12th, 2010. Dan Med Bull 2011;58:(2):C4243.

Diagnosis

The diagnosis is mainly based on **clinical examination;** ultrasonography, CT or MRI are rarely needed (with some associations/precipitating factors), while herniography is not recommended. In patients with indicative symptoms of hernia, but no detectable hernia, diagnostic laparoscopy may be an option.

Indication

Hernia repair is recommended in the presence of symptoms affecting daily life.

In Male Patients

With minimal or absent symptoms watchful waiting is recommended; with primary unilateral or bilateral groin hernia the preferred method is mesh repair, either at open surgery (Lichtenstein) or laparoscopically, irrespective of age.

In Females

Repair is recommended not only in symptomatic but also in all asymptomatic patients (due to increased risk of strangulation in females). Laparoscopic approach is recommended whether inguinal or femoral; unilateral or bilateral. Risk of recurrence in women is higher when performing an open repair compared with a laparoscopic repair for a primary hernia.

Due to excellent exposure of the myopectineal orifice including the femoral canal during the laparoscopic dissection it is recommended that all women with a groin hernia (inguinal or femoral) should be offered a laparoscopic repair.

In Young Age

Since young age may be a risk factor for chronic pain, after inguinal hernia repair the use of mesh repair in young male patients (e.g. 18-30 years) is controversial but so far data does not support any disadvantages but rather the contrary. The use of a mesh is, therefore, recommended in all adult patients (>18 years) with indication of inguinal hernia repair.

In Recurrent Hernia

In patients with recurrent hernia with a previous open repair laparoscopic repair is preferred. Patients with recurrence after laparoscopic repair should undergo open mesh repair.

Type of Surgery

Compared to the Lichtenstein operation, laparoscopic repair is associated with less acute pain and faster recovery.

Furthermore, available data suggest less chronic long-term pain after laparoscopic repair.

Conventional tension-producing methods like Bassini, McVay or Shouldice are no longer recommended in a routine elective setting.

Use of a plug mesh for an inguinal hernia is not recommended.

Tissue repair is done in strangulated hernia or with sepsis.

TEP and TAPP are equally safe and effective in skilled hands.

In case of severe comorbidity, previous extensive pelvic surgery or radiation therapy it may be advisable to perform the operation as an open procedure.

In Bilateral Groin Hernia

Laparoscopic approach is preferred but different data show different conclusions in comparison to open versus laparoscopic.

Large Inguinoscrotal Hernia

Large inguinoscrotal or incarcerated hernia may preferably be treated by open repair, although international expert centers have shown good results after laparoscopic repair.

In Direct Hernia

Asymptomatic small direct hernias can be left to be watched carefully; large and symptomatic direct hernia should be operated. Laparoscopic or open Lichtenstein repair is used.

Both sides are operated in single sitting in open method.

Design of Mesh Used

Mesh in Open Repair

14 × 7 cm mesh with 2 cm medial overlap—Lichtenstein repair is used; below continuous sutures non absorbable; above always interrupted sutures; folding of the mesh should be avoided; three nerves should be safeguarded.

Mesh in Laparoscopic Repair

Minimum 15 × 10 cm sized mesh should be used; larger hernia defects (direct > 4 cm; indirect > 4 cm)—17 × 12 cm sized mesh may be a need.

Type of Mesh

Recent data suggest that light weight meshes may be followed by less complaint after surgery although the risk of recurrence may be slightly elevated. Slitting the mesh for the passage of cord can be used in open method.

However, it is in general recommended *not to cut a slit* in the mesh in laparoscopic inguinal hernia repair.

Fixation of Mesh

It has been agreed in the database at different national meetings to use nonabsorbable monofilament suture material for mesh fixation.

Fixation in Laparoscopy

Mesh fixation in laparoscopic inguinal hernia repair is controversial.

Current evidence suggests that fixation of the mesh with tacks may be followed by increased risk of acute and chronic pain and recent reports have suggested that laparoscopic repair can be performed without fixation or with glue fixation without increased risk of recurrence.

However, because of the limited amount of data, the recommendation is mesh fixation during laparoscopic repair, and this can be performed by *nonabsorbable tacks*, absorbable tacks or by glue fixation. There is not yet sufficient data to support one method for another.

Anaesthesia in Hernia Surgery

Elective surgery for groin hernia should be performed in an out-patient setting, using cost-effective local anaesthesia for open mesh repair. General anaesthesia can also be used for open.

General anaesthesia is used and recommended for laparoscopic repair.

***Note*:** Spinal anaesthesia is not recommended.

Antibiotic Need in Hernia Surgery

Routine prophylactic antibiotics are not indicated.

In patients with increased risk of infections antibiotics may be indicated, although the evidence for this is lacking.

Antithrombotic Prophylaxis in Groin Hernia Surgery

In open hernia repair

There are no guidelines available for open inguinal hernia repair, and for this operation, routine prophylaxis is not recommended.

In laparoscopic hernia repair

LMWH is recommended if > 2 of following criteria is present—Duration of surgery > 1 hour; History of venous thromboembolism, congestive heart failure; Age >40 years; Previous myocardial infarction, Immobility, HRT, varicose veins, OCP use, multiparity, peripartum; Cancer, Chronic renal failure, Inflammatory bowel disease; Obesity. *Regime*—Single perioperative dose of LMWH.

Hospital Stay

Inguinal hernia surgery as day surgery is as safe and effective as inpatient treatment and more cost effective. This applies for all patients including selected elderly and ASA-III-patients, but may depend on local factors such as social backup etc. It is therefore recommended that inguinal hernia repair is performed in an outpatient setting unless argued otherwise from specific factors.

Convalescence and Restrictions

It depends on post operative pain and operative approach – open/ laparoscopic. There is no evidence supporting prolonged convalescence periods to avoid recurrence, and patients can therefore be active immediately after surgery when pain is not a hindrance.

Treatment of Chronic Pain (3 Months After Repair)

Surgical treatment is recommended only after 12 months. Neurectomy or mesh removal may be the need.

Chapter

31

Surgeries of Penis, Scrotum and Testis

SURGICAL ANATOMY OF PENIS

Penis has got two parts—root and body.

Root of the Penis

Root of the penis is located in superficial perineal pouch containing two crura and one bulb. Each crus is attached to pubic arch and is covered by ischiocavernosus. Bulb is attached to perineal membrane in between crura and is covered by bulbospongiosus. Urethra pierces its deep surface traversing bulbospongiosus. Ischiocavernosus becomes corpus cavernosum (two in number one on each side); bulbospongiosus forms corpus spongiosum **(Fig. 31-1).**

Body of Penis

It is covered by thin dark coloured skin, begins at pubic symphysis; contains two corpora cavernosa which are extensions of ischiocavernosa of both sides from the root and corpus spongiosum which is continuation of the bulbospongiosus located in the median plane. Corpora cavernosa does not reach the end of the penis; each ends under cover of the glans. Tunica albuginea, a strong fibrous cover surrounds the corpora cavernosa of the penis; it has got superficial part which is longitudinal and covers both corpora; deep part which is circular surrounds each corpus separately with a median septum in between. Corpus spongiosum forms glans penis. Projecting margin at the base of glans is called as corona glandis with groove just proximal to it, which is neck of the penis. Dilated portion of the urethra within the root of the glans is called as navicular fossa **(Fig. 31-2)**.

Skin over the Penis

Skin over the glans continues as prepuce; it is foreskin which is freely mobile over the glans and has got two layers. On the ventral surface of the glans skin forms a fold called as frenulum. Preputial sac is a potential space between foreskin and glans. Numerous preputial sebaceous glands on the corona glandis and neck secrete smegma sebaceous material which collects in the sac.

Fascia of the Penis

Inner Scarpa's membranous part of the superficial layer of the abdomen continues below over the penis as superficial fascia of penis which contains only areolar tissue and few muscle fibres without any fat (fat is totally absent). This superficial fascia contains superficial

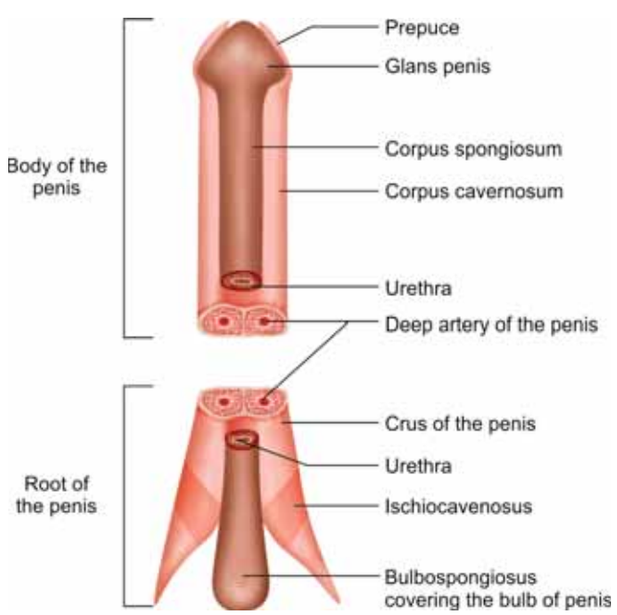


Fig. 31-1: Parts of the penis—root and body.

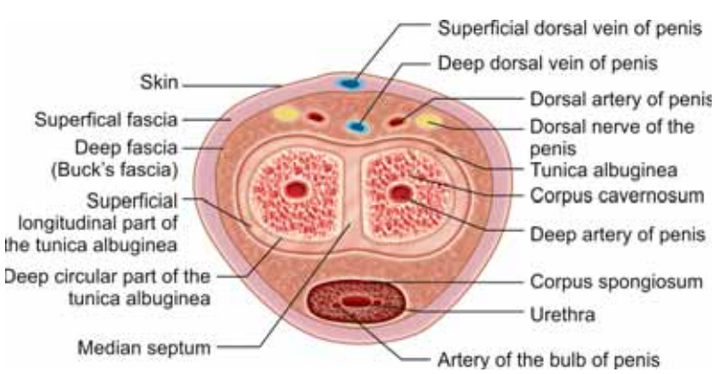


Fig. 31-2: Coverings and anatomy of penis (cross section).

dorsal vein of the penis. Deep fascia of penis is actual fascia of penis called as Buck's fascia. Buck's fascia covers both cavernosa and spongiosum; it does not extend into the glans. Deep dorsal vein, dorsal arteries, dorsal nerves are deep to Buck's fascia. Only proximally, it is covered with Dartos.

Ligaments of the Penis

Linea alba extends downwards as fundiform ligament of penis which splits to cover the penis. Deep to the fundiform ligament lies the suspensory ligament of penis, which extends from pubic symphysis and blends with deep fascia of the penis.

Arterial Supply of Penis

Internal pudendal artery supplies penis, which is a smaller terminal branch of anterior division of internal iliac artery. It runs downwards in front of the pyriformis, sacral plexus and inferior gluteal artery; pierces the pelvic fascia passing through the greater sciatic foramen below the pyriformis; from the gluteal region it enters the pudendal canal across the ischial spine. It gives three branches to penis. *Artery of the bulb* of penis supplies bulb and proximal half of the corpus spongiosum. *Deep artery of the penis* runs in the corpus cavernosum forming helicine arteries. *Dorsal artery of the penis* runs deep to deep fascia on the dorsum supplying distal part of the corpus spongiosum, glans penis, prepuce and frenulum. Skin and superficial fascia of the skin is supplied by the superficial external pudendal artery, a branch of femoral artery **(Fig. 31-3)**.

Venous Drainage of Penis

Single superficial dorsal vein lies in the superficial fascia; later divides into right and left branches draining into superficial external pudendal vein on each side. Deep dorsal vein is deep to deep fascia runs proximally between pubic symphysis and perineal membrane to drain into the prostatic plexus of veins. Dorsal vein, deep cavernosus vein, vein of the bulb drain to the internal pudendal vein.

Nerve Supply of the Penis

Sensory supply is from dorsal nerve of the penis and ilioinguinal nerve. Motor (to muscles) supply is by perineal branch of the pudendal nerve. Autonomic supply is from pelvic plexus through prostatic plexus (S2,3,4).

Pudendal Canal

It is the fascial tunnel just above the sacrotuberous ligament which travels forward on the lateral wall of the ischiorectal fossa 4 cm above the ischial tuberosity, leading from the lesser sciatic foramen posteriorly to the perineal membrane anteriorly. It contains internal pudendal vessels and pudendal nerve. It is formed by splitting of the fascia lunata with obturator fascia laterally and perineal fascia medially.

Pudendal nerve is derived from ventral divisions of S2, 3, 4 nerve roots leaving the pelvis (between pyriformis and coccygeus) to enter gluteal region medial to internal pudendal vessels and sciatic nerve through the greater sciatic foramen; crosses ischial spine again enters the pelvis through lesser sciatic foramen to run at the lateral wall of the ischiorectal fossa. It is the main nerve of the perineum and external genitalia. Branches—Inferior rectal nerve supplies the external sphincter, levator ani, skin of the anal canal and anus. Anus also gets its nerve supply from perineal branch of 4th sacral nerve, perforating cutaneous branches of the 2nd and 3rd sacral nerves and gluteal branches of posterior cutaneous nerve of the thigh. Perineal branch (larger terminal branch) gives medial and lateral posterior scrotal / labial branches and supplies urogenital diaphragm. Dorsal nerve of the penis or clitoris is purely sensory. It supplies skin of the body of penis and glans or clitoris **(Fig. 31-4)**.

Pudendal nerve block is done by blocking the nerve with local anaesthetic agent where it crosses the ischial spine. Ischial spine is palpated per vaginally. Sensory branches of the perineal skin are also derived from ilio-inguinal nerve, perineal branch of posterior cutaneous nerve of the thigh and genital branch of genitofemoral nerve.

Pudendal artery is branch of internal iliac artery. From its origin it follows same path as the pudendal nerve on its medial side to supply perineum. It gives inferior rectal artery, perineal artery and artery of penis or clitoris. In females it is much smaller.

TREATMENT OF CHORDEE

Chordee due to hypospadias is corrected by staged procedure. In chordee following circumcision, initially stilbestrol 6 mg daily is given.

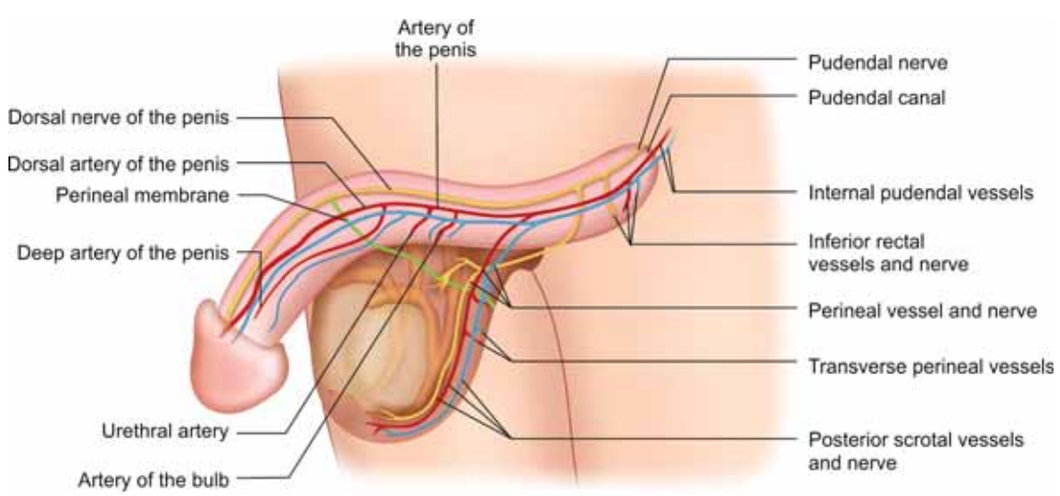


Fig. 31-3: Blood and nerve supply of penis.

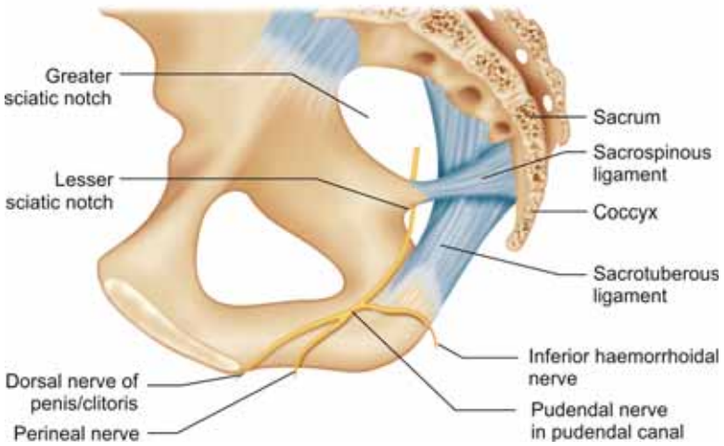


Fig. 31-4: Anatomy of pudendal nerve.

Later chordee is corrected surgically by excising fibrous tissue followed by skin grafting. More often they require surgical intervention.

TREATMENT PEYRONIE'S DISEASE (INDURATIO-PENIS PLASTICA)

Some cases resolve spontaneously. Drugs—steroids; vitamin E; potassium aminobenzoate 12 mg/day; tamoxifen 20 mg daily; terfenadine and fexafenadine; colchicine therapy; intralesional injection of verapamil 10 mg once in 2 weeks—12 injections.

Surgery is needed in many cases. Excision and plication to opposite side is done—*Fitzpatrick operation*. Multiple incisions over the fibrous plaque and temporal fascia bridging gives often good success—*Gelhard's operation*. Excision of fibrous plaque and corporotomy is covered with overlay flap like tunica vaginalis flap (*Lockhart's*) / dermal flap (*Devine and Horton's*). Intracorporeal penile prosthesis placement is often needed.

TREATMENT OF CARCINOMA OF PENIS

Sentinel lymph node biopsy: ***Cabana sentinel node*** is located above and medial to the junction of saphenous and femoral vein. It is the first node to get involved in carcinoma penis. So this sentinel lymph node biopsy (SLNB) after isosulphan blue dye injection into the primary is done to decide for the necessity for ilioinguinal block dissection. In operable cases surgery is the prime and initial method of treatment.

In case of carcinoma in situ, T_1 lesion of glans penis or well differentiated tumour in young individual, circumcision and curative radiotherapy to the penis can be given using radioactive tantalum wire implantation (6000 cGy in 7 days) or by wearing radium penile mould continuously or intermittently (6000 cGy in 7 days) or by linear accelerator external beam radiotherapy (6000 cGy in 5 weeks). Involvement of nodes in these patients is less than 10%. Postoperative radiotherapy to inguinal region is often given.

In advanced fixed inguinal nodes palliative external radiotherapy is given. It is to palliate pain, fungation and anticipated erosion into femoral vessels.

Role of radiotherapy in carcinoma penis: Carcinoma in situ; small lesion less than 2 cm; lesion confined to glans; small lesion in young individual; advanced inoperable disease; palliation to inoperable inguinal nodes in groin; postoperative RT.

Staging of carcinoma of penis

Jackson's staging of carcinoma penis:
Stage I – Tumour involving only 90% five-year glans/prepuce/both survival
Stage II – Tumour extending into 70% body of penis
Stage III – Tumour having mobile 50% inguinal nodes
Stage IV – Tumour spreading to 5% adjacent structures/fixed nodes

TNM staging:
T_0 – No primary tumour
Tis – Carcinoma in situ
T_1 – Tumour < 2 cm without deep invasion
T_2 – Tumour between 2-5 cm with minimal deep invasion
T_3 – Tumour > 5 cm with deep invasion/urethral spread
T_4 – Tumour spread to adjacent tissues
N_0 – No nodal spread
N_1 – Mobile regional nodes—unilateral
N_2 – Mobile regional nodes—bilateral
N_3 – Fixed regional nodes
M_0 – No distant spread
M_1 – Distant spread present

Topical 5 FU cream or Nd:YAG laser photoirradiation is useful in carcinoma in situ.

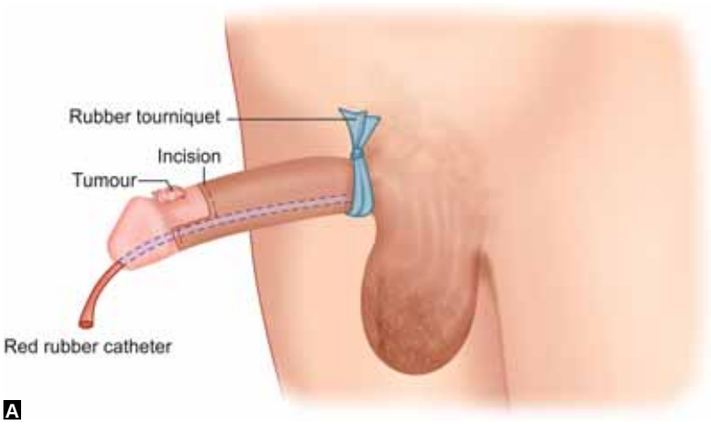
Chemotherapy: 5 FU; methotrexate, bleomycin, cisplatin and vincristine are useful. MBP/VBM combinations are used. Bleomycin is a radiosensitiser and so beneficial if RT is planned later.

Partial Amputation of the Penis

If growth involves the glans or prepuce without extending into the proximal part of shaft of the penis, then *partial amputation of the penis* is done. In olden days if growth is extending to the body then partial amputation was not done; instead total amputation was done. A length of 2.5 cm stump is retained. Clearance of 2 cm from the proximal extended part of the tumor is needed. Advantage is proper streaming of the urine is possible.

Under spinal anaesthesia, in supine position cleaning and draping is done including both groins. Red rubber catheter is passed per urethrally which facilitates the easier identification and dissection of the urethra in the corpus spongiosum. A rubber tourniquet to the base of the penis may be used. Incision is by flap method. Two flaps are used. Dorsal/superior flap is 2.5 cm from the root of the penis; ventral or inferior flap is longer by 1 cm so that urethra is brought out through this flap in its centre and closed wound will come on the end of the dorsal part. Inferior flap is incised through skin, subcutaneous tissue up to the fascial sheath and is initially elevated up to the level of the superior dorsal flap which is more proximal. Incision is deepened through skin and subcutaneous tissue to the fascial sheath of the corpora cavernosa and corpus spongiosum all round along the both flaps. These flaps are elevated using scissor proximally up to the base of the penis to expose the entire corpora cavernosa and corpus spongiosum. Monopolar cautery is better avoided as retained proximal part of the body may undergo necrosis. Corpora cavernosa are divided at the level of the beginning of the superior dorsal flap; as it bleeds profusely (as it is very vascular) proximal corpora cavernosa needs suture transfixation on each side using no. 1 vicryl in cutting needle. Alternatively, a pair of Kocher's clamps can be placed on the each corpus cavernosum and divided distally; transfixation are done deep to the Kocher's clamps which is released after transfixation. Corpus spongiosum with urethra is dissected, isolated carefully

(prior passed red rubber catheter facilitates the easier dissection). Red rubber catheter is removed. Urethra with corpus spongiosum is divided 1.5 cm distally. Tourniquet if placed at the root of the penis should be removed now. Site of urethral passage through the ventral inferior flap is marked; stab incision is made; cut end of the urethra is passed through it. Emerged cut end of the urethra is split vertically for 1 cm; each side of the split urethra is sutured not to the edge of the stab wound of the skin but skin just beyond it to facilitate protrusion of the urethral mucosa so as to reduce the chances of stricture formation. Foley's catheter 18 F sized is passed and is kept in situ for 7 days. If stricture develops then regular dilatation of the urethra is needed.



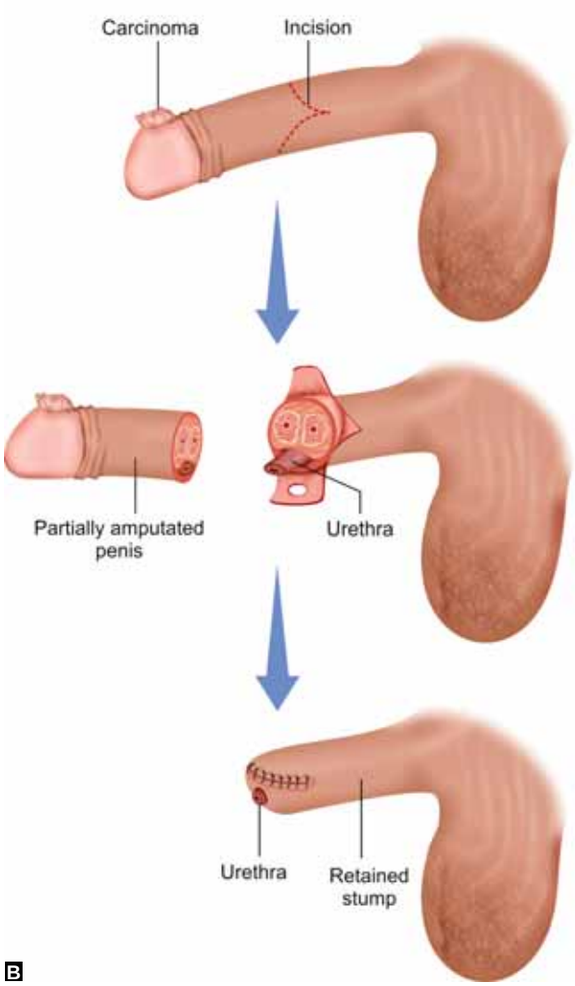


Fig. 31-5A and B

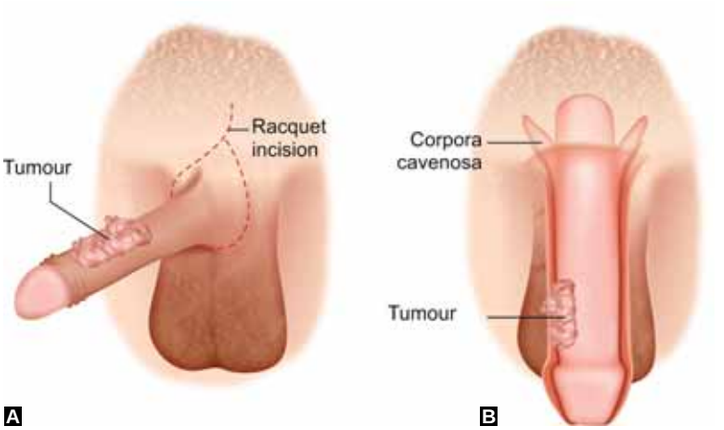
Figs 31-5A to C: Partial amputation of penis with catheter in situ.

Partial amputation of penis with bilateral ilioinguinal lymph node block dissection is called as *Young's operation* **(Figs 31-5A to C)**.

Total Amputation of Penis

If tumour involves the proximal part of the body of penis or if it is anaplastic/poorly differentiated tumour *total amputation of penis* is done with *perineal urethrostomy*. It is done when body of the penis involved and when there is impossible to do partial amputation of the penis. It is done under spinal anaesthesia **(Figs 31-6A and B)**.

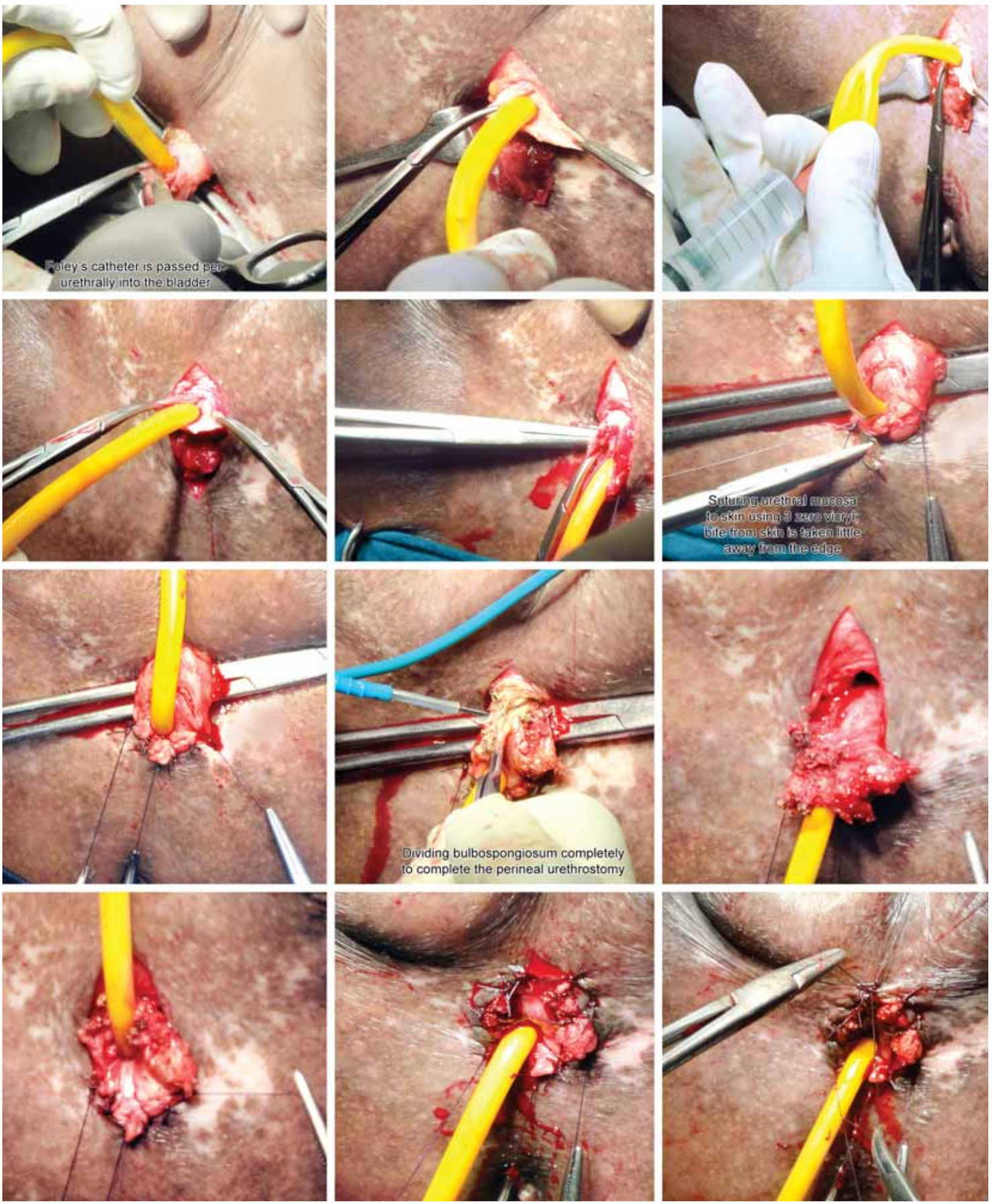
Lithotomy – Trendelenburg position is used. Red rubber catheter is passed per urethra or a metal bougie or male metal catheter can also be used for this purpose. Penile growth is covered with a sterile glove and sterile band or tie is used to fix it the body of the penis. A racquet shaped incision is made covering the penis; it begins as a vertical midline from the pubis downwards encircling the root of the penis again joining on the ventral aspect and extending downwards in the midline scrotal raphe and towards the perineum 3 cm in front of the anus. Scrotum is split into two halves; retracted laterally. Anteriorly fundiform and suspensory ligaments of the penis are split. Dorsal vessels are dissected and ligated. With blunt and sharp dissection and also using cautery perineal incision is deepened. Both crura and bulb are exposed; dissected. Bulb is separated from the perineal membrane; crura are detached from the pubic arch. Urethra is dissected from the muscular component of the bulb; red rubber catheter is removed. Urethra is transected 5 cm distal to the perineal membrane through which it passes out. No. 18 Foley's catheter is passed and inflated. Haemostasis is achieved using cautery **(Fig. 31-7)**.



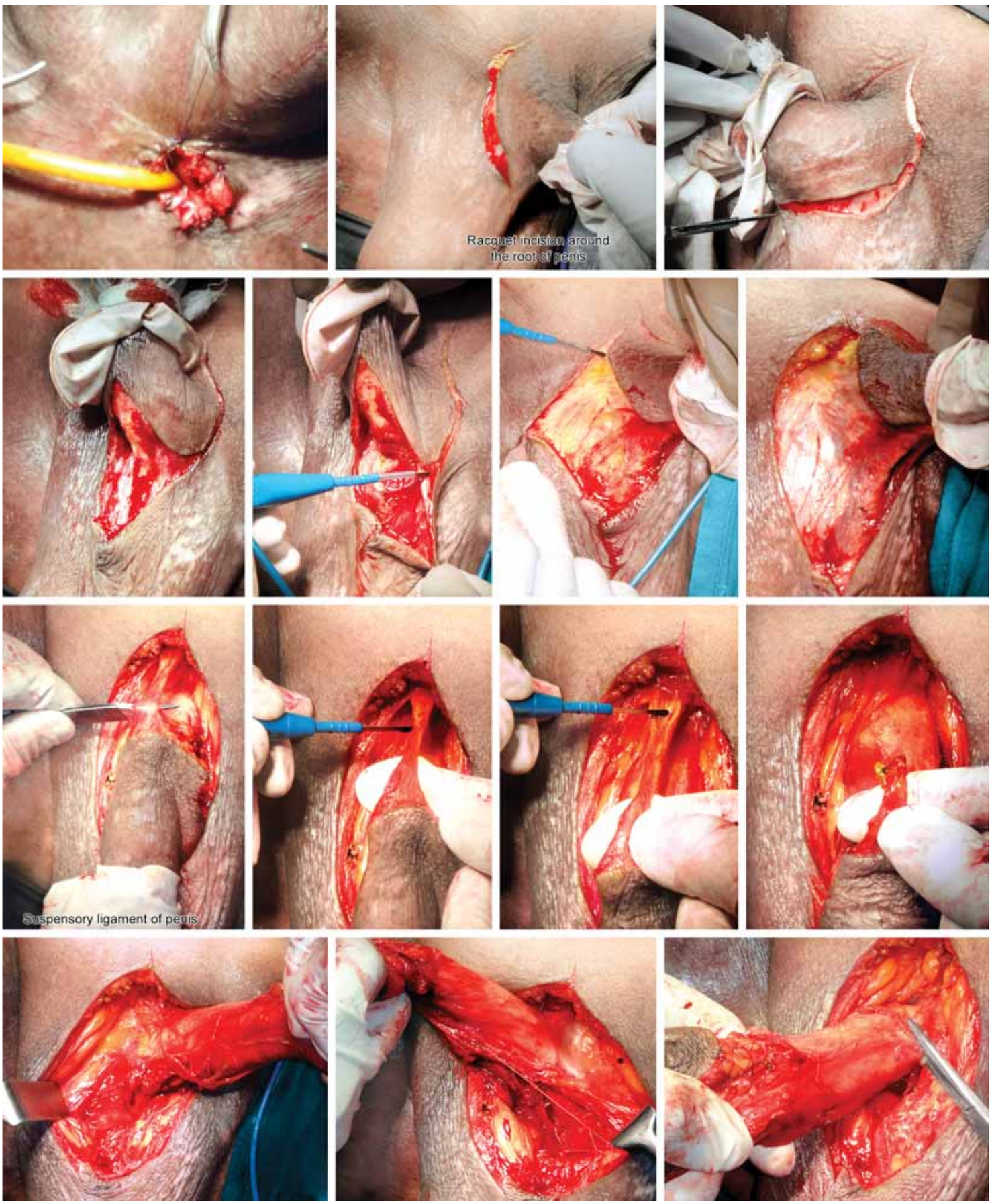
Figs 31-6A and B: Diagram showing total amputation of penis.

Carcinoma penis
Cleaning and draping
Lithotomy position
Red rubber catheter is placed in the urethra for identification and easier dissection of urethra
Growth is covered with sterile glove
Incision for penneal urethrostomy
Identification of the bulbar urethra
Dissection and encircling the urethra
Opening urethra vertically using no 15 blade
Opened bulbar urethra

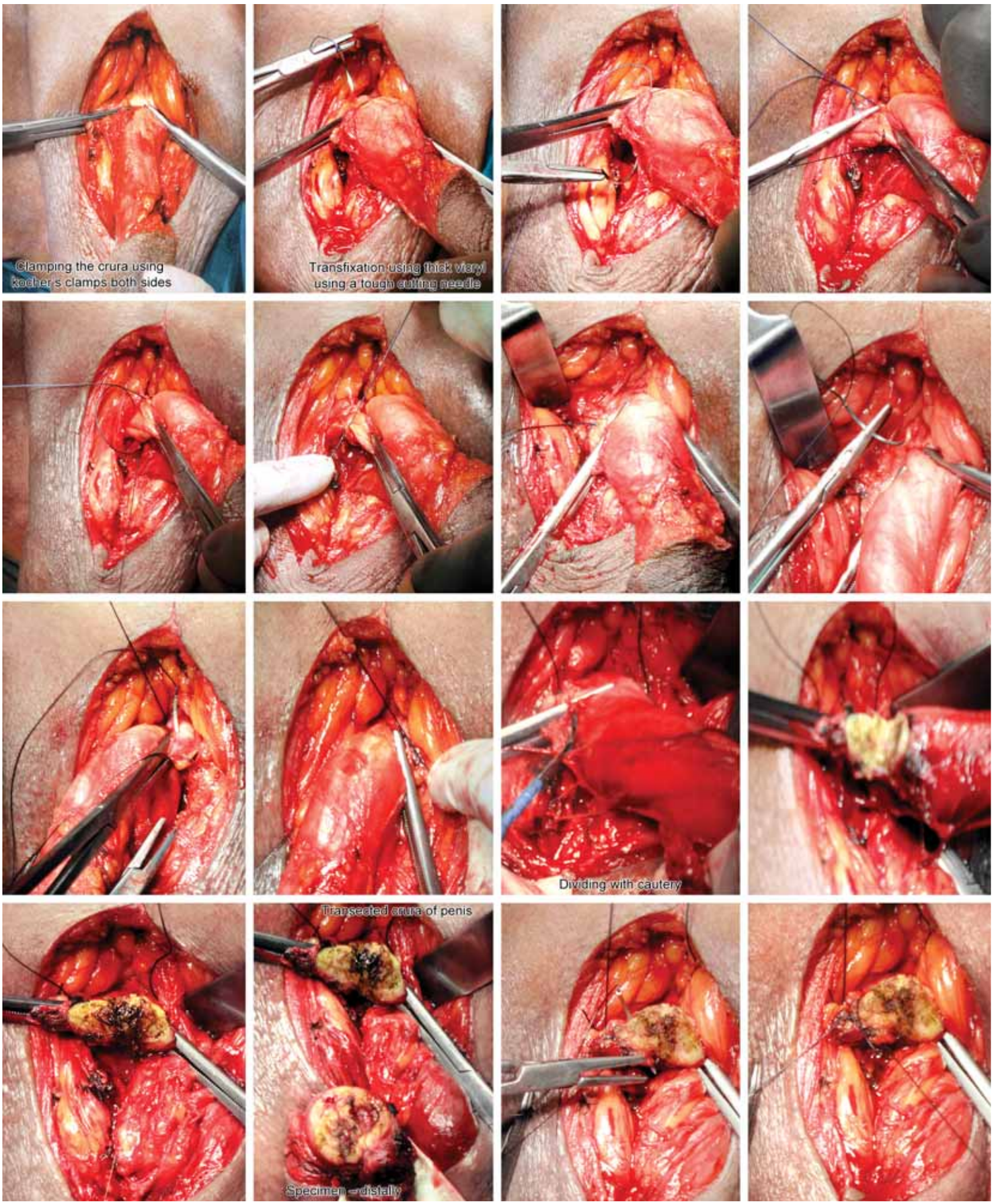
Figs 31-7(1)


Foley's catheter is passed per urethrally into the bladder
Suturing urethral mucosa to skin using 3 zero vicryl; bite from skin is taken little away from the edge
Dividing bulbospongiosum completely to complete the perineal urethrostomy

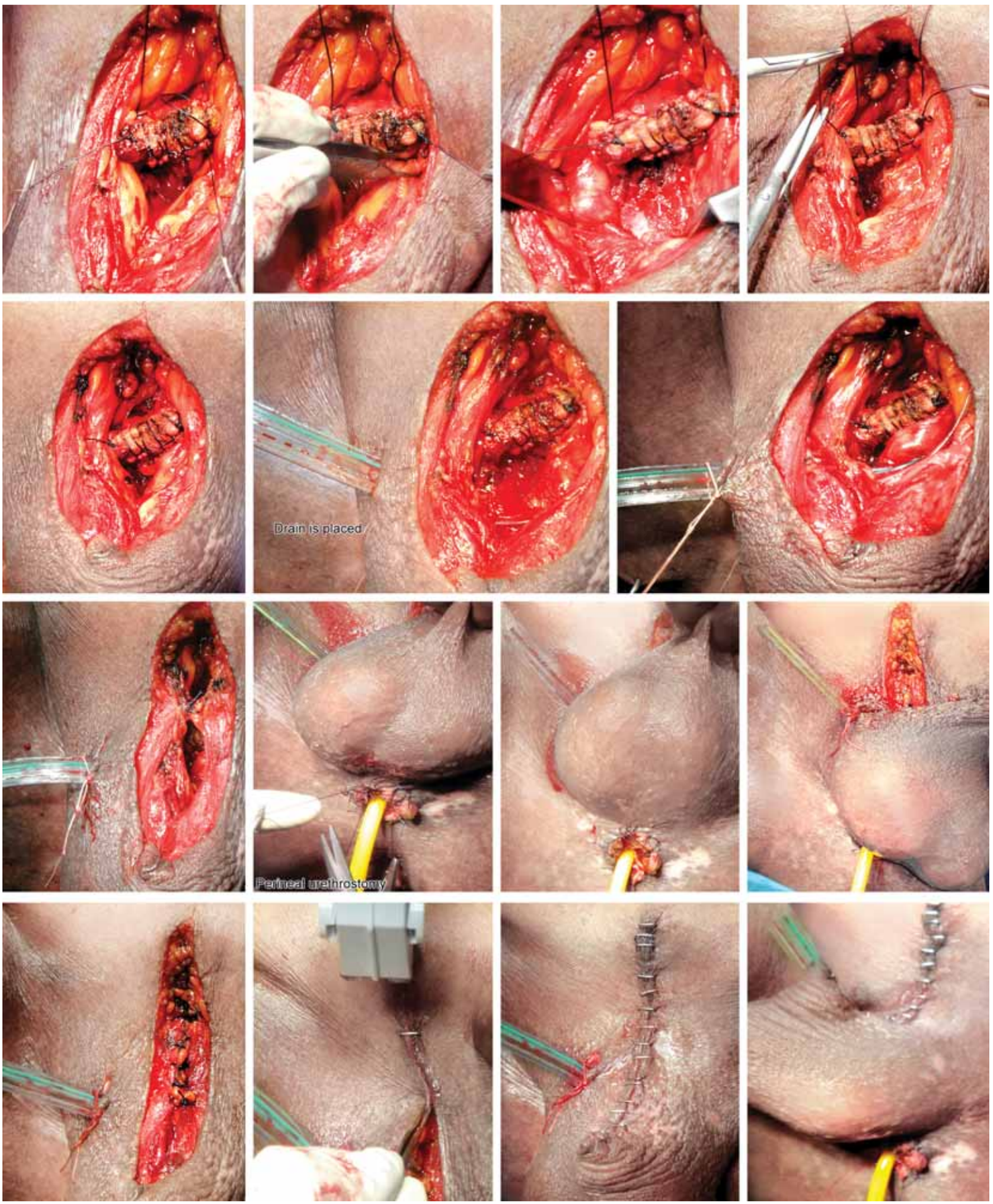
Figs 31-7(2)


Racquet incision around the root of penis
Suspensory ligament of penis

Figs 31-7(3)


Clamping the crura using kocher's clamps both sides
Transfixation using thick vicryl using a tough cutting needle
Dividing with cautery
Transected crura of penis
Specimen – distally

Figs 31-7(4)



Figs 31-7(5)

Figs 31-7(6)

Figs 31-7(1 to 6): Technique of total amputation of penis.

Often if detachment of the crura from the pubic arch is difficult then a Kocher's clamp is applied one on each side of the corpora and is transfixed each side using thick no. 1 vicryl with cutting needle. It is impossible to transfix the corpora using round body needle. Drain is placed on the anterior part of the wound. Skin is closed vertically leaving space posteriorly for perineal urethrostomy. Urethral stump is split longitudinally for 5 mm both in front and behind (this prevents stricture formation) and is sutured to the skin little beyond the cut margin of the skin using 3 zero interrupted vicryl sutures.

Alternatively perineal urethrostomy is done first in lithotomy position. Urethra distally is transected. Racquet incision is placed around the root of the penis. And total amputation of the penis is done in same way.

Problems with perineal urethrostomy are scrotal ammoniacal dermatitis and stricture at urethrostomy site. Dermatitis is prevented by asking the patient to urinate in sitting position lifting the scrotum upwards. Stricture needs dilatation. Stricture of the urethra is not uncommon. It needs regular urethral dilatation **(Fig. 31-8)**.

Total scrotectomy with orchidectomy is done along with total amputation of the penis with perineal urethrostomy —*Sir Piersey Gold operation*. This avoids ammoniacal dermatitis and lymphoedema of the scrotum, a sequelae which may occur after inguinal node dissection. It also reduces the sexual desire.

Fig. 31-8: Perineal urethrostomy with stricture in the created urethra.

INGUINAL BLOCK DISSECTION – RADICAL GROIN DISSECTION

Principles

It is clearing the inguinal nodes with fat and fascia en bloc from the groin. It is done in carcinoma penis, skin carcinomas of the limb including melanoma and squamous cell carcinoma, carcinoma anal canal or drainage areas like scrotum/vagina etc. Dissection is done between adductor longus, sartorius, base of femoral triangle and inguinal ligament; with clearing fat and fascia 5 cm above the inguinal ligament in front of the external oblique aponeurosis. Long saphenous vein is ligated and divided 10 cm below the saphenofemoral junction. It covers the *Dresslers quadrangle*.

Presence of metastatic inguinal node even though is a more important prognostic factor than tumour grade. Even the 50-55% of patients present with palpable inguinal nodes in carcinoma penis only 50% of these patients will have histologically positive nodes. But 25% of patients without clinically palpable nodes will have positive metastatic nodes. When lymph nodes are involved on one side, contralateral nodes are involved in 50% of cases and iliac nodes are involved in 30% of cases. When lymph nodes are involved and are mobile, *bilateral ilioinguinal nodal dissection* is done. *Primary inguinal block* is doing block dissection within 4 weeks of surgery for primary tumour. *Secondary inguinal block* is doing block dissection after 4 weeks of surgery for primary disease. Only 50% of palpable

inguinal nodes are involved by metastatic spread. So often a course of antibiotic is given and waited for 6 weeks. Complications of ilioinguinal block dissection are *flap necrosis*, lymphoedema of lower limb, femoral blow out, infection, lymphorrhoea and haemorrhage.

If primary tumour is poorly differentiated (high grade), and if tumour is T_2 or above, chances of inguinal nodal spread is more than 50% and so a prophylactic inguinal nodal dissection is done even though nodes are not involved clinically. 5 year survival improves by 50% in these patients by prophylactic lymphadenectomy.

Often, involvement of inguinal nodes may be due to infection. So a trial of antibiotic therapy is given for 6 weeks to reduce the size of the inguinal node.

Removal of iliac nodes (pelvic lymphadenectomy) does not alter the outcome. It is done to confirm the spread, so that further therapy can be planned and prognosis can be predicted.

Elective prophylactic inguinal block is done in high-risk group—invasive carcinoma; T2 and T3 tumours; with vascular invasion. *Therapeutic inguinal block* is done whenever FNAC of node shows positive tumour.

Superficial lymph node block is dissected superficially to fascia lata in N0 disease. It should undergo frozen section biopsy. If nodes are positive, then formal block dissection should be done.
Standard inguinal lymphadenectomy—is classical block dissection.

Modified inguinal block dissection (Catalona): Small incision, limited dissection, preservation of saphenous vein—this reduces the morbidity and lymphoedema of the limb. However, there is not much evidence to confirm its advantages.

Surgical Anatomy of Femoral Region

It is a triangle in front of the upper 1/3rd of thigh immediately below the inguinal ligament; it is bounded laterally by the medial border of the sartorius medially by the medial border of the adductor longus, base is by inguinal ligament apex is below at a point of joining of sartorius and adductor longus. Roof is formed by skin, superficial fascia, superficial inguinal nodes, femoral branch of the genitofemoral nerve, branches of the ilioinguinal nerve, superficial branches of the femoral artery and associated veins, upper part of long saphenous vein, deep fascia, saphenous opening and cribriform fascia. Floor is formed by adductor longus, pectineus, iliacus and psoas major from medial to lateral. *Contents are*—femoral artery and branches (superficial external pudendal, superficial epigastric, superficial circumflex iliac; deep branches are profunda femoris, deep external pudendal and muscular); medial and lateral circumflex branches of the profunda femoris artery; femoral vein and its tributaries (vein is medial and posteromedial to artery); femoral sheath extends 4 cm along the femoral vessels; femoral nerve is lateral to artery in the iliopsoas groove; nerve to pectineus, femoral branch of genitofemoral nerve, lateral cutaneous nerve of thigh and deep inguinal lymph nodes. *Tributaries of the femoral vein are*—great saphenous vein; veins along the profunda, deep external and muscular branches of the femoral artery; medial and lateral circumflex femoral veins; descending genicular vein. Branches at saphenofemoral junction are—lateral and medial circumflex femoral, external pudendal, superficial and deep circumflex iliac, superficial epigastric veins **(Fig. 31-9)**.

Femoral nerve is about 2 cm in length. It divides into anterior and posterior divisions. Anterior division supplies sartorius and gives medial and intermediate cutaneous nerves of the thigh; posterior division supplies rectus femoris, three vasti and gives saphenous nerve branch the only cutaneous one. Nerve also gives articular and vascular branches **(Fig. 31-10)**.

Superficial external pudendal artery pierces the cribriform fascia travelling medially in front of the spermatic cord supplying the external genitalia; superficial external pudendal vein lies below and medial to artery. Superficial epigastric artery pierces the cribriform fascia travels upwards towards umbilicus to supply anterior abdominal wall. Superficial epigastric vein is medial to artery. Superficial circumflex iliac artery pierces the fascia lata lateral to the saphenous opening travelling upwards below the inguinal ligament anastomosis with branches of the deep circumflex iliac, superior gluteal, lateral circumflex femoral arteries at the level of the anterior superior iliac spine. Superficial circumflex iliac vein is below and lateral to the artery.

Dresslers quadrangle—upper border is formed by line joining anterior superior iliac spine and pubic tubercle; laterally line joining anterosuperior iliac spine and a point 20 cm below it; medially pubic tubercle and a point 15 cm below it. Nodal block dissection for carcinoma penis should cover this area adequately **(Fig. 31-11)**.

Deep fascia of thigh is also called as fascia lata; is attached anteriorly to inguinal ligament, laterally to iliac crest, behind through gluteal fascia to sacrum, coccyx and sacrotuberous ligament, medially to the pubis, pubic arch and ischial tuberosity. Below it is attached to bone and knee joint and continues as popliteal fascia posteriorly. Lateral thickened 5 cm wide band like iliotibial tract above splits into superficial lamina which is attached to iliac crest tubercle and deep lamina to capsule of the hip joint. Below it is attached to the anterior part of the lateral condyle of tibia. Tract stabilises the knee joint and has got insertions of gluteus maximus and tensor fascia latae in its upper part.

Saphenous oval opening in the fascia lata is 4 cm below and lateral to pubic tubercle; it is vertically 2.5 cm and transversely 2.0 cm (vertically oval); it is directed down and lateral. Its lateral crescentic sharp margin lies in front of the femoral sheath; its medial margin is deeper and is formed by pectineal fascia.

Funnel shaped femoral sheath encloses upper 4 cm of femoral vessels; its anterior wall is formed by downward extension of transversalis fascia; its posterior wall is formed by the fascia iliaca. Sheath is asymmetrical with vertical lateral wall and oblique medial wall directed below and laterally. Sheath is divided into lateral arterial, intermediate venous and medial lymphatic compartments by two septa. Medial one is called as femoral canal 1.5 × 1.5 cm at base above (femoral ring) and narrow below. Femoral ring is bounded by fascia over pectineus behind, lacunar ligament medially, septum laterally and inguinal ligament in front **(Fig. 31-12)**.

Femoral canal contains lymph node of Cloquet (one of the deep inguinal nodes); femoral hernia can occur through it; abnormal obturator artery arising from the inferior epigastric artery or pubic branch of obturator artery may communicate with the pubic branch of inferior epigastric artery. Any of these may run on the lacunar ligament on the medial wall of the femoral canal injury of which during surgery may cause torrential haemorrhage.

Inguinal Lymph Nodes

Superficial lymph nodes drain from skin and fascia of the lower limb, perineum and trunk below the watershed umbilical line. It is classified as lower vertical; upper lateral and upper medial. Upper medial and lateral group is often called as horizontal group. *Lower vertical group*

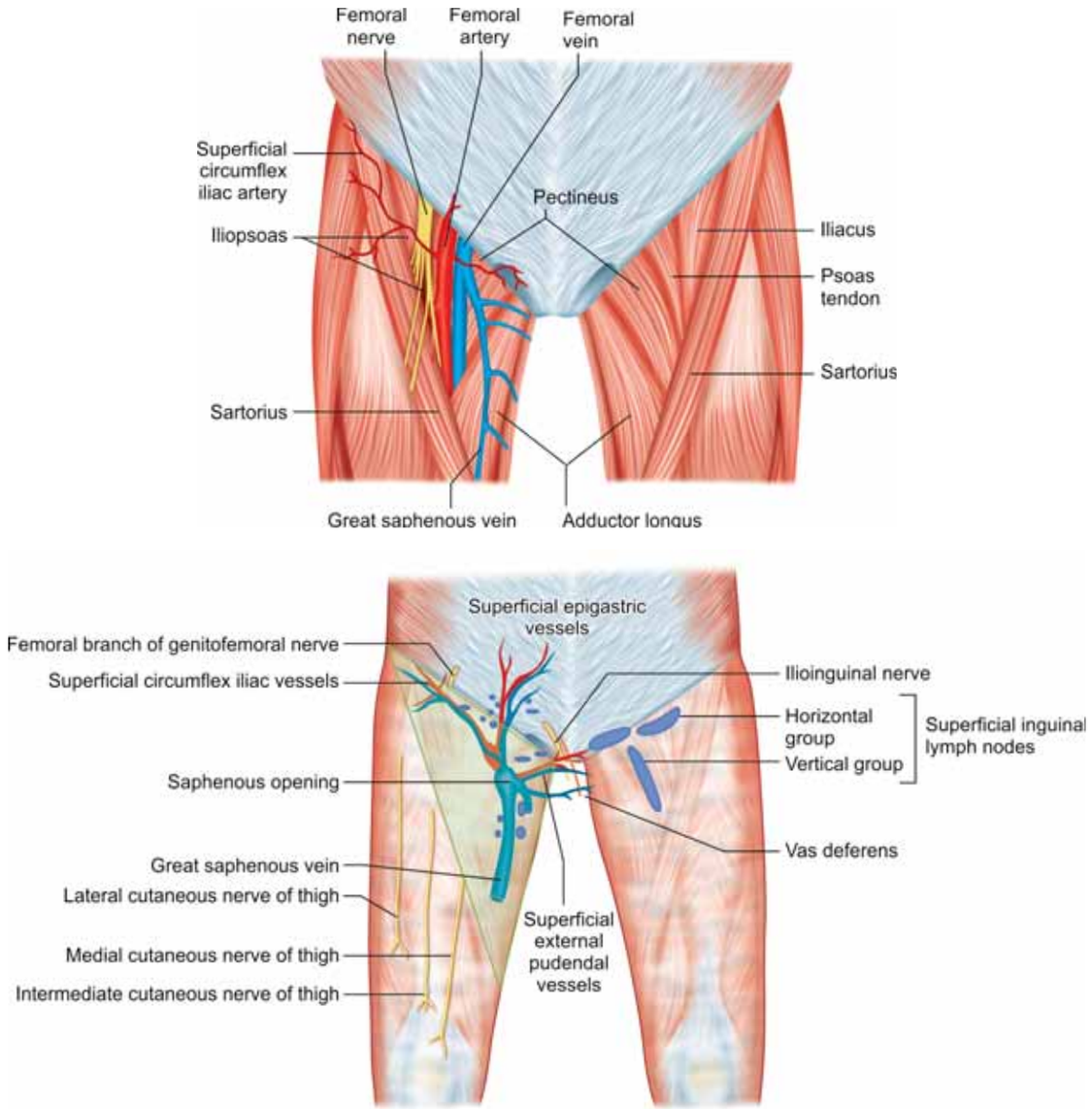


Fig. 31-9: Surgical anatomy of femoral triangle—boundaries; floor, relations; contents; inguinal lymph nodes.

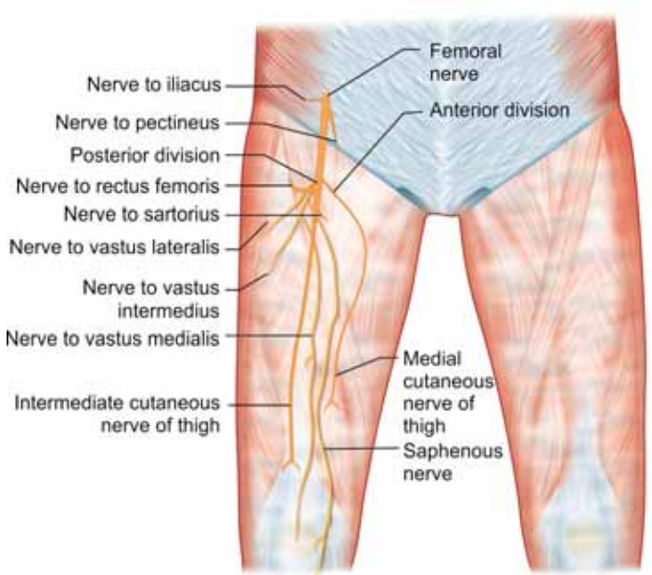


Fig. 31-10: Anatomy of femoral nerve in the thigh.

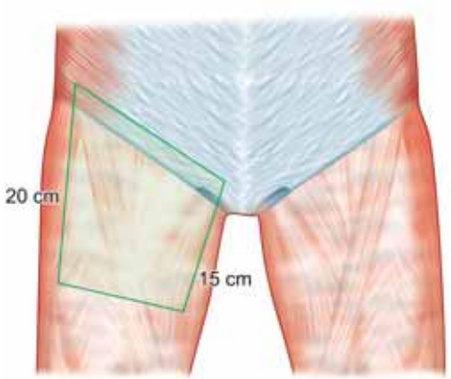


Fig. 31-11: Dressler's quadrangle.

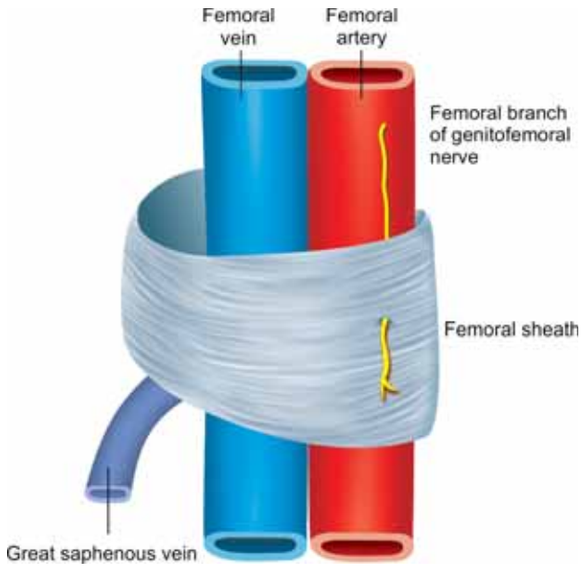


Fig. 31-12: Femoral sheath – anatomy.

(4-5) is located along the both sides of the saphenofemoral junction which drain from the lower limb except buttock. 2-3 upper lateral nodes are located below the lateral part of the inguinal ligament draining skin and fascia of lateral thigh, buttock, flank and back below the umbilical line. *2-4 upper medial nodes* are located below and medial part of the inguinal ligament; few nodes lie above the inguinal ligament along the superficial epigastric vessels. They drain the anterior abdominal wall below the umbilical level; perineum with anal canal below the pectinate line, vagina below the hymen, with external genitalia except glans, penile part of the male urethra superolateral angle of the uterus through round ligament. Efferents from superficial nodes drain into the deep inguinal nodes after piercing cribriform fascia; few drain directly into external iliac nodes.

Deep inguinal nodes (4-5) are located medial to the upper part of the femoral vein. They receive afferent from superficial inguinal nodes, popliteal nodes, glans penis/clitoris and deep lymphatics of the lower limb. Efferent from deep nodes reach external iliac nodes. Proximal most deep node is called as *Cloquet/Rosenmuller* node which is located in the femoral canal.

Technique of Inguinal Block Dissection

It is properly called *as inguinofemoral lymphadenectomy*. If pelvic lymphadenectomy is added then it is called as *ilioinguinal lymphadenectomy* (Ilioinguinal block dissection).

Preoperative antibiotics are given (1 hour before surgery); heparin prophylaxis is also recommended.

It is done under spinal anaesthesia. Supine, with hip slightly abducted and knee flexed, position is used. Lower abdomen, groin, entire thigh is prepared and draped.

Different incisions are used—S; two incisions one vertical and one horizontal; two parallel incisions suprainguinal and infrainguinal; vertical L; oblique with elliptical excision (3 cm wide) of skin over the femorals **(Fig. 31-13)**.

Flap is elevated with retaining some amount of fat in the skin otherwise necrosis of skin flap will occur. 5 cm above the inguinal ligament fat and fascia is dissected towards the inguinal ligament. Flap is elevated laterally over the sartorius; medially above over the pubic tubercle to expose the cord structures and external ring; medially and below over the adductor magnus below up to the apex of the femoral triangle. Great saphenous vein is identified at the apex and ligated. Fascia over the sartorius adductor magnus and pectineus can be removed along the specimen. Fascia over the sartorius is incised and swept medially; near the apex once long/great saphenous vein is ligated. Dissection begins from lateral aspect towards medially; all branches of the femoral vessels are ligated, divided or clipped or fulgurated. Bipolar cautery is better otherwise femoral nerve branches may be injured especially motor nerves (if monopolar is used). Scissor dissection offers good mobilisation of the tissues. Femoral sheath covering the femoral vessels is incised to expose the both femoral vein and artery; femoral vein is posteromedial to artery. Care should be taken not to injure the vein. Small direct branches of the vessels are ligated securely after meticulous dissection. Above femoral canal is identified and Cloquet's lymph node is dissected and removed. When saphenofemoral junction is reached, great saphenous vein is again ligated with transfixation. Cloquet node is bridging node between inguinal and pelvic nodes; if on frozen section Cloquet node is positive then pelvic lymphadenectomy is done to clear iliac nodes. All nodes in front of the femoral vessels should be cleared. It

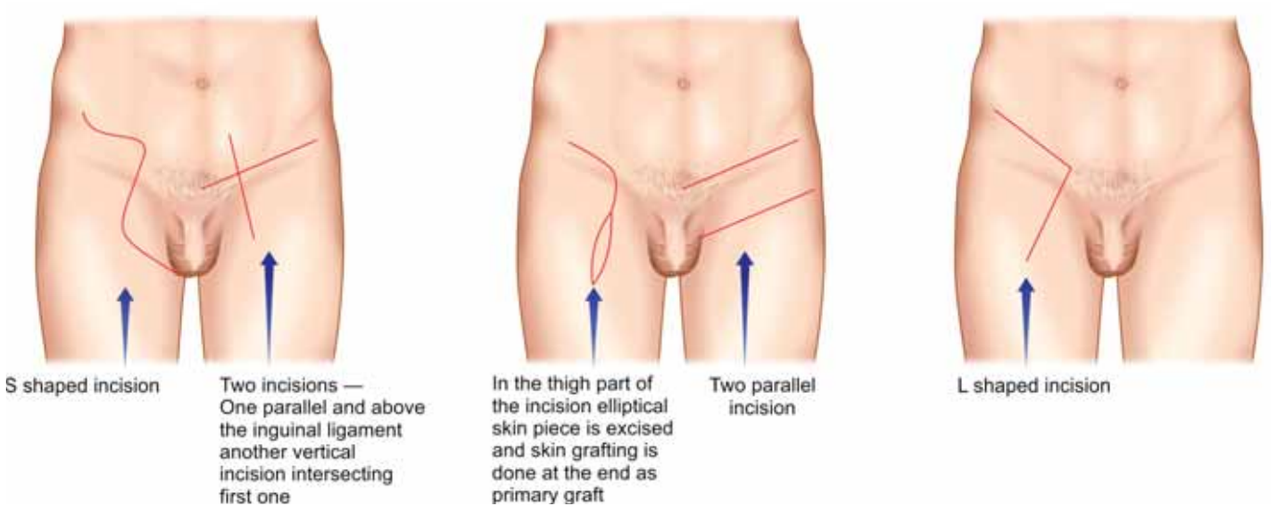

S shaped incision
Two incisions — One parallel and above the inguinal ligament another vertical incision intersecting first one
In the thigh part of the incision elliptical skin piece is excised and skin grafting is done at the end as primary graft
Two parallel incision
L shaped incision

Fig. 31-13: Different incisions which can be used for inguinal block dissection.

is better to place a retractor under the inguinal ligament and remove uppermost lymph nodes of the groin. Distilled water wash is given to the wound. Femoral canal is closed with interrupted nonabsorbable sutures between lacunar ligament and inguinal ligament **(Fig. 31-14)**.

Deep Ilio-obturator (Pelvic) Lymphadenectomy

It is done by extending the groin incision upwards and laterally. Inguinal ligament is divided after placing a flat instrument or finger over the femoral vessels. Skin, superficial fascia and external and internal oblique muscles are incised; transversus abdominis is split. Peritoneum is swept medially towards midline with blunt finger dissection to expose the common iliac vessels and pelvis. Peritoneum should not be opened. Peritoneum with its contents is retracted using broad Deaver retractor. Alternatively self-retaining retractor may be used. Pelvic lymph node dissection begins from common iliac vessels downwards; laterally from genitofemoral nerve towards medially. All nodes along the common iliac vessels are cleared; nodes in front and in between the external iliac vessels (between external iliac artery and vein) should be properly dissected and removed. Dissection in proceeds downwards and medially along the internal iliac vessels (hypogastric vessels) by clearing all nodes. Obturator nerve (thick nerve) is identified in the triangle formed by external and internal iliac vessels. Branches of the internal iliac arteries may be identified. All fat, tissues and lymph nodes are cleared from the endopelvic fascia preserving obturator nerve and important branch vessels from bladder medially, obturator foramen below, up towards the external iliac vessels and inguinal ligament. Haemostasis is achieved by bipolar cautery. Drain may be placed into the pelvis.

Closure

Internal oblique and external oblique muscles are closed using 2 zero vicryl. Femoral canal is closed with interrupted nonabsorbable sutures. Often it is necessary to place a mesh between the groin and retroperitoneum to prevent hernia formation. Lateral attachment of the sartorius in the anterior superior iliac spine is divided and is rotated over the femoral vessels keeping its blood supply intact. Mobilised/transposed sartorius is sutured to inguinal ligament above and adductor magnus muscle medially using interrupted 2 zero vicryl sutures (*Sartorius muscle transposition, its blood supply is segmental*). It covers the femoral vessels and so gives protection to them; also it seals the large defect under the groin thus preventing herniation of the abdominal content. Alternatively, if sartorius is not adequate or is removed for clearance purpose then *rectus abdominis flap or tensor fascia lata flap* will be very useful. Skin grafting may be needed over the possible necrosed area which is excised **(Fig. 31-15)**.

Closed suction drain should be placed until drain fluid becomes less than 50 ml/day; usually in 3 weeks.

Complications of Inguinal Block Dissection

Early Complications

Haemorrhage, infection, flap necrosis—common. Infection is common in the wound. It may be skin infection, cellulitis, abscess formation. Sutures are removed if there is collection inside. Thorough irrigation with normal saline is done. Discharge is sent for culture and sensitivity. Antibiotics and drainage under anaesthesia is often required in such situation. Usually wound will granulate and heal in 6 weeks. Once it granulates well occasionally skin grafting may be required. Postoperative DVT is not uncommon. Venous Doppler will confirm the diagnosis. LMWH should be started immediately. Lymphorrhoea is lymph ooze from the wound; usually occurs in 6 weeks, often persists for long time. It is due to disruption of lymphatic drainage.

Late Complications

Lymphoedema is a distressing complication. It is more common in obesity, old age, after additional adjuvant RT, deeper node clearance and saphenous vein ligation (not proved). Limb elevation, manual massaging, stockings, avoiding injury, prevention of recurrent infection are the therapeutic methods used.

SURGICAL ANATOMY OF SCROTUM

It is a cutaneous bag containing the right and left testis, epididymis and lower part of spermatic cord. It is divided into right and left half by a raphe which is continued in front along the penis and backwards along the perineum towards anus. Left hemiscrotum is lower than right. In cold environment scrotum is contracted, short and corrugated due to contraction of dartos muscle. In warm environment, it is flaccid and elongated due to dartos relaxation.

Layers of the Scrotum (From without Inwards)

1. Skin
2. Dartos muscle
3. External spermatic fascia
4. Cremasteric fascia
5. Internal spermatic fascia

Blood Supply

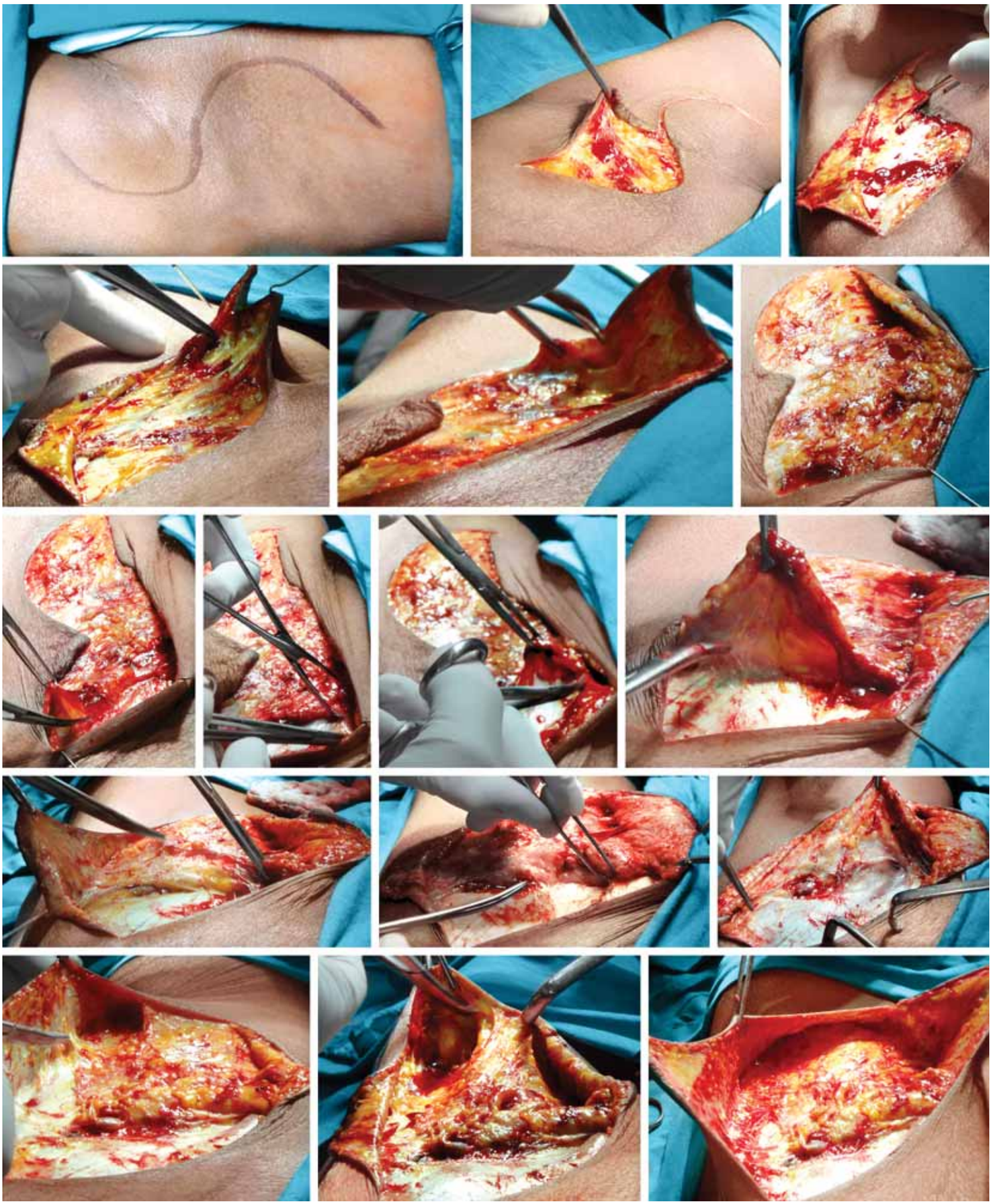
From external pudendal, deep external pudendal scrotal branches of internal pudendal and cremasteric branch of inferior epigastric arteries.

Nerve Supply

Anterior 1/3rd portion is supplied by (segment L1 of spinal cord) ilioinguinal nerve and genital branch of genitofemoral nerve. Posterior 2/3rd portion is supplied by (S3) posterior scrotal branch of pudendal nerve and perineal branch of posterior cutaneous nerve of thigh. Dartos is supplied by sympathetic nerve.

TREATMENT FOR HYDROCOELE (FIGS 31-16 AND 31-17)

Surgeries
Sub-total excision
Partial excision and eversion (Jabouley's operation)
Evacuation and eversion
Lord's plication
Sharma and Jhawer's technique



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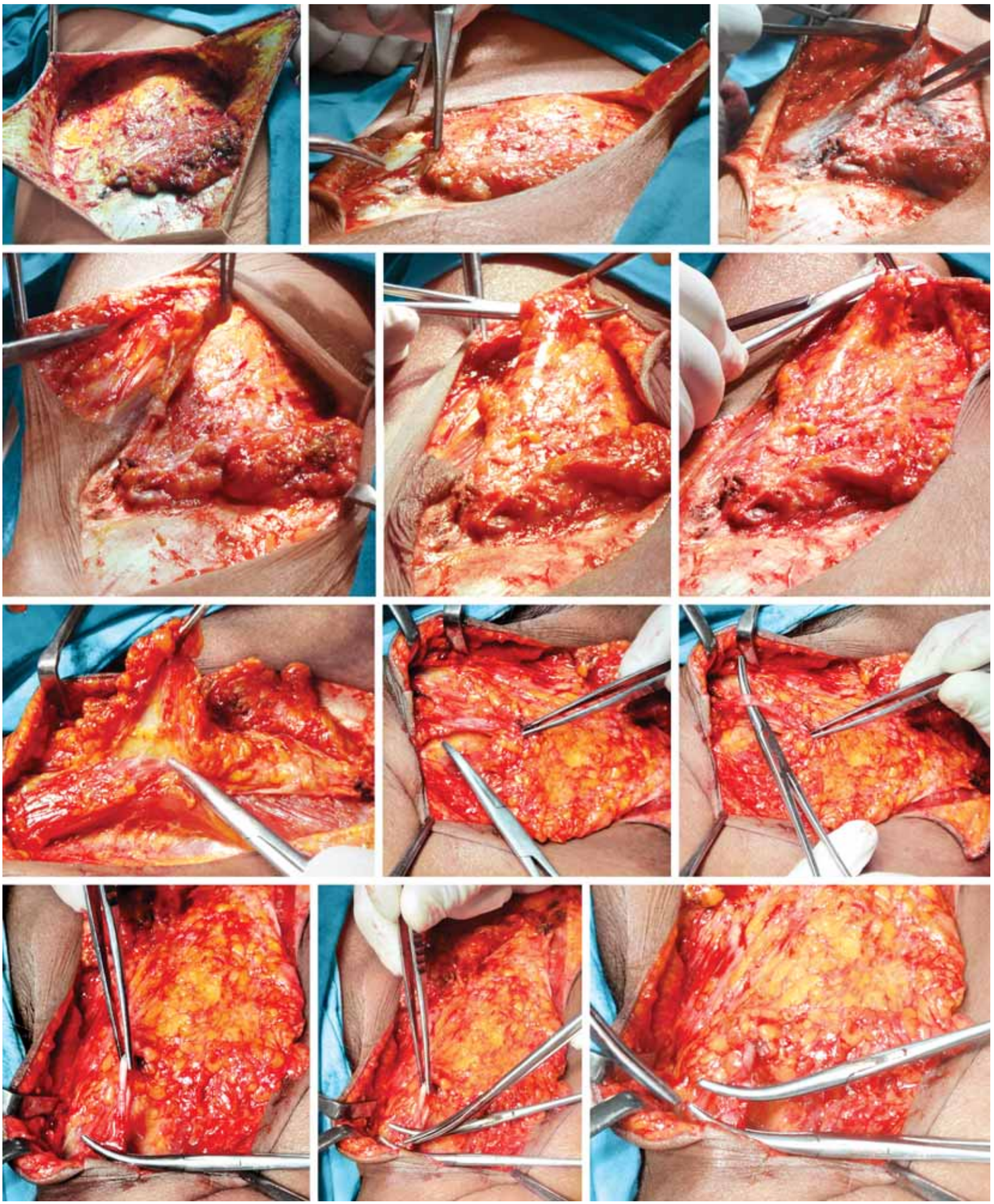

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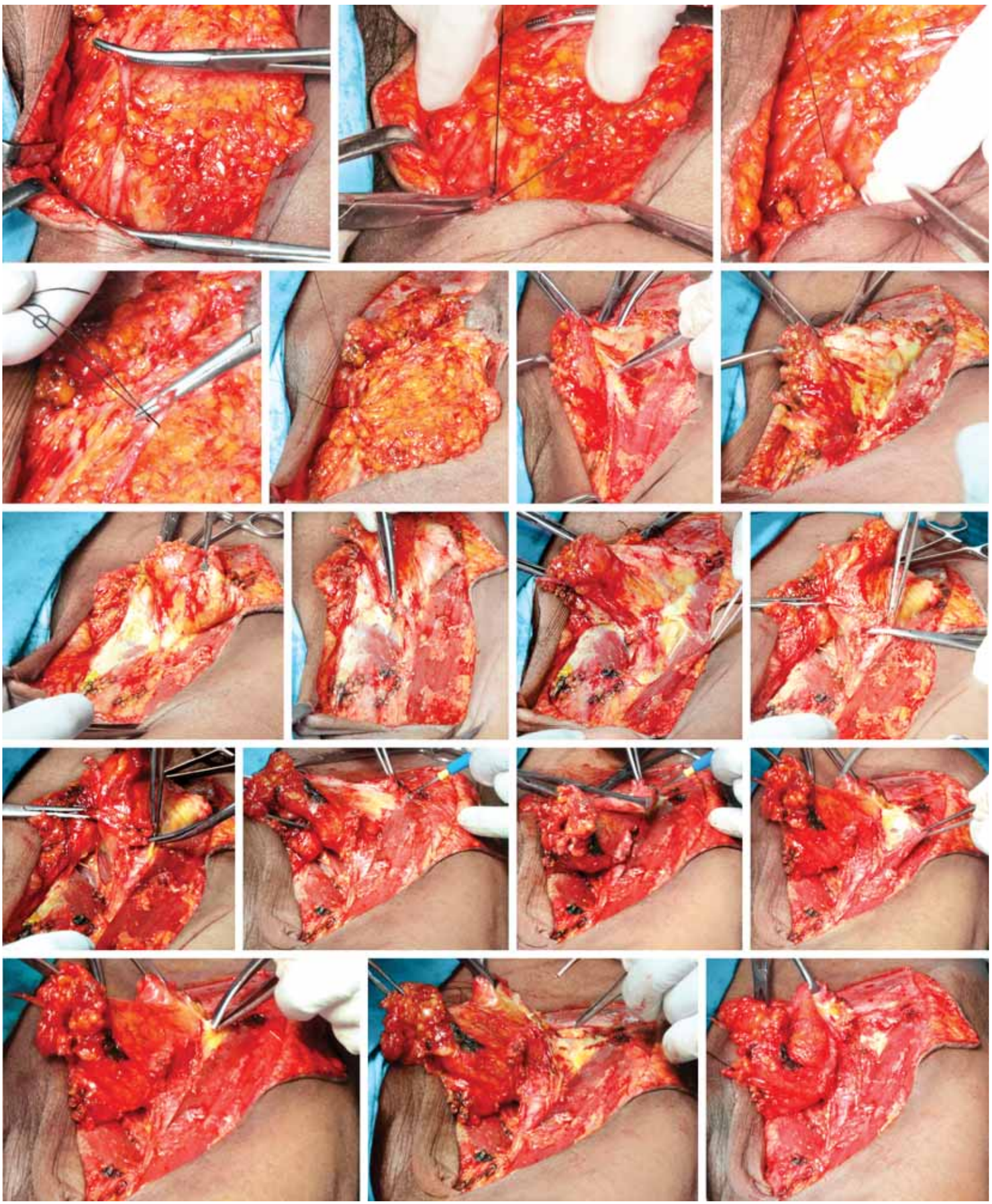
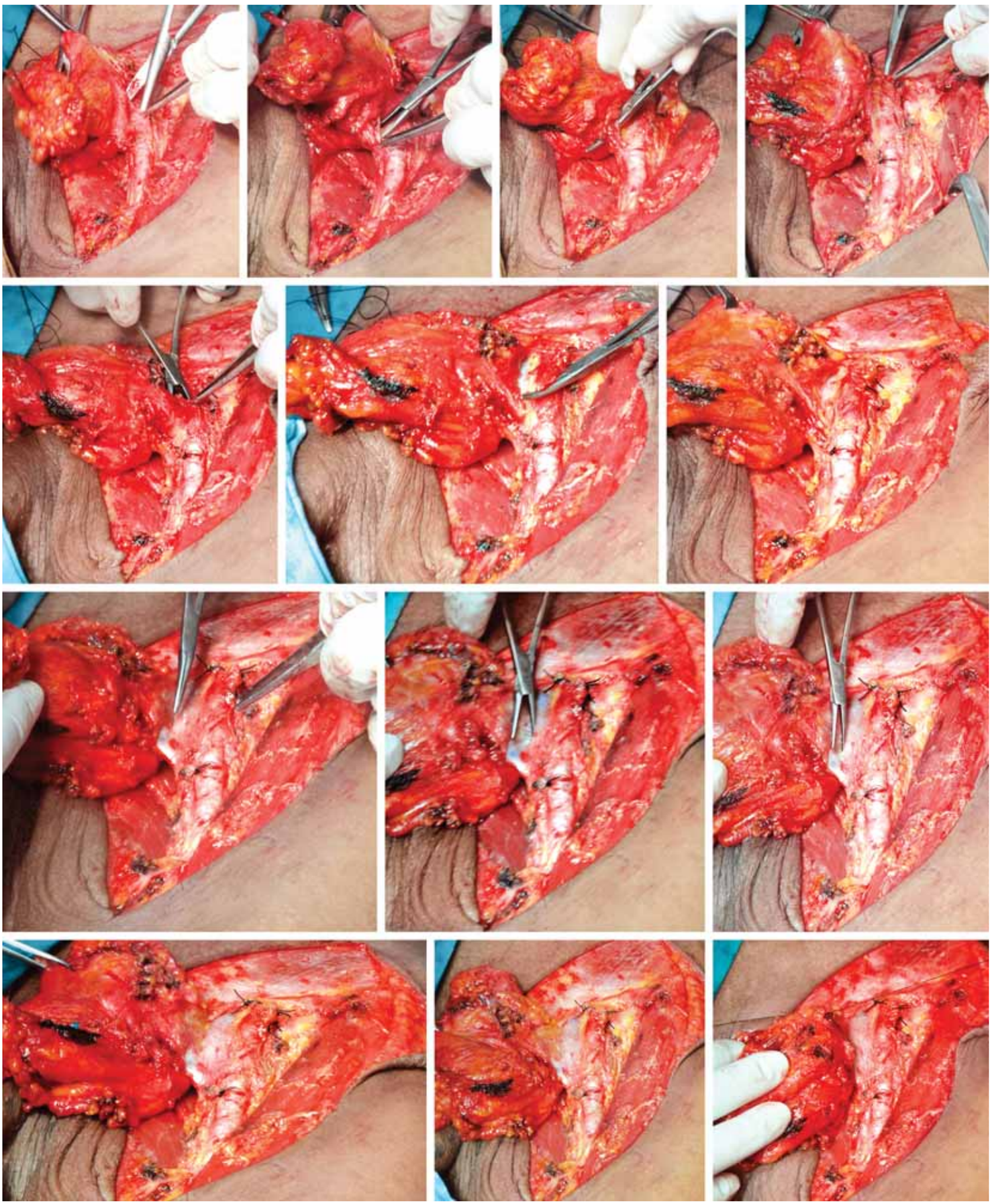


Figs 31-14(3)



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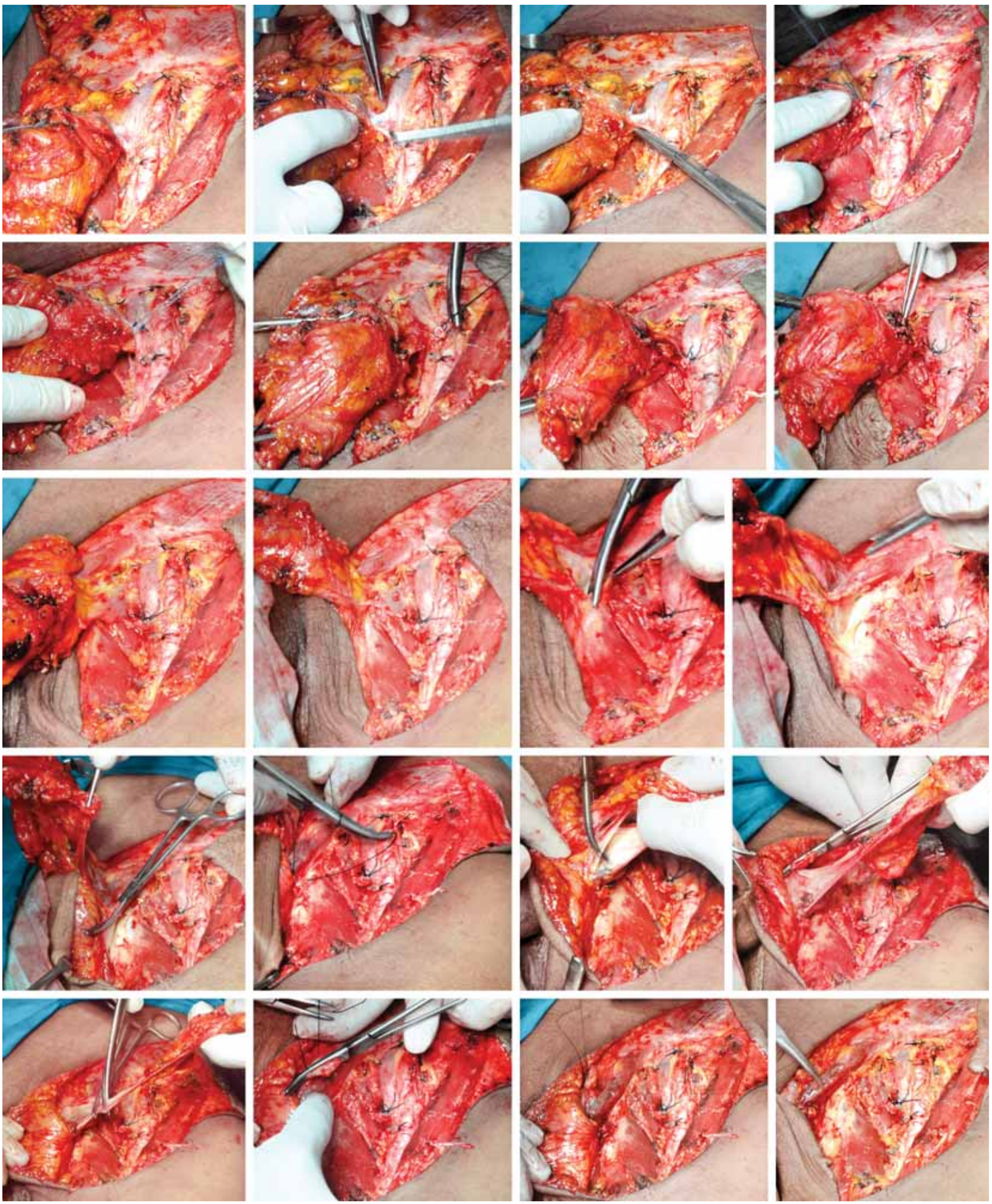
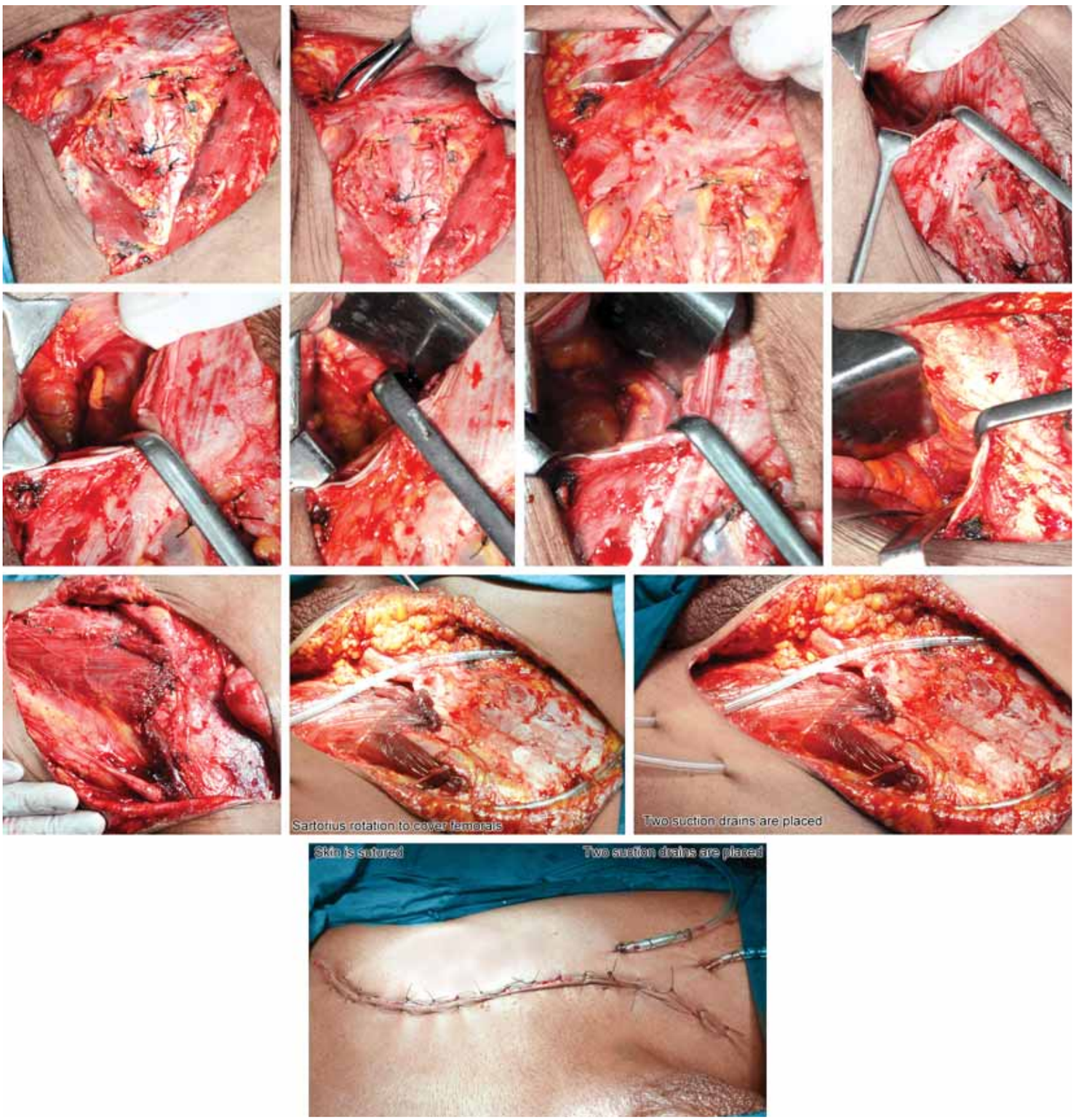


Figs 31-14(5)



Figs 31-14(6)

Figs 31-14(1 to 6): Technique of ilioinguinal block dissection done for carcinoma penis. 'S' incision is used here. 5 cm above the inguinal ligament is cleared. Pelvic lymphadenectomy (ileo-obturator/iliac) is also done; sartorius rotation is done; two drains are placed.

Procedure

Under G/A or spinal or local anaesthesia (cord block) , after cleaning and draping, vertical incision of about 6-8 cm in length is made over the scrotum, anteriorly 1 cm lateral to the median raphe. Skin, dartos, external spermatic fascia, internal spermatic fascia are incised. *Bluish* hydrocoele sac is identified, i.e. parietal layer of tunica vaginalis of testis (it is bluish due to congested venous network over the stretched sac). Fluid is evacuated using trocar and cannula. Sac is opened. Monopolar cautery should be used carefully otherwise testicular artery goes for spasm causing testicular atrophy. It is better to use bipolar cautery or fine ligatures for these bleeders **(Fig. 31-18)**.

Fig. 31-15: Split skin graft is often placed on the centre of the wound with excision of the skin over the femoral area around 3 cm with which avoids flap necrosis.

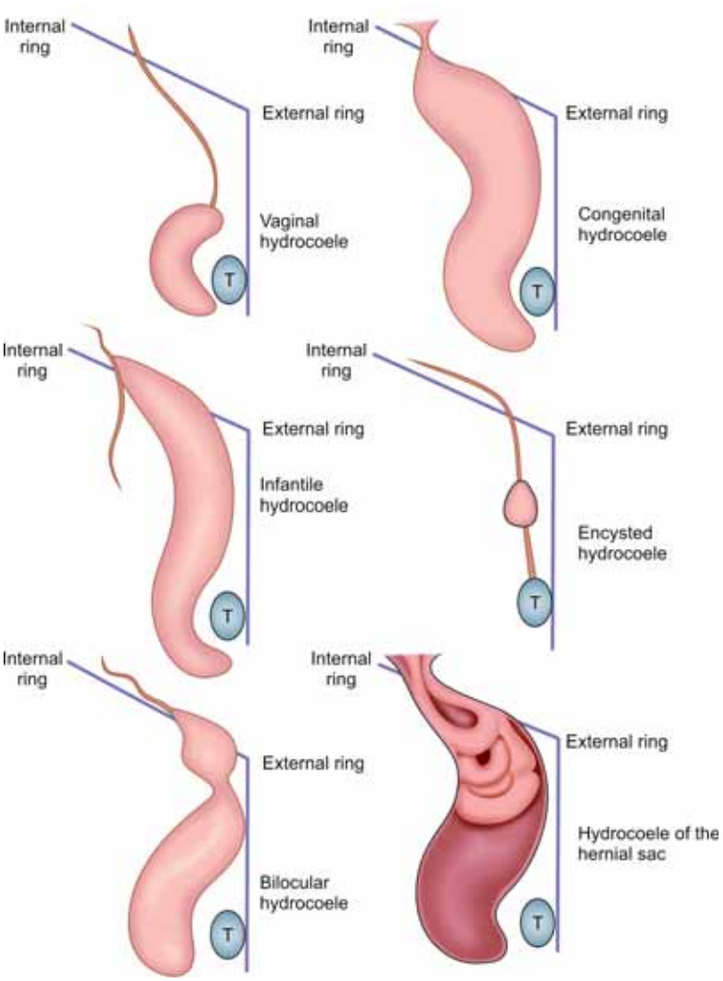


Fig. 31-16: Different types of hydrocoele.

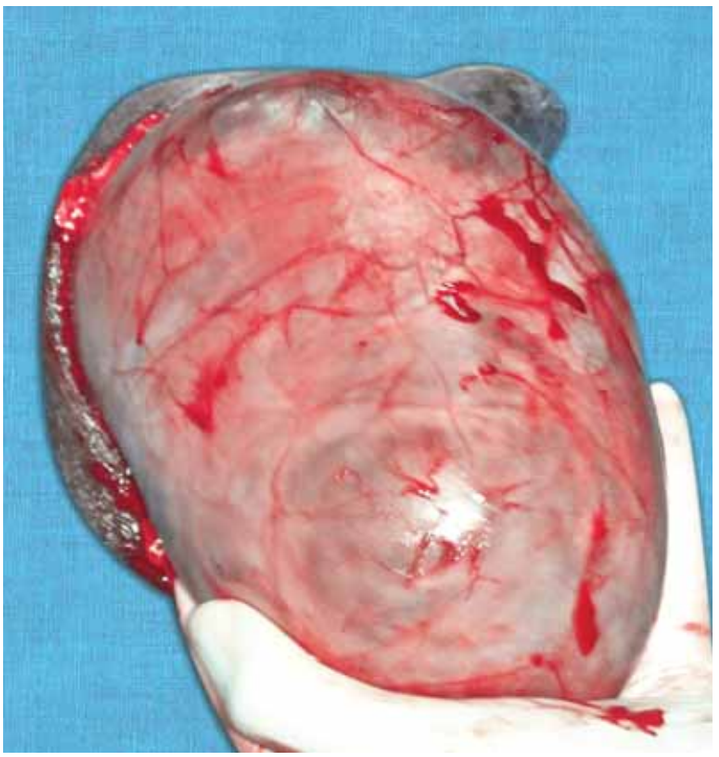


Fig. 31-17: Bluish coloured sac of the large hydrocoele.

Fig. 31-18: Trocar and cannula used to evacuate the hydrocoele fluid.

If the sac is small, thin and contains clear fluid, Lord's plication can be done, i.e. tunica is bunched into a "ruff" by placing series of multiple interrupted chromic catgut/vicryl sutures so as to make the sac to form fibrous tissue (It is relatively avascular and so haematoma will not occur).

Evacuation and eversion of the sac behind the testis also can be done if sac is thin and fluid is not infected. After eversion, everted sac is sutured with chromic catgut/3-0 vicryl by continuous sutures **(Fig. 31-19)**.

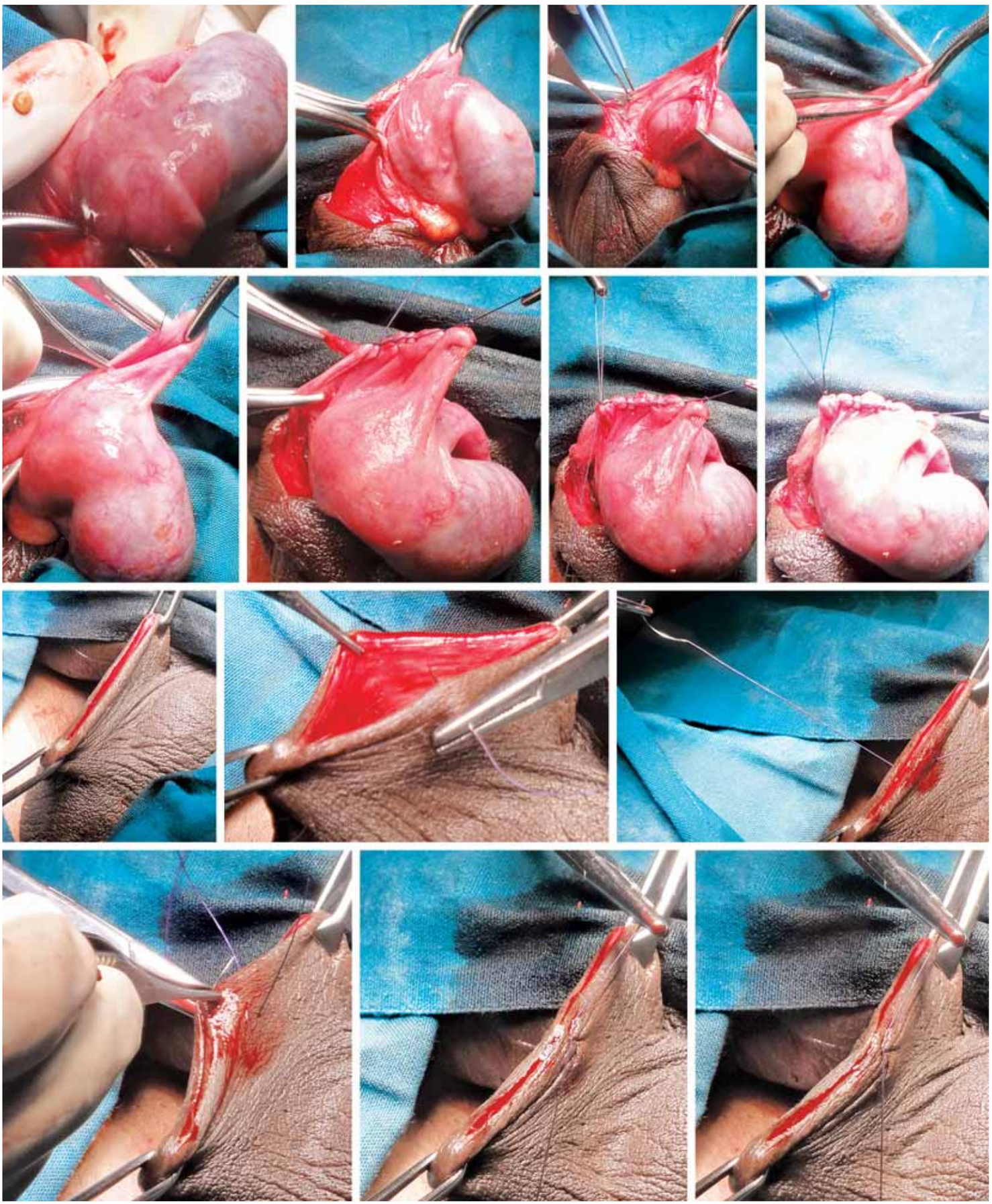
If the sac is thick, in large hydrocoele and chylocoele, subtotal excision of the sac is done (as tunica vaginalis is reflected on to the cord structures and epididymis posteriorly, total excision leads to orchidectomy with division of cord). It is also called as *radical cure or hydrocoelectomy*. It is ideal procedure for hydrocoele with least complications and recurrence **(Figs 31-20 and 31-21)**.

Alternatively, the sac is excised partially and then eversion is done and everted edges are sutured together, which is called as *Jabouley's* operation.

After evacuation, the sac with the testis can be placed in a newly created pocket between the fascial layers of the scrotum—*Sharma and Jhawer's technique.*

A drain is placed near the root of the scrotum on the lateral aspect because it becomes the most dependent portion, when scrotal support is given. Scrotal support is given to reduce the scrotal oedema.

Figs 31-19(1)



Figs 31-19(2)

Figs 31-19(3)

Figs 31-19(1 to 3): Technique of evacuation and eversion for hydrocoele surgery.

Fig. 31-20: chylocele.

Routinely, it may not be necessary but in large hydrocoele, infected hydrocoele it is better to keep a drain. Corrugated drain is commonly kept.

Wound is closed in layers, inner dartos with absorbable; outer skin with interrupted nonabsorbable sutures. *Presently* skin with dartos is closed as single layer with interrupted nonabsorbable monofilament sutures. Scrotal support is given to elevate the scrotum so that oedema of the scrotum will reduce and so also pain. Drain is removed in 48 hours **(Fig. 31-22)**.

In bilateral hydrocoeles, each side is dealt separately by two incisions on each hemiscrotum and two drains are kept. In small bilateral hydrocoele through median raphe approach both sides can be treated with evacuation, excision and eversion the sac (*single layer procedure*). However, in bilateral large hydrocoeles median raphe approach is not advisable.

Note

Aspiration must be avoided as much as possible as it is only a temporary measure (recurrence occurs very early) and chances of haematocele, infection are higher.

Encysted hydrocoele of the cord—It is located in the root of the scrotum. It is brilliantly transilluminant; traction test is positive; mimics epididymal cyst. It is treated by excision of the encysted hydrocoele through scrotal approach. Normal tunica vaginalis is also usually opened and everted **(Fig. 31-23)**.

Multiloculated hydrocoele is known to occur. If found each loculi should be opened and their sacs are removed **(Fig. 31-24)**.

Complications of Surgery

Reactionary haemorrhage is common. It causes haematoma formation with swelling, pain, distress. Small haematoma can be left alone, as it will resolve spontaneously. If haematoma is large it is evacuated after re-exploration, bleeders are ligated using vicryl. Wound is closed with a drain.

Infection is not uncommon. It may lead into wound disruption, sinus formation, and orchitis. Suitable antibiotics control this problem.

Pyocele can occur due to severe infection especially in diabetics. It is treated by proper drainage under general anaesthesia with warm saline irrigation and suitable antibiotics. On table Doppler can be used to check the viability of the testis. Orchidectomy can be postponed at a later period if needed during reinspection of the wound and testis under general anaesthesia.

Sinus formation—persistent sinus may be due to suture material reaction, or focus of infection or retaining the thick diseased sac. So, it is always better to excise the sac if it is thick, infected and diseased. Rarely need may arise to re-explore the sinus for complete excision. Specific disease like tuberculosis of the epididymis has to be thought of. Sinus track excised should be sent for histology.

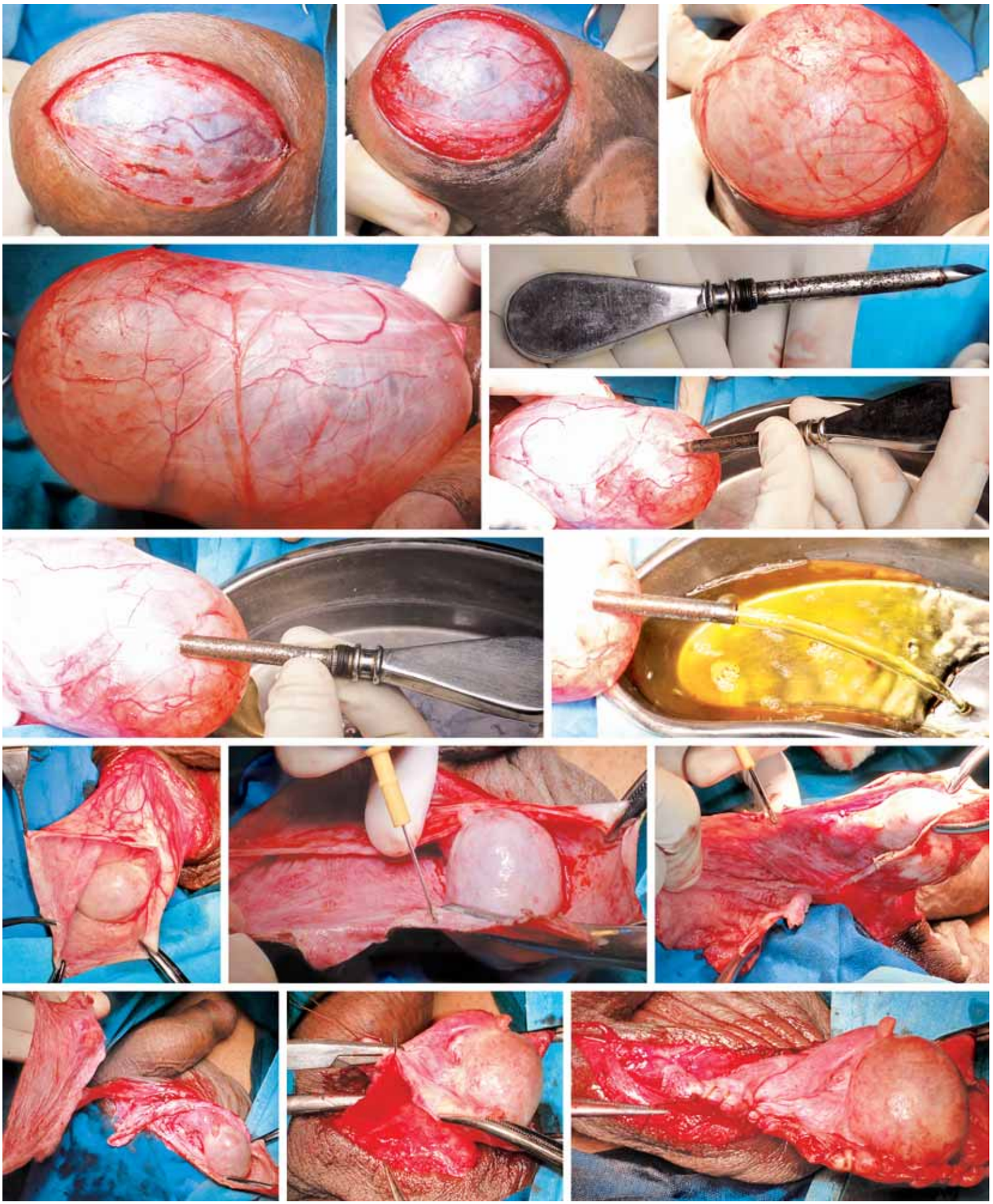
Recurrent hydrocoele is due to retained sac, formation of another sac or loculated sacs if present. It should be treated by resurgery again.

Conditions Where Orchidectomy is Done in Hydrocele

Pyocele with testicular destruction; Clotted haematocele with testicular destruction. Doppler study is a must before doing orchidectomy. Consent has to be taken. Doppler study of the opposite side also should be done. Low orchidectomy is done **(Fig. 31-25)**.

TREATMENT OF HAEMATOCELE

Acute haematocele is treated by incision and drainage under general anaesthesia. Chronic clotted organised haematocele is treated with low orchidectomy **(Fig. 31-26)**.



Figs 31-21(1)

Figs 31-21(2)

Figs 31-21(1 and 2): Radical cure/hydrocoelectomy/subtotal excision of the sac for large hydrocoele.

Fig. 31-22: Scrotal support is used in all scrotal surgeries to reduce oedema and pain.

Fig. 31-23: Encysted hydrocoele of the cord.

Fig. 31-24: Multiloculated hydrocoele.

Fig. 31-25: Pyocoele with nonviable testis is an indication for low orchidectomy.

TREATMENT OF PYOCELE

Antibiotics are started. Under general anaesthesia, scrotum is explored immediately and pus is evacuated. Viability of the testis is checked. On table Doppler study is ideal. If viable, pus is evacuated and sent for culture, wound is loosely closed with a drain or *ideally* left open and at a later date examination is done under anaesthesia to check for viability and secondary suturing is done with a drain if testis is viable. If the testis is not viable, then *orchidectomy* is done (after taking consent). When in doubt, always testis is left in place and observed. Often, testis will show signs of viability. If not, then low orchidectomy is done at a later stage.

VARICOCELE

It is dilatation and tortuosity of the pampiniform plexus of veins and so also the testicular veins. Normally, there will be numerous plexus of veins (pampiniform) in the scrotum, which all join together to form about 4-8 veins in the inguinal canal. Above, in the abdominal cavity, in the posterior abdominal wall all join to form a single testicular vein. On left side, it drains the left renal vein; on the right side it drains the inferior vena cava.

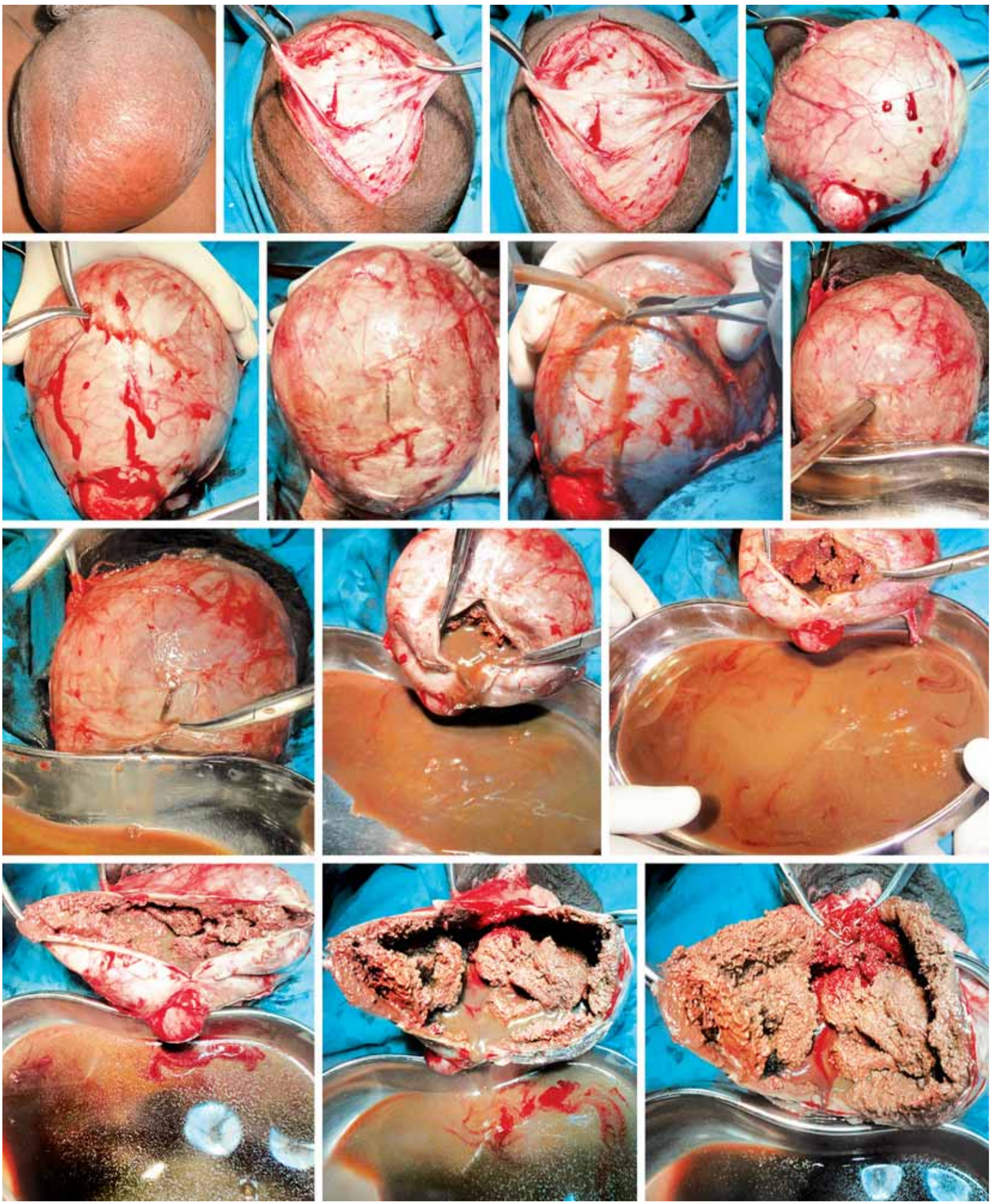
Varicocele is common in *tall, thin young men*. More common on the *left side*, but often can be bilateral **(Fig. 31-27)**.

Commonly, it is idiopathic in origin, may be due to absence or incompetent valve at the junction of left testicular vein and left renal vein causing inefficient drainage of blood. Other reason is, due to perpendicular (right angle) entry of the left testicular vein into the left renal vein. In left sided renal cell carcinoma, tumour proliferates into the left renal vein and blocks the entry of left testicular vein causing varicocele on left side which is *irreducible*. Varicocele causes increased temperature in the scrotum which depresses the spermatogenesis and so causes *infertility* (correctable infertility) **(Fig. 31-28)**.

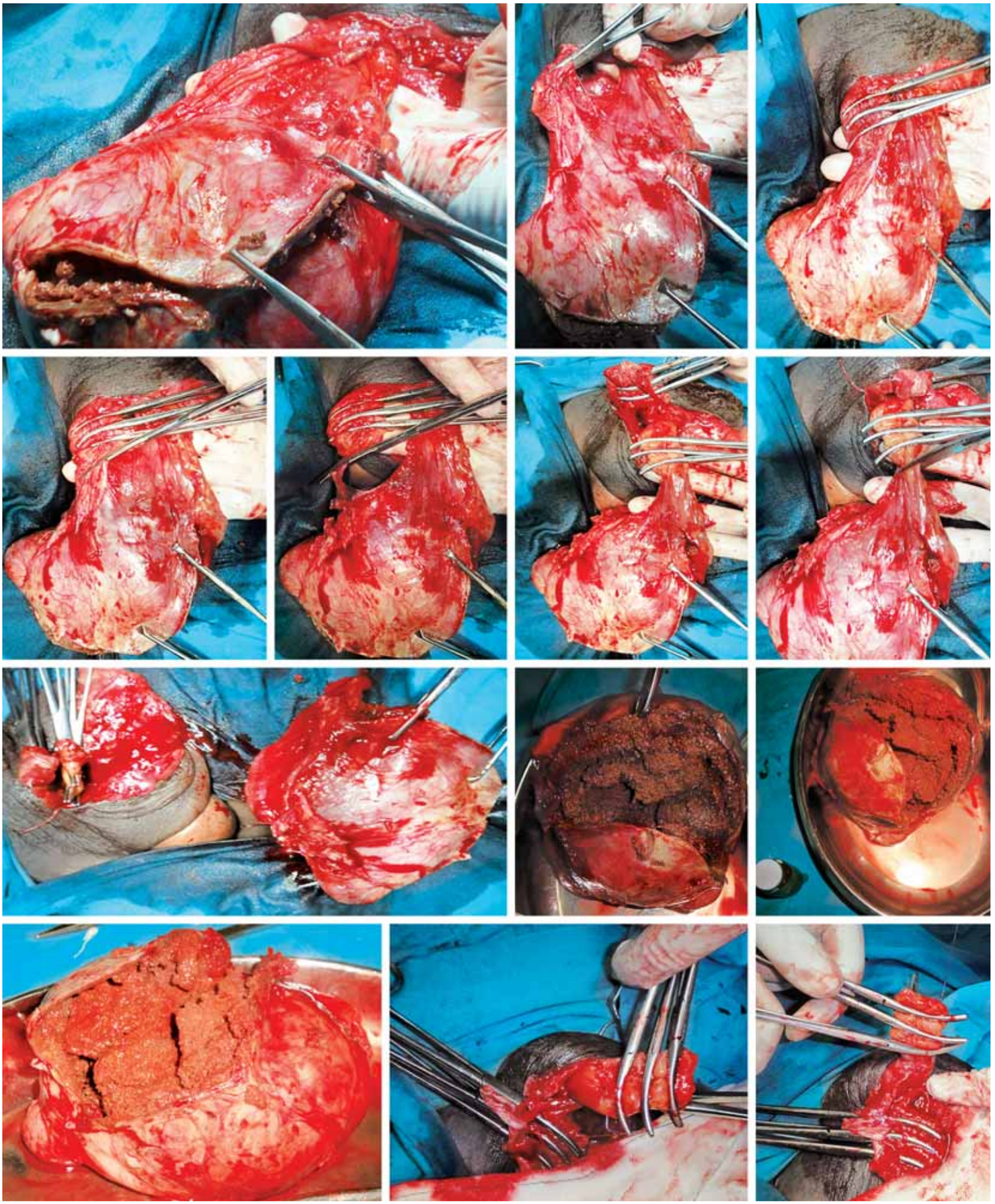
Types of Varicocele

Primary/idiopathic—95%: No cause is found. There is incompetence of valves of the testicular vein. It is common on left side because left testicular vein joins left renal vein perpendicularly and left side vein is longer and liable to get compressed by loaded sigmoid colon. Left renal vein is often compressed between aorta and SMA.

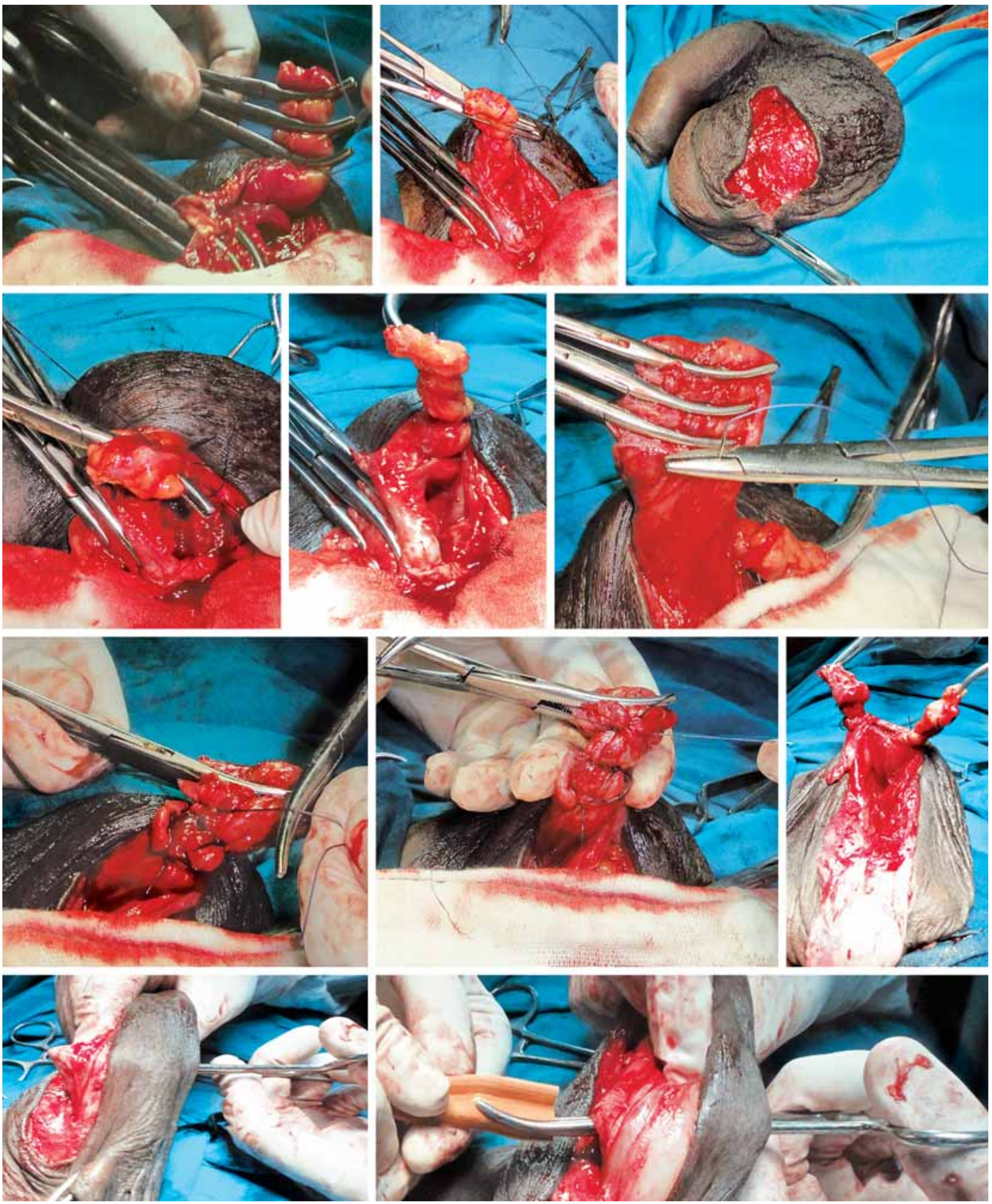
Secondary—due to specific cause like left-sided renal cell carcinoma with a tumour thrombus in left renal vein causing obstruction to venous



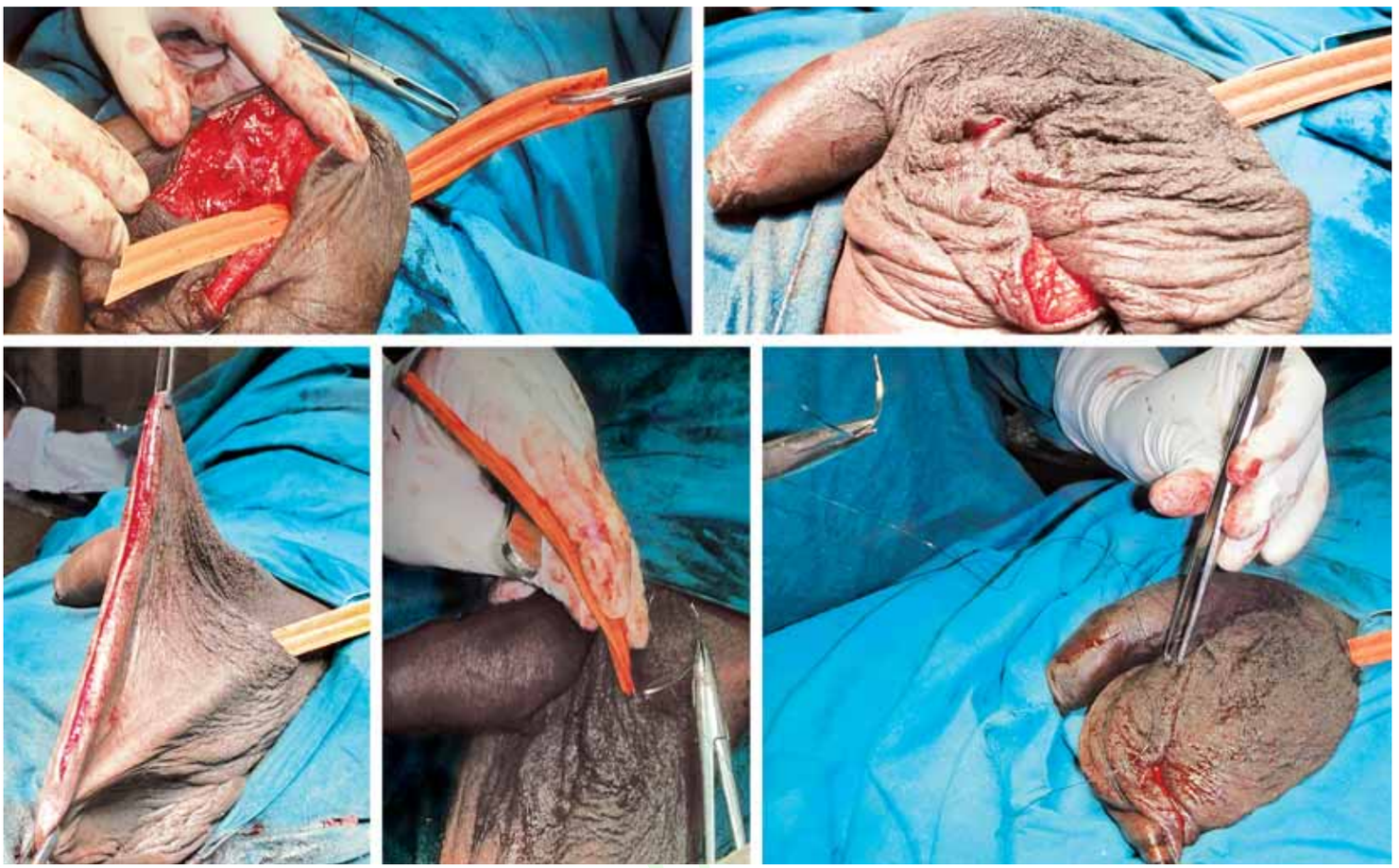
Figs 31-26(1)



Figs 31-26(2)



Figs 31-26(3)



Figs 31-26(4)

Figs 31-26(1 to 4): For chronic haematocele low orchidectomy is done through scrotal approach. Cord is divided between clamps and ligated by transfixation using 1 zero vicryl (absorbable) suture.

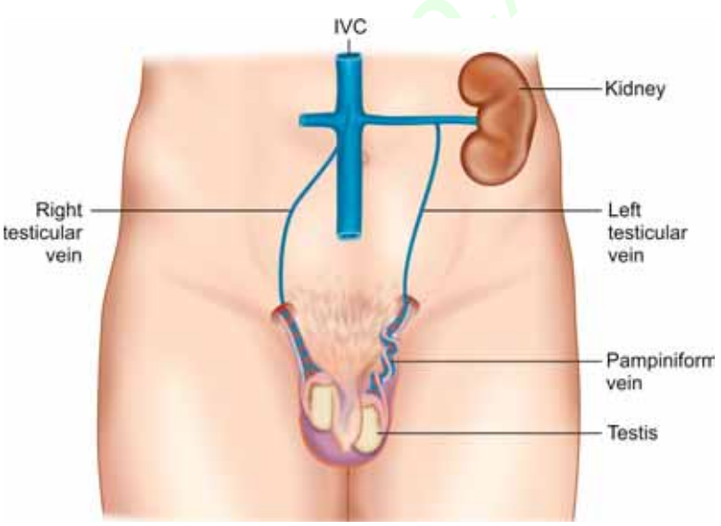


Fig. 31-27: Anatomy of testicular veins. Left testicular vein joins into left renal vein in perpendicular fashion. Right vein joins IVC directly.

Fig. 31-28: Varicocele—It is common on left side—'*bag of worms*' look. Note the on table look of dilated veins.

flow of left testicular vein. *Subfertility/infertility* are observed even in unilateral varicocele. It is a debate whether it really causes subfertility. Possible causes are: Altered heat exchange mechanism of the scrotum due to varicocele; hyperthermia; inhibition of spermatogenesis; increased blood flow; increased temperature in the testes; increases the metabolic activity using glycogen storage; depletion of glycogen → injury of parenchyma of testes; oligospermia; hypoxia of testes; same cause leads into Leydig cell dysfunction, decreasing testosterone levels. Final effect is maturation arrest and poor spermatogenesis.

Features

Swelling in the root of the scrotum; dragging pain in the groin and scrotum; *"Bag of worms"* feeling; impulse on coughing; on lying down it gets reduced (except in renal cell carcinoma); *Bow sign*: After holding the varicocele between thumb and fingers, patient is asked to bow. Varicocele gets reduced in size. Bowing reduces the blood flow of testicular vein and pampiniform plexus causing reduction in size.

Grading of varicocele—I. Small; II. Moderate; III. Large; IV. Severely tortuous.

Investigations—Venous Doppler of the scrotum and groin; U/S abdomen to look for kidney tumour; Semen analysis.

Treatment

Indications for surgery

Pain; Oligospermia—usually in 6-12 weeks oligospermia improves very well and also the conception rate.

Surgeries

Palomo's operation: Suprainguinal extraperitoneal ligation of testicular vein. Under spinal anaesthesia, above the inguinal canal in the line of anterior superior iliac spine lateral to the rectus muscle, horizontal incision is made; skin superficial fascia, external oblique are incised; internal oblique and transversus abdominis is split to reach extraperitoneal space. Careful blunt dissection identifies the testicular vein which runs upwards towards IVC on right side and towards left renal vein on left side. Testicular vein is dissected using right angle instrument, ligated and divided.

Inguinal approach (Inavissevich approach): Easier and safer. It is same as approaching for inguinal hernia in open method. After opening the external oblique, cord is mobilised and cremaster is opened; pampiniform veins are observed; dilated veins are individually dissected and ligated securely using silk or vicryl. There is no indication to do any repair of the posterior inguinal canal in this procedure.

Subinguinal approach *(Marc-Goldstein)*: It is subinguinal approach at superficial inguinal ring outside the external oblique aponeurosis without opening the external oblique aponeurosis. Here cord is easily identified through a small incision. Under local anaesthesia, pubic tubercle is marked. Cord after exiting though the external ring passes in front of the pubic tubercle before entering into the root of the scrotum. A small horizontally oblique incision is made directly on the pubic tubercle. Gentle careful dissection directly visualises the cord. Cord is dissected all around for a short distance. Ilioinguinal nerve is outside the cord very closely which should not be injured. Fine haemostat is passed underneath the cord structure to stabilise the cord. Cord is dissected by opening the overlying cremaster; dilated veins are individually dissected and ligated securely. One should not allow tear of the vein, if it happens upper part will retract and bleed which is difficult to identify and ligate. Skin is closed using absorbable sutures (subcuticular / interrupted). It is technically easier; inguinal canal is not opened **(Figs 31-29 to 31-30)**.

Scrotal approach: In case of grade IV, veins have to be excised through this approach. Vertical paramedian incision is made in the scrotum, cord is identified and dilated veins are dissected and securely ligated with vicryl. Often tunica vaginalis sac is opened and everted to prevent possible chance of developing hydrocoele due to lymphatic disruption.

Laparoscopic approach: Earlier it became very popular as technically, it was very easy. Under general anaesthesia, with head down position, after creation pneumoperitoneum, laparoscope is passed through umbilical port. Additional 5 mm or 10 mm ports are placed. Testicular veins are identified on both sides which run retroperitoneally upwards and medially. Peritoneum is incised; vein is dissected and clipped; alternatively bipolar fulguration or intracorporeal ligation can also be done. Once a enthusiastic procedure due to high recurrence rate its efficacy and acceptance is slowly going way.

Complications of varicocele surgery

Haemorrhage and scrotal haematoma; infection, pyocele; injury to testicular artery; injury to ilioinguinal nerve and pain; recurrence—5-10%.

TREATMENT OF CYST OF EPIDIDYMIS

It is due to the cystic degeneration of: Paradidymis (organ of Geraldes)—is the most common cause; appendix of the epididymis; appendix of the testis; the vas aberrans of Haller. Eventhough it is of congenital origin, it occurs in middle age. It is tensely cystic, contains clear fluid; often bilateral. They are aggregation of number of small cysts and so *multiloculated.* They feel like *'bunch of tiny grapes'* situated behind the body of the testis. Because of numerous septae they are finely tessellated and so are brilliantly transilluminant, appear like *'chinese lantern pattern'* **(Figs 31-31A and B)**.

Avoid excision as much as possible as it results in infertility in young individual as it may block the sperm transfer. In old age, excision can be done. Approach (scrotal) and technique is similar like for hydrocoele. Cyst is excised and scrotal wound is closed.

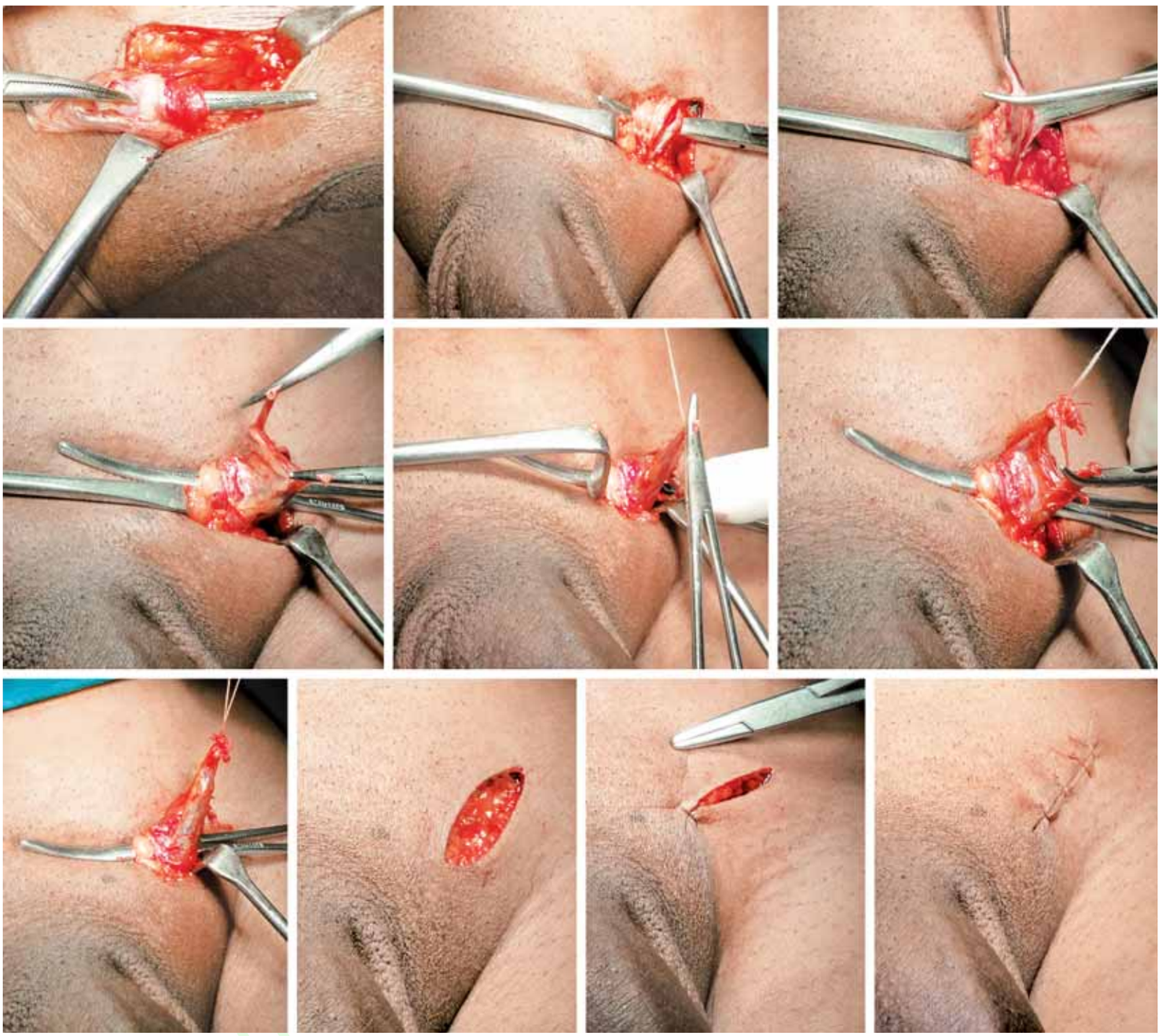
TREATMENT OF SPERMATOCELE

It is a *unilocular, acquired retention cyst* derived from blockage of some portion of the sperm conducting mechanism of the epididymis. It is situated in the head of the epididymis, above and behind the body of the testis. Swelling contains *barley water like fluid,* which contains spermatozoa. It is soft, cystic and transilluminant. It is often considered by the patient as having an additional testis. Aspiration cytology confirms the diagnosis. *Treatment:* It can be left alone. If it is large, excision is done through scrotal approach **(Fig. 31-32)**.

SURGICAL ANATOMY OF TESTIS

It is the male gonad**.** It is suspended in the scrotum by the spermatic cord. It lies obliquely such that its upper pole is tilted forwards and

Figs 31-29(1)



Figs 31-29(2)

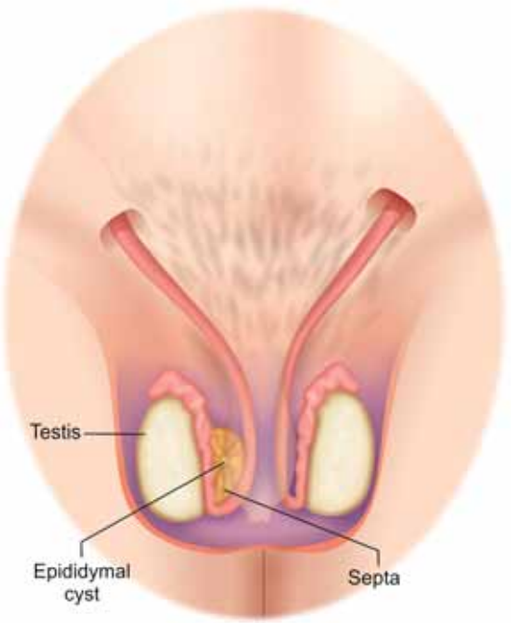
Figs 31-29(1 and 2): Technique of subinguinal varicocele repair.

Fig. 31-30: Subinguinal incision both sides for bilateral varicocele ligation of veins.

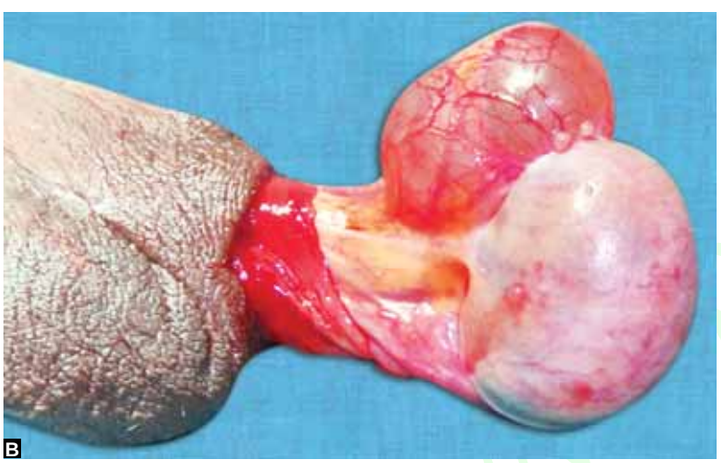
laterally. It is 4 cm long, 2.5 cm broad, 1.8 cm thick with a weight 15 grams (adult). Epididymis lies along the lateral part of the posterior border **(Fig. 31-33)**.

Descent of Testis

Testis develops from mesonephros at T10,11,12 segments. Both side they descend downwards towards scrotum. It appears in 2nd month of intrauterine life; reaches iliac fossa in 3rd intrauterine month; between 4th to 7th month rests in deep inguinal ring; 8th month reaches external ring; at 9th month before delivery reaches to bottom of the scrotum. Factors are hormones, gonadotrophins, differential growth of body wall; action of gubernaculum; intra-abdominal pressure and temperature **(Fig. 31-34)**.



A



B

Figs 31-31A and B: Epididymal cyst.

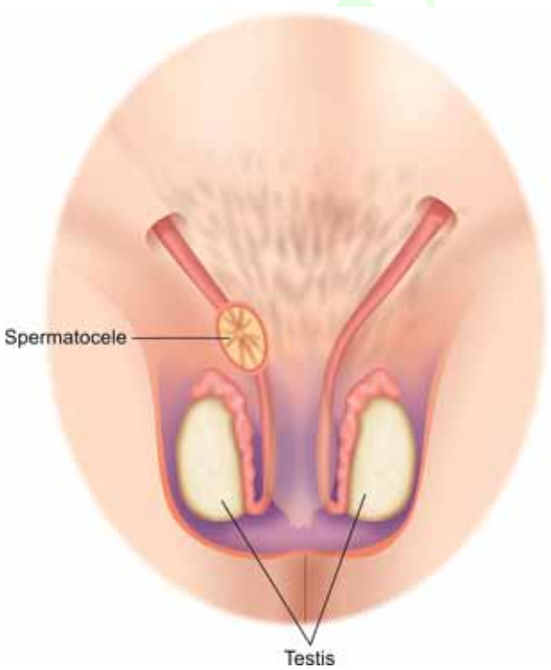


Fig. 31-32: Diagram showing position of spermatocele.

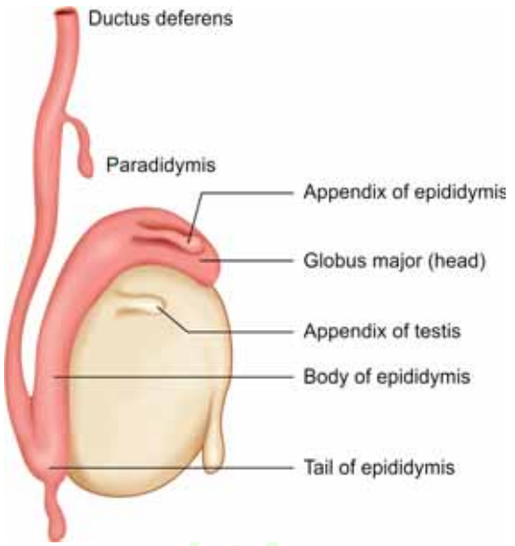


Fig. 31-33: Anatomy of the testis.

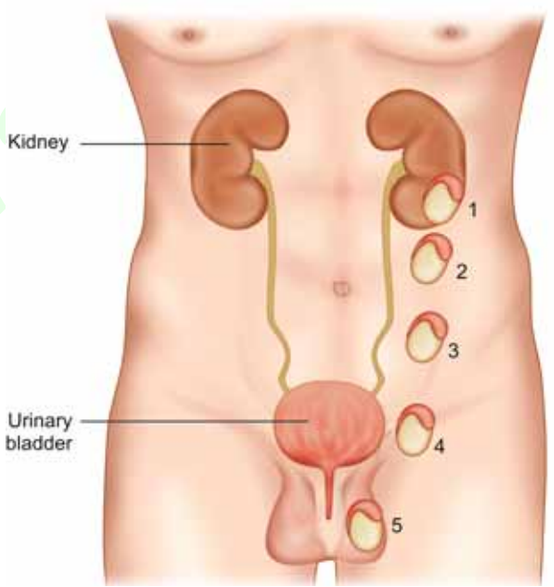


Fig. 31-34: Stages of testicular descent.

Coverings of the Testis

1. Tunica vaginalis—lower persistent portion of processus vaginalis.
2. Tunica albuginea—dense, white fibrous coat covering the testis; the posterior border of which is thickened to form the mediastinum testis. Numerous septa extend from it into the inner surface to create around 300 lobules.
3. Tunica vascularis is innermost vascular layer lining the lobules.

Structure of Testis

Testis contains 200-300 lobules, each containing 2-3 seminiferous tubules. Each tubule is 60 cm in length but heavily coiled. Diametre of the tubule is 0.2 mm. Lining of tubule contain cells of different stages of spermatogenesis. These seminiferous tubules join together to form around 30 straight tubules; they enter mediastinum of testis; after joining each other to form rete testis which contains network of

tubules. Rete testis gives 30 efferent ductules which comes out at the superior pole of the testis and enters the epididymis with a coiled ductules to form head of the epididymis. A single duct is formed in the body and tail of the epididymis to continue as vas deferens at the lower pole of the testis.

Arterial Supply

Testicular artery, a branch of abdominal aorta arises at the level of 12th vertebra a little below the origin of renal arteries; runs downwards and laterally on the psoas major in the posterior abdominal wall crosses the IVC, ureter and genitofemoral nerve on the right side. On right side, it is deep to the ileum (small bowel, terminal ileum). On the left side, artery crosses the left ureter, left genitofemoral nerve running on the left psoas major lying deep to colon. It travels downwards to enter the internal inguinal ring and inguinal canal. It runs in the spermatic cord (within the cord anterior to the vas deferens) to reach the posterior border of the upper pole of the testis. It divides into smaller and larger branches. Medial and lateral branches pierce the tunica albuginea to reach tunica vasculosa.

Venous Drainage

It is by forming pampiniform (*like a vine)* plexus of veins which ultimately fuse to form single vein, which drains into IVC on right side, left renal vein on left side. In the scrotum, its anterior part is around the testicular artery; middle part is around vas deferens and testicular artery; posterior part is isolated. It forms four veins at external ring; two veins at internal ring; single vein at retroperitoneum.

Lymphatic Drainage

It is into para-aortic and pre-aortic group of lymph nodes at the level of L_2 vertebra.

UNDESCENDED TESTIS

Complications of Undescended Testis

Sterility; trauma and pain; an associated indirect inguinal hernia (70%); torsion testis; epididymo-orchitis (as the pain will be high up it mimics acute appendicitis); testicular atrophy; *malignant transformation in undescended testis is 20 times more common* than normally descended testis. It is higher in abdominal than in inguinally located testis. *Seminoma* is the most common malignancy in undescended testis. The testis which has normally descended on other side (in case of unilateral undescended testis), is also more prone for malignant transformation than normal individual.

Investigations

Abdominal ultrasound (U/S) is done but intra-abdominal testis is difficult to detect in U/S. Assessment of FSH, hCG. If FSH is high in a young boy, that means there is bilateral anorchia. CT scan can be done probably to locate the abdominal testis; gonadal venogram; laparoscopy—quiet useful and therapeutic also; blind ending *vas deferens* in laparoscopy is called as *vanishing testis*. It means testis has completely atrophied **(Figs 31-35 and 31-36)**.

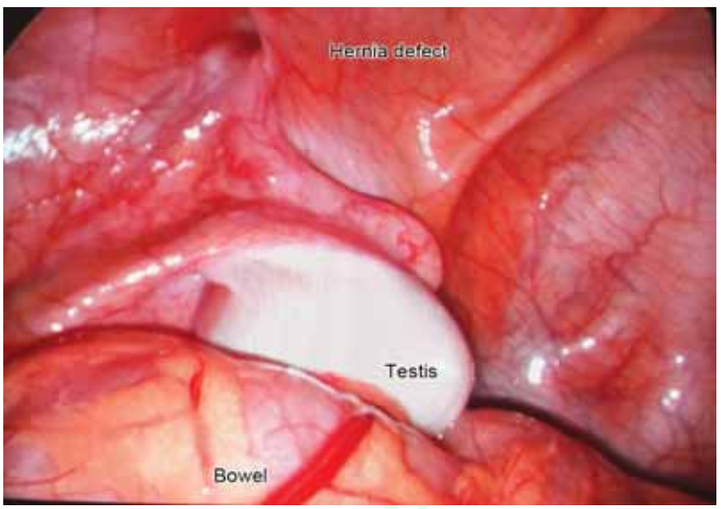
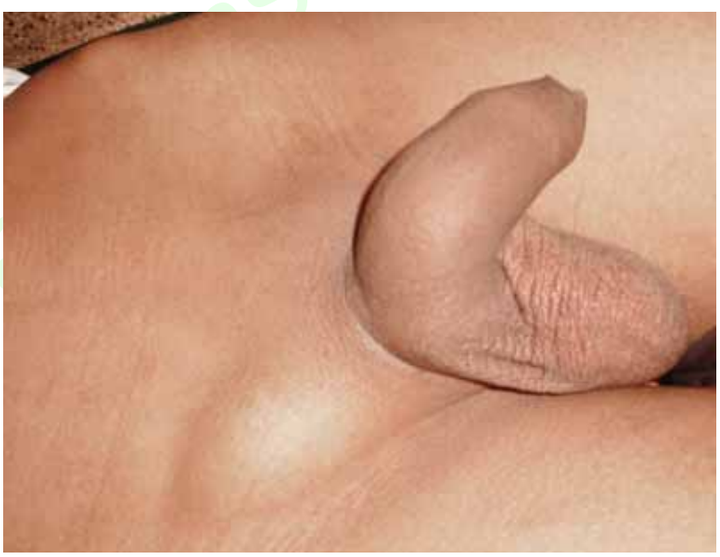


Fig. 31-36: Laparoscopic view of undescended testis adjacent and deep to internal ring.



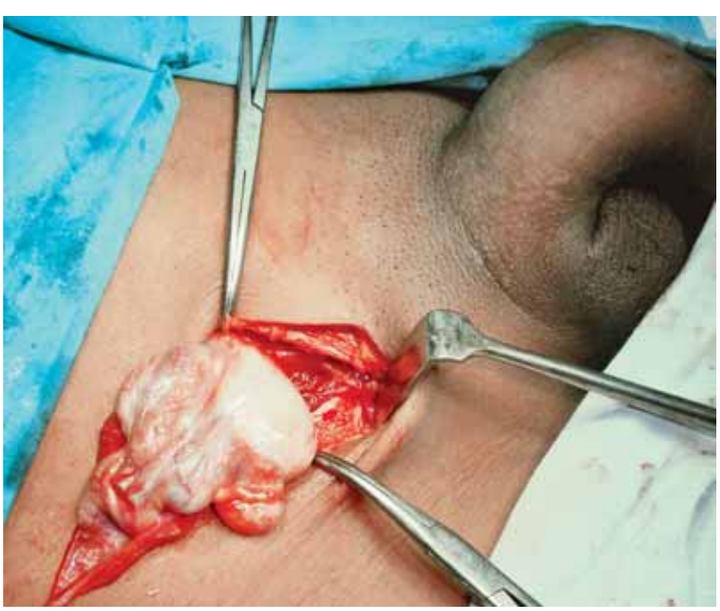


Fig. 31-35: Undescended testis; on table finding.

Treatment

Treatment is always surgery. Surgery is done between two and four years of age.

Principles

Mobilisation of cord to achieve adequate length is important. Repair of associated inguinal hernia is essential as it is a very common association. Finally needs adequate scrotal fixation without tension which will keep the testis in place and prevents its retraction into the groin during healing.

Mobilisation of Spermatic Cord

Under general anaesthesia in children, spinal in adult after cleaning and draping, inguinal canal is opened with lengthy incision like for inguinal hernia. Hernial sac is identified; often cord will be less developed and testis will be smaller than normal. Unless sac or tunica vaginalis is opened it is often difficult to identify the undescended testis. Herniotomy is done. Inferior epigastric vessels are ligated to lengthen the cord. If length is still required, vas and testicular vessels are mobilised retroperitoneally. If further length is required then a soft clamp is applied to the testicular artery and the viability of testis is checked. If it is viable that means it is also receiving blood supply from the artery of vas or cremaster vessels. Then testicular artery can be ligated safely so that adequate length can be achieved to bring down the testis to the scrotum—*Stephen-Fowler's technique.*

Fixation of the Testis

Proper scrotal pouch is created by finger dissection. Fixation of the testis into the scrotum is done using nonabsorbable interrupted sutures (polypropylene). A small scrotal incision is made at the bottom of the scrotum. Long haemostat is passed through the scrotal wound across the scrotum to inguinal wound; stay suture placed at the gubernaculum is held with haemostat and pulled gently out towards the scrotal wound. Interrupted bites are taken between tunica albuginea and scrotal wall; usually three bites are taken from below upwards using 3 zero polypropylene suture. Knots are tied at the end. Scrotal wound is sutured. Inguinal wound is closed in layers.

In bilateral cases, testis is passed into the opposite scrotum through an opening in the scrotal septum —*Ombredanne's operation* **(Fig. 31-37).**

If the testis is totally atrophied, *orchidectomy* should be done after taking consent, because even though this is a nonfunctioning testis, it is highly prone for malignant transformation. Removed testis should be sent for histology.

Laparoscopic orchidopexy: Laparoscopic mobilisation of the testis is very useful. Under general anaesthesia, head down position, ports are placed on both sides at the level of the umbilicus. Gonadal vein is identified and traced downwards to reach the testis. Usually it will be very close to the internal ring. Peritoneum is incised close to the cord and the testis and mobilised. Hernial sac is dissected like in laparoscopic hernia repair. Once adequate mobilisation is done like in open method small scrotal incision is made and through a long haemostat mobilised testis is pulled down to scrotum to fix it similarly. Inferior epigastric vessels can be clipped and divided through laparoscopy safely which will add on to the extra length of the cord.

Role of hormone therapy: Not much. Only indications are cryptorchidism associated with hypogenitalism and obesity and doubtful retractile testis. It should be given at or after the age of eight. hCG (Chorionic gonadotrophin) 1000 I/U—twice weekly for maximum of ten weeks (not more than 10 weeks). It stimulates Leydig cells to produce testosterone. GnRH—1.2 mg/day as nasal spray for one month.

Note: In bilateral case surgery is done with an interval of 6 months.

Ladd and Gross procedure: After placing the testis in the scrotal pouch, it is fixed by a polypropylene suture into tunica albuginea, across scrotal skin and into the thigh skin outside. This suture is removed in 14 days.

Keetley-Torrek procedure: Testis is mobilised and is brought into the scrotal pouch first. Then it is brought out through scrotal skin. A pouch is created on the medial aspect of the thigh outer to fascia lata, deep to thigh skin after making skin incision. Testis delivered from scrotal pouch is placed into the thigh pouch. Scrotal and thigh incisions are sutured around the cord inside. After 6 months scrotal sac with cord and testis is separated and placed in the scrotal pouch.

Laparoscopic approach: Orchidopexy has become popular and accepted method.

Orchidopexy may not alter the chances/risk of developing carcinoma of testis. But it makes easy observation and evaluation by ultrasound to detect the possible changes early.

Orchidectomy is considered if there is atrophy; torsion; inability to bring down abdominal testis.

Testicular biopsy in infertility to study spermatogenesis is sent in *Bouin's fluid*—picric acid (75%); acetic acid (25%). It should not be sent in usual formalin.

Surgeries in undescended testis

External anchorage—Ladd and Gross
Ombredanne's procedure
Denis-Brownes operation—narrowing of the neck and external anchorage
Keetley-Torrek procedure into the thigh
Dartos pouch creation and placing the testes
Stephen-Fowler's technique
Silbar procedure—autotransplantation with microvascular anastomoses into inferior epigastric vessels

ECTOPIC TESTIS

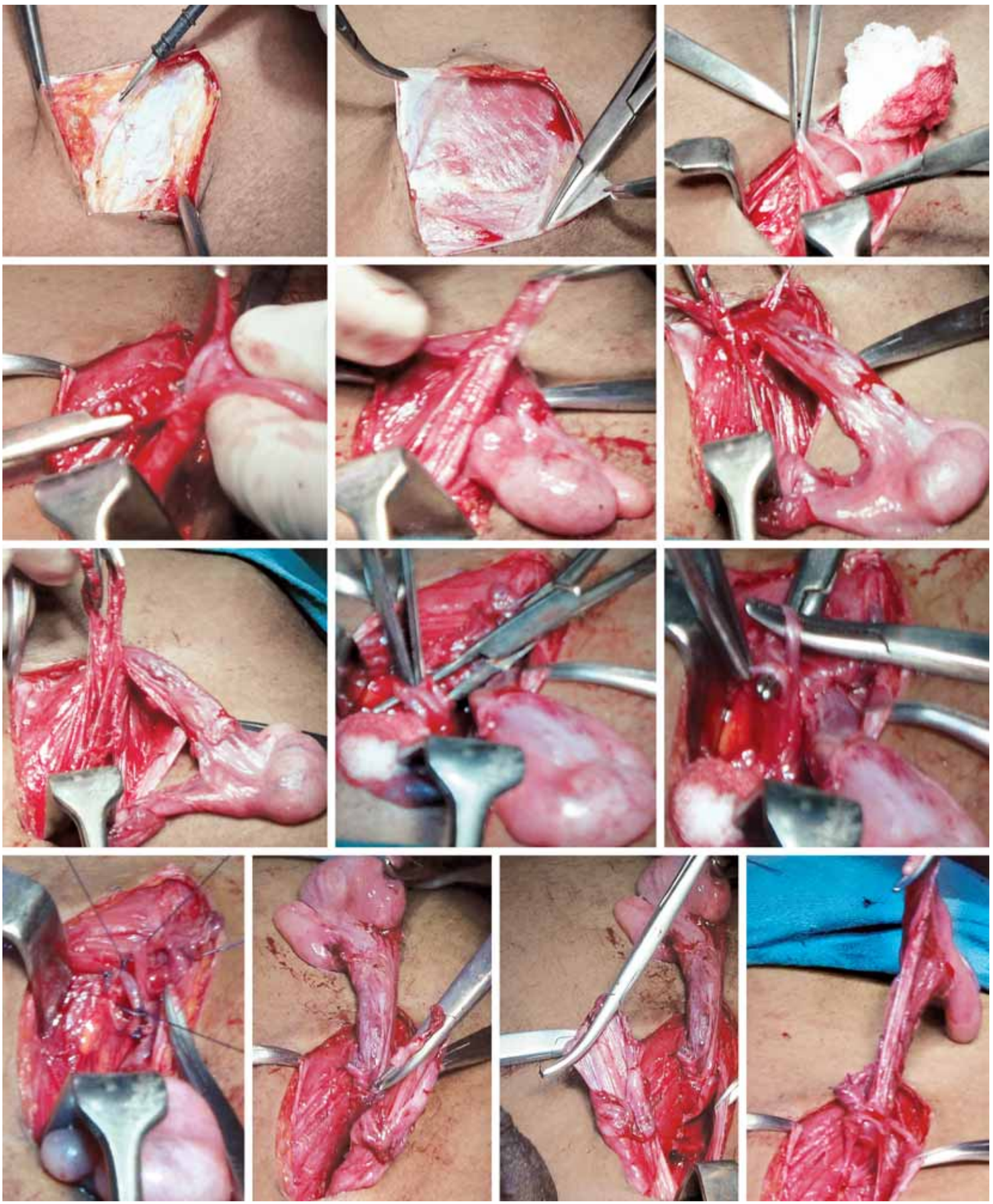
Lockwood theory: Even though there are multiple gubernaculum, scrotal tail normally gets activated better and so testis is brought down to the scrotum. In ectopic testis, scrotal tail weakens or ruptures and so one of the other accessory tails will act and pulls the testis in direction according to its site.

Different Sites

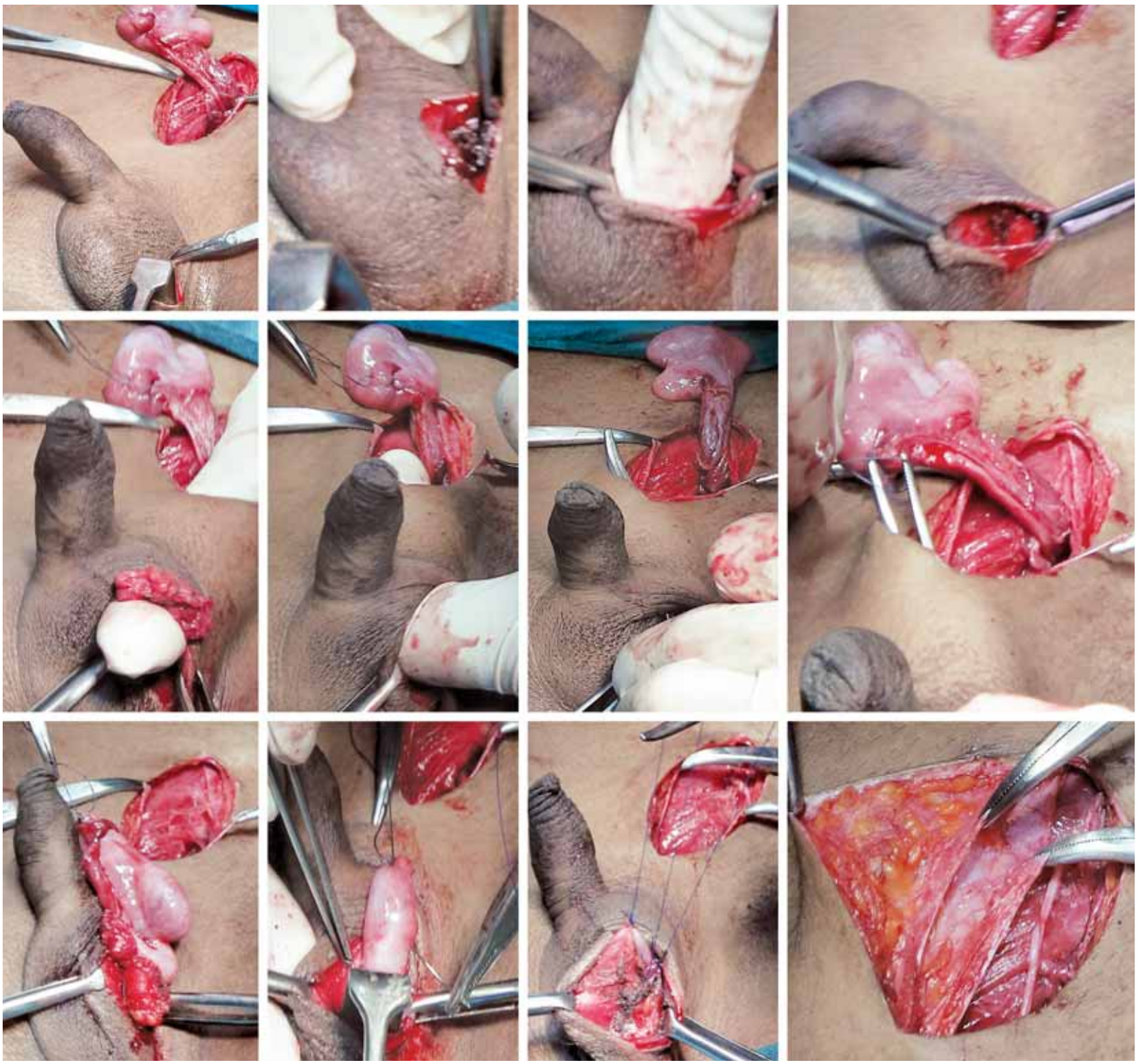
Superficial inguinal pouch; perineum; root of the penis; femoral triangle (thigh) **(Fig. 31-38)**.

Testis, here functions normally and is of normal in size. It is more prone for trauma and can cause psychological problem.

Superficial inguinal pouch is a space between external oblique and Scarpa'a fascia. On raising the legs, ectopic testis in superficial inguinal pouch becomes more prominent but not in case of undescended testis located in inguinal canal.



Figs 31-37(1)



Figs 31-37(2)

Figs 31-37(1 and 2): Orchidopexy—technique in undescended testis.

Treatment

Mobilisation and creation of a new scrotal pouch to place and fix the testis to scrotal pouch using polypropylene interrupted sutures.

TREATMENT OF TORSION TESTIS

Emergency exploration of the scrotum and untwisting of the torsion testis is done. Then viability of testis is checked. Arterial Doppler of both sides is must. Twisted testis will be viable only for 6 hours—critical period/golden period so urgent correction twist and fixation is essential **(Figs 31-39 to 31-41)**.

Once viability is confirmed, the testis is fixed to the scrotal sac using three interrupted nonabsorbable sutures (3-0 polypropylene). Fixation should be done using only nonabsorbable sutures, never absorbable sutures. If surgery is done within 6-12 hours, viability of the testis may be retained. If delayed, testis becomes gangrenous and *orchidectomy* is done after taking informed consent. *When in doubt, testis is retained and orchidectomy can be postponed to later period* so as to give a chance to have a viable testis. Here *early exploration is an important aspect.* When diagnosis is in doubt, exploration is advised.

Postoperatively, a repeat Doppler study helps to confirm the viability. As often the condition is *bilateral, other side testis should also be fixed to prevent the torsion.* Approach to other side should

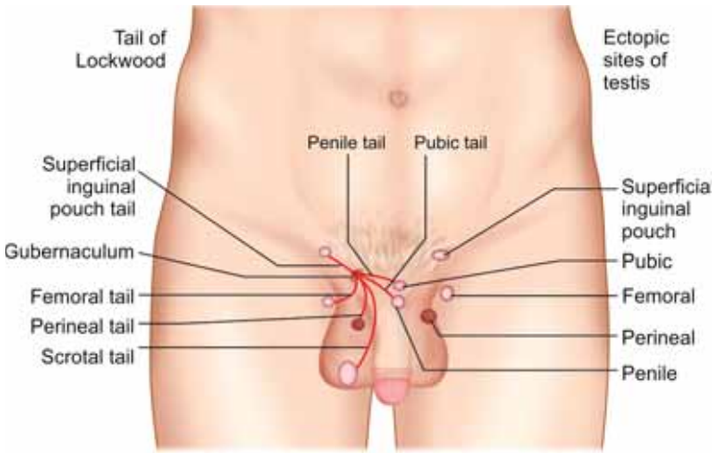


Fig. 31-38: Tails of Lockwood and ectopic testes.

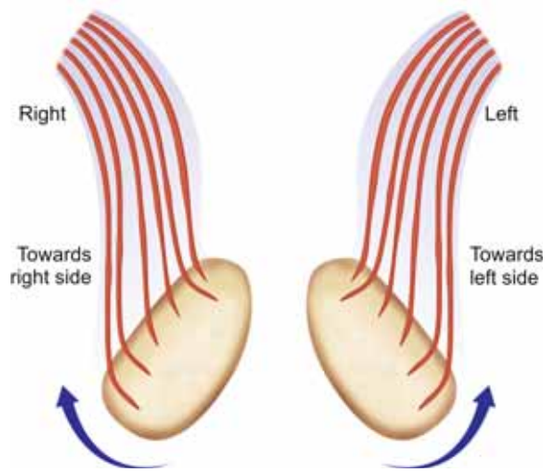


Fig. 31-39: Direction of torsion of testis is always outwards.

be different through other side hemiscrotum. It is better to avoid approaching other side through same ipsilateral incision.

TESTICULAR BIOPSY

It is done in infertility with low sperm count. It is usually done under local anaesthesia. Only one side is done. After injecting local anaesthesia xylocaine without adrenaline (plain), skin, dartos, spermatic fasciae are incised. Tunica vaginalis is incised. Testis is exposed. With no. 15 blade small incision is made on the tunica albuginea. Protruding seminiferous tubules less than 5 mm size is excised. Tunica albuginea is sutured using 3 zero vicryl or monocryl continuous sutures. Tissue is placed in *Bouin's fluid*—picric acid (75%); acetic acid (25%). It is sent for spermatogenesis assessment. Skin is closed **(Fig. 31-42)**.

TREATMENT OF TESTICULAR TUMOUR

Spread of Testicular Tumour

Local

To epididymis, cord, tunica albuginea, scrotum and so inguinal nodes.

Lymphatic Spread

Lymphatics drainage of testis is through its mediastinum along the gonadal vessels to para-aortic and retroperitoneal nodes. Through the lymphatics along the medial side of testis may run with the artery of vas draining into the common iliac nodes at the bifurcation of common iliac artery. Spread mainly occurs to ***para-aortic***; often to retroperitoneal and common iliac nodes. Malignancy spreads to inguinal nodes, only if scrotal skin is involved.

Right testicular tumour spreads to interaortocaval nodes immediately below the renal vessels as *primary landing zone* (L2 level), then to para-aortic nodes. Paracaval, preaortic, common iliac nodes can be involved.

Left testicular tumour spreads to true para-aortic nodes to begin with just below the renal vessels; then to preaortic and common iliac nodes.

From retroperitoneal and para-aortic nodes spread occurs to left supraclavicular nodes and posterior mediastinal nodes. Seminoma mainly spreads through lymphatics than teratoma.

Extranodal Spread

It occurs to lungs, liver, brain, bone, kidney, adrenals in order of frequency.

Investigations

No FNAC; No scrotal approach; No incision biopsy.
Through inguinal approach, cord and testis are exposed. A soft clamp is applied to the cord at or above the level of the deep ring so has to prevent dissemination through blood. Frozen section biopsy is done from the suspected area. If tumour is positive, *high orchidectomy is done (Chevassou maneuver).*

Measurement of tumour markers (HCG, AFP, LDH) are important. AFP and hCG are elevated in nonseminomatous germ cell tumours (teratomas)—65%. Raised AFP always indicates teratomatous tumour. *AFP level increase is not seen in pure seminomas*. hCG may be elevated in *advanced* cases of seminomas (10%). LDH level depends on growth rate/cellular proliferation/tumour burden. LDH is increased in 80% of advanced seminomas and 60% of nonseminomatous germ cell tumour. hCG is never found in normal individual. It is secreted by syncytiotrophoblasts. Half life is 18-36 hours. It is increased in choriocarcinoma (100%); embryonal carcinoma (65%); teratoma testis; recurrent or residual disease in testicular tumour after therapy. Placental alkaline phosphatase (PLAP) is increased in seminoma.

Chest X-ray is done to look for lung secondaries. HRCT scan is ideal. *Ultrasound abdomen* is done to see nodal status like para-aortic nodes and liver secondaries. *Ultrasound scrotum to see* echogenicity of testis and tumour within is essential.

CT scan abdomen and pelvis is to look for secondaries, iliac and para-aortic nodes. CT chest is needed to confirm lung secondaries.

Based on presence of AFP; hCG; LDH; nonpulmonary visceral secondaries (bone/liver/brain), germ cell tumour risk group classification is done to both seminomatous germ cell tumour (SGCT) and also to nonseminomatous germ cell tumour (NSGCT).

Good risk and intermediate risk group for SGCT.

Good risk; intermediate risk and poor risk for NSGCT **(Fig. 31-43)**.

Fig. 31-40: Torsion testis – early intervention shows viable testis. It should be fixed to scrotal wall; opposite testis is also fixed using nonabsorbable interrupted sutures.

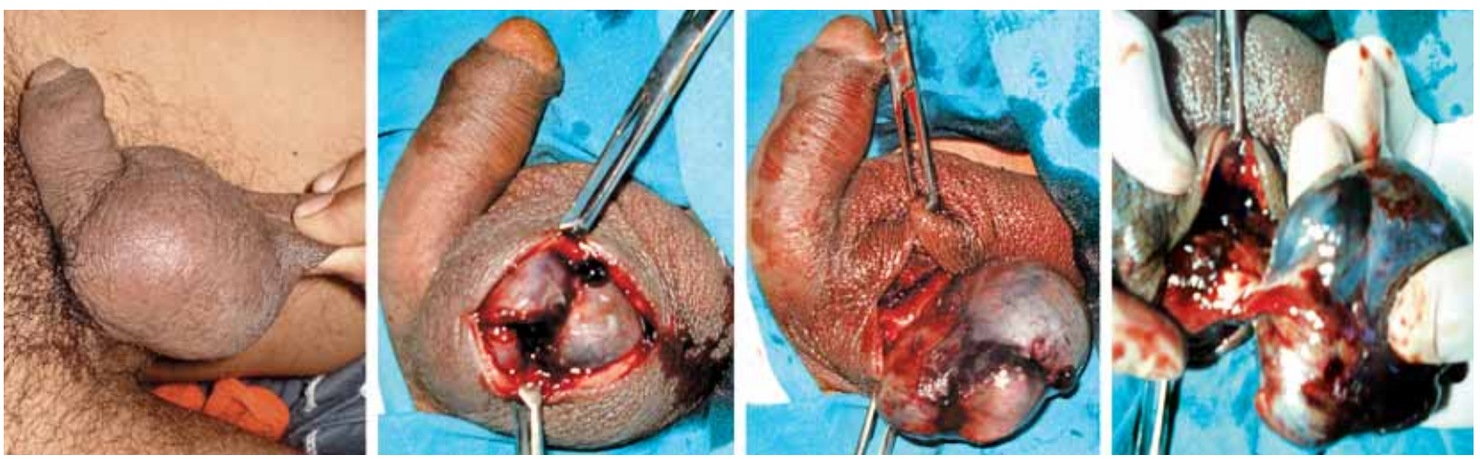


Fig. 31-41: Testicular torsion with gangrene testis. This testis is not viable; so needs orchidectomy.

Staging of testicular tumours

I. Lesion confined to testis
II. Nodes involved below the diaphragm
III. Nodes involved above the diaphragm
IV. Distant (blood) spread

TNM staging

T_0 – No evidence of tumour
Tis – Carcinoma in situ
T_1 – Tumour limited to testis and epididymis. Vascular/lymphatic invasion not present. Tumour may invade tunica albuginea but not tunica vaginalis
T_2 – Tumour limited to testis and epididymis with vascular/lymphatic invasion. Or tumour extends through the tunica albuginea with involvement of tunica vaginalis
T_3 – Tumour invades to spermatic cord with or without vascular/lymphatic invasion
T_4 – Tumour invades to scrotum with or without vascular/lymphatic invasion
N_0 – Regional lodes not involved
N_1 – Single/multiple nodes—not more than 2 cm in size
N_2 – Regional nodes—between 2-5 cm
N_3 – Regional nodes > 5 cm

Contd...

Contd...

M_0 – Distant spread not present
M_1 – Distant spread present
M_{1a} – Distant spread to nonregional nodes or to lungs
M_{1b} – Distant spread to other than nonregional nodes or lungs

Serum tumour markers (S)

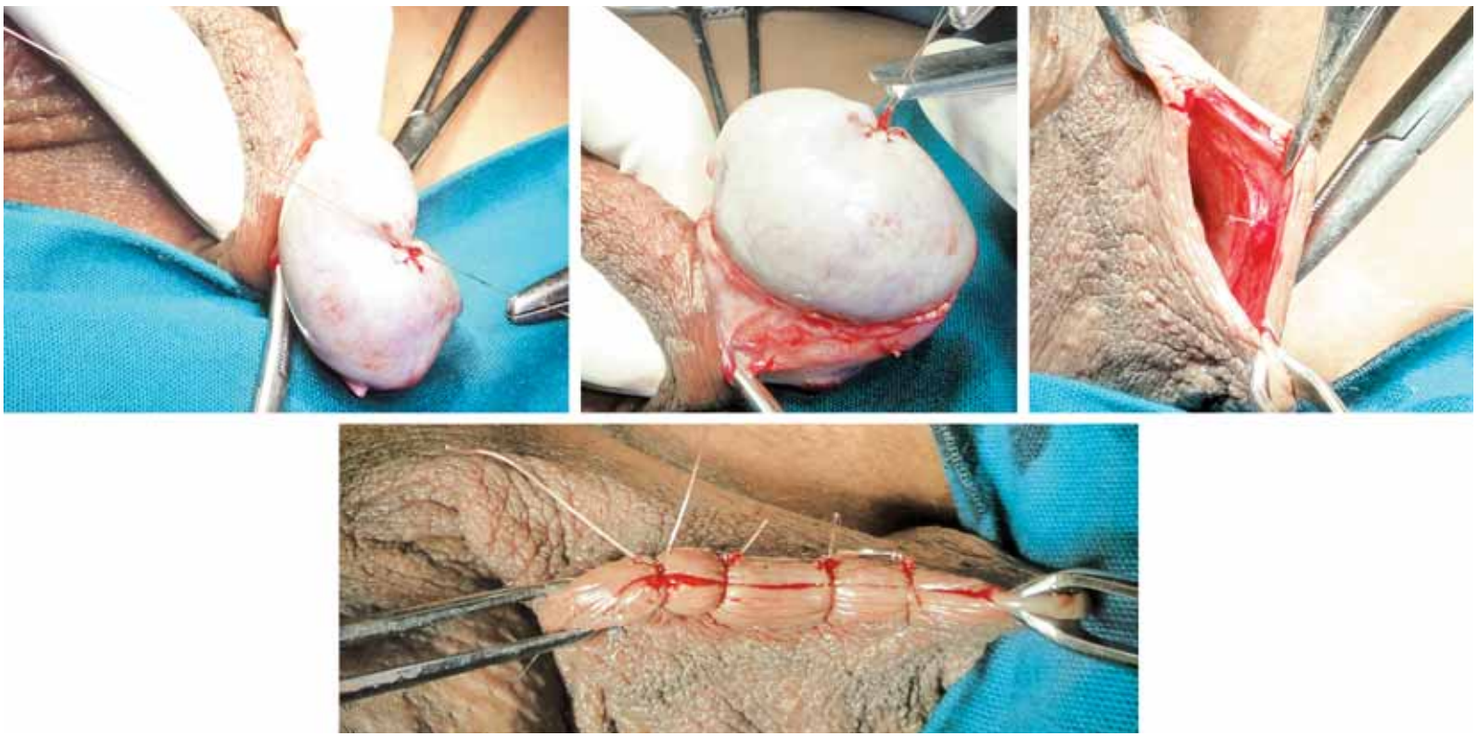
S_x – Marker study not done
S_0 – Normal marker study
S_1 – LDH < 1.5 × N (upper limit of normal) and hCG < 5000 mIU/ml and AFP < 1000 ng / ml
S_2 – LDH 1.5-10 × N or hCG 5000-50000 mIU/ml or AFP 1000-10000 ng/ml
S_3 – LDH > 10 × N or hCG > 50000 mIU/ml or AFP > 10000 ng/ml

Treatment

Initially high orchidectomy is done in all patients through inguinal approach by ligating and dividing the cord at internal ring level **(Fig. 31-44)**.

Seminomas are radiosensitive. So after high orchidectomy, *radiotherapy* is given to increase the cure rate and also to reduce relapse. It is

Figs 31-42(1)



Figs 31-42(2)

Fig. 31-42: Testicular biopsy is done to study stages of spermatogenesis in infertility with low sperm count. Bouin's fluid is used. Only one side is done.

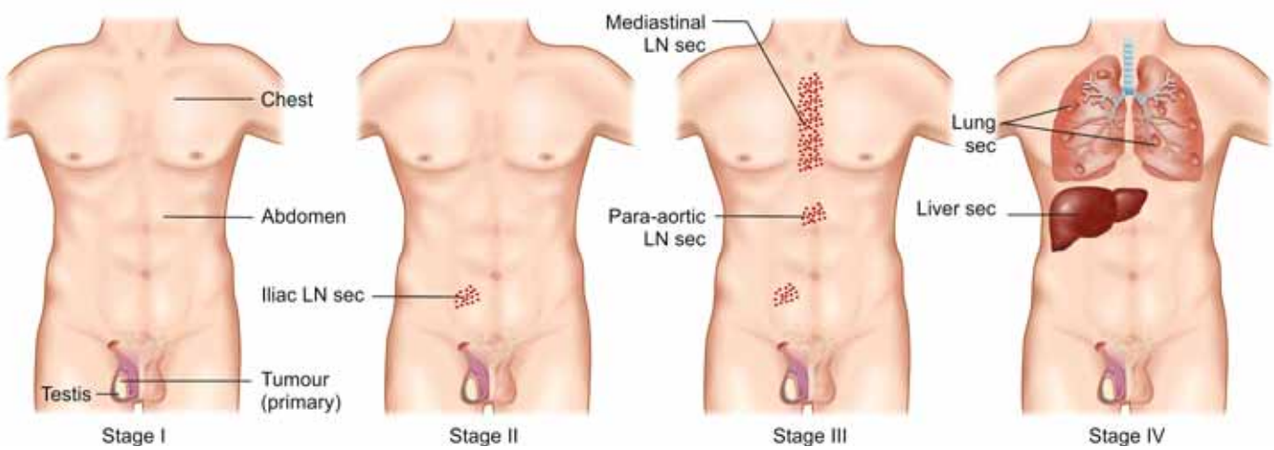


Fig. 31-43: Staging of testicular tumours.

the treatment of choice in stage I seminomas. Opposite testis should be shielded during radiotherapy. Seminomas with high levels of tumour marker are treated as nonseminomatous tumours.

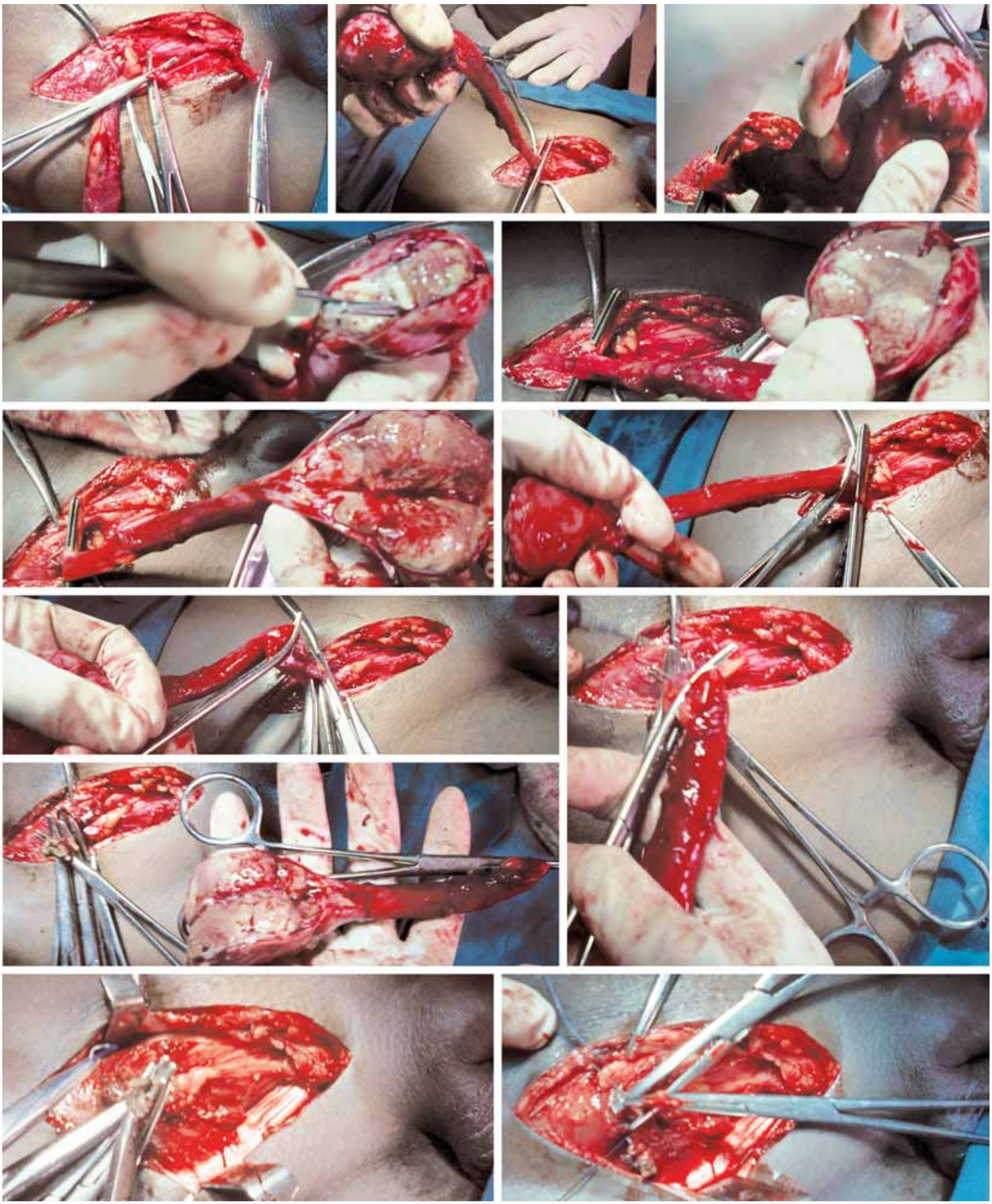
Chemotherapy is also effective. *Cisplatin* is very useful drug in seminoma. *In teratoma, retroperitoneal radical lymph node Dissection (RPLND)* is beneficial after high orchidectomy. Even in stage I disease, chances of existing retroperitoneal spread is 30%. So RPLND (infrahilar) has a major role especially in teratomas which are relatively radioresistant. It involves removal of precaval, retrocaval, paracaval, interaortocaval, retroaortic, para-aortic, common iliac nodes along with removal of gonadal vein and adjacent fibrofatty tissues from internal ring level to its insertion into renal vein on left side and inferior vena cava on right side. Commonly bilateral RPLND is done as contralateral nodes also can be involved. Mortality in RPLND is only 1%. RPLND may cause ejaculatory problems. Nerve sparing RPLND is ideal if technically possible. Nerve sparing dissection is done on opposite side of the tumour. Laparoscopic RPLND is also advocated safely.

Note:
Please refer chapter 26 retroperitoneal surgeries for description of RPLND.

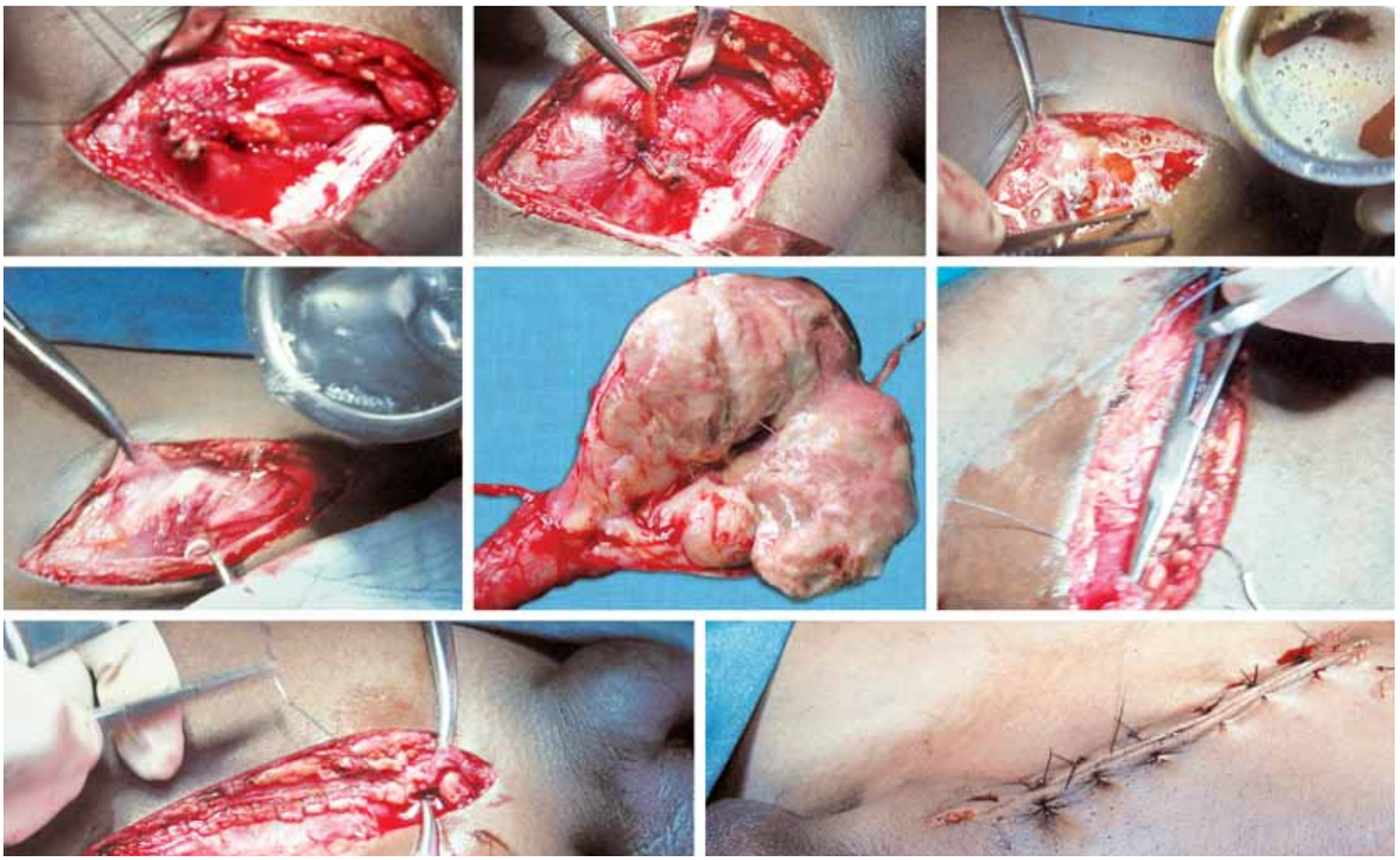
Modified RPLND is same side lymph node dissection both above and below the inferior mesenteric artery (IMA); opposite side dissection is limited to above the level of IMA so that sympathetic chain on opposite side is preserved to retain ejaculation.

Complications of RPLND: Haemorrhage; injury to main structures like major vessels/ureter/bowel; chylous ascites; lymphocele; retrograde ejaculation.

Figs 31-44(1)



Figs 31-44(2)



Figs 31-44(3)

Figs 31-44(1 to 3): High orchidectomy is done for testicular tumour through inguinal approach. Not through scrotal incision. Cord is ligated at the level of the internal ring.

Chemotherapeutic drugs for teratoma are *cisplatin, bleomycin,* vinblastine, *etoposide,* ifosfamide, mesna, paclitaxel. BEP regime is commonly used (Bleomycin, etoposide, cisplatin).

ORCHIDECTOMY

Testis is removed for variety of reasons. However, formal written consent should be taken before doing orchidectomy. It is done in pyocele, chronic haematocele, testicular tumour, undescended testis where testis is atrophied. Bilateral orchidectomy is done in carcinoma prostate to achieve hormone control.

Types

- Low orchidectomy.
- High orchidectomy.
- Subcapsular orchidectomy.

Low Orchidectomy

It is done in pyocele, old clotted chronic haematocele. Arterial Doppler is a must to confirm the nonviability of testis. In case of pyocele, on table Doppler is ideal to confirm nonviability and also to document for legal purpose.

Under spinal or general anaesthesia after cleaning and draping incision is made on the scrotum lateral to the median raphe. Skin, dartos, spermatic fascia is incised. Nonfunctioning testis is mobilised up to the root of the scrotum by blunt finger dissection. Cord is mobilised for adequate length. At the root of the scrotum cord is clamped using three strong clamps or Kocher's forceps. Distally one more haemostat is applied **(Fig. 31-45)**.

Cord is divided and testis is removed and sent for histology. Transfixation suture is placed using 1 zero vicryl or chromic catgut.

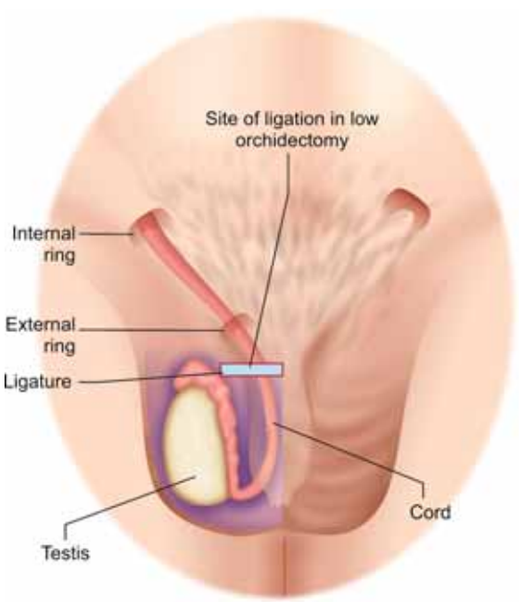
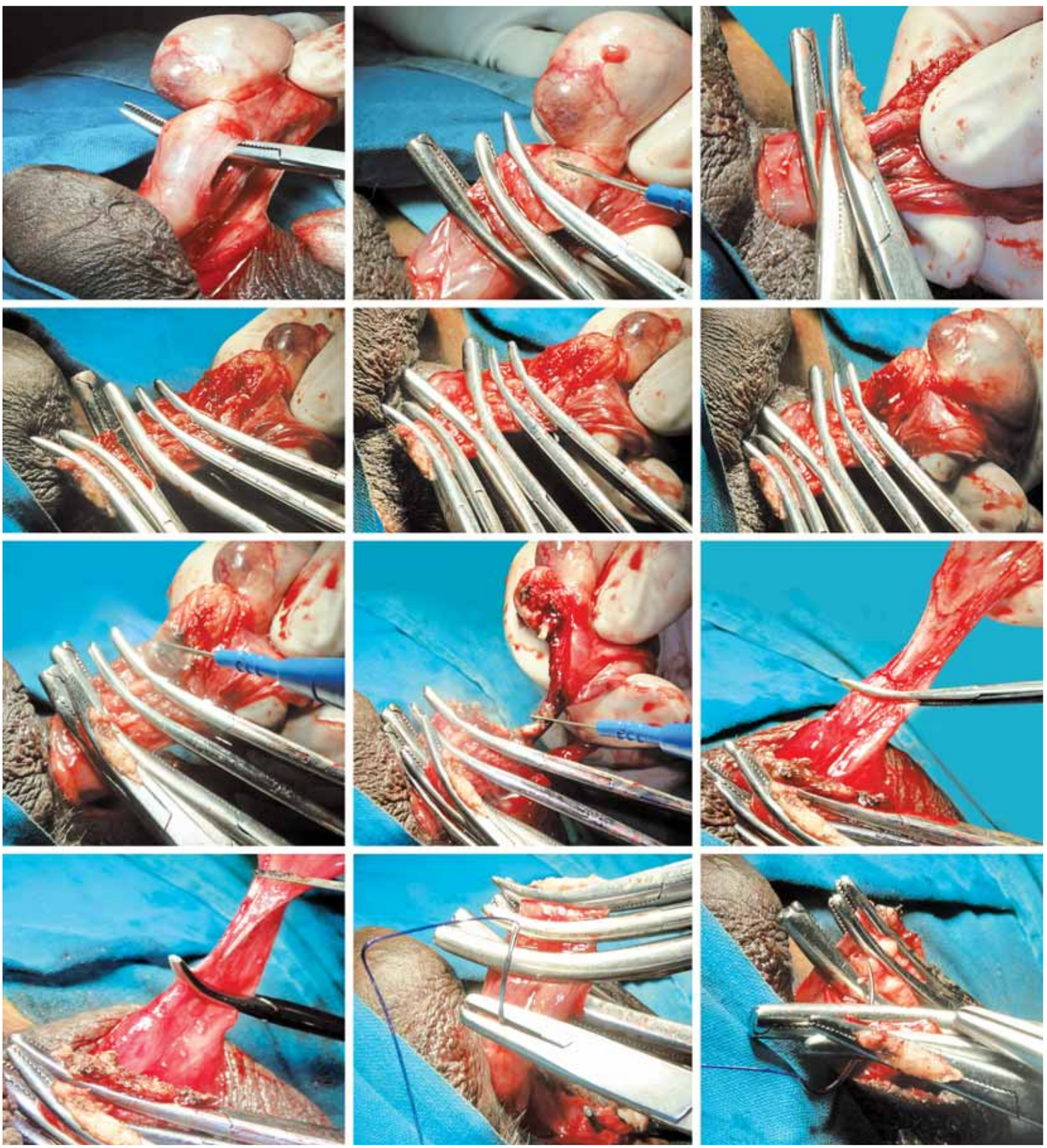


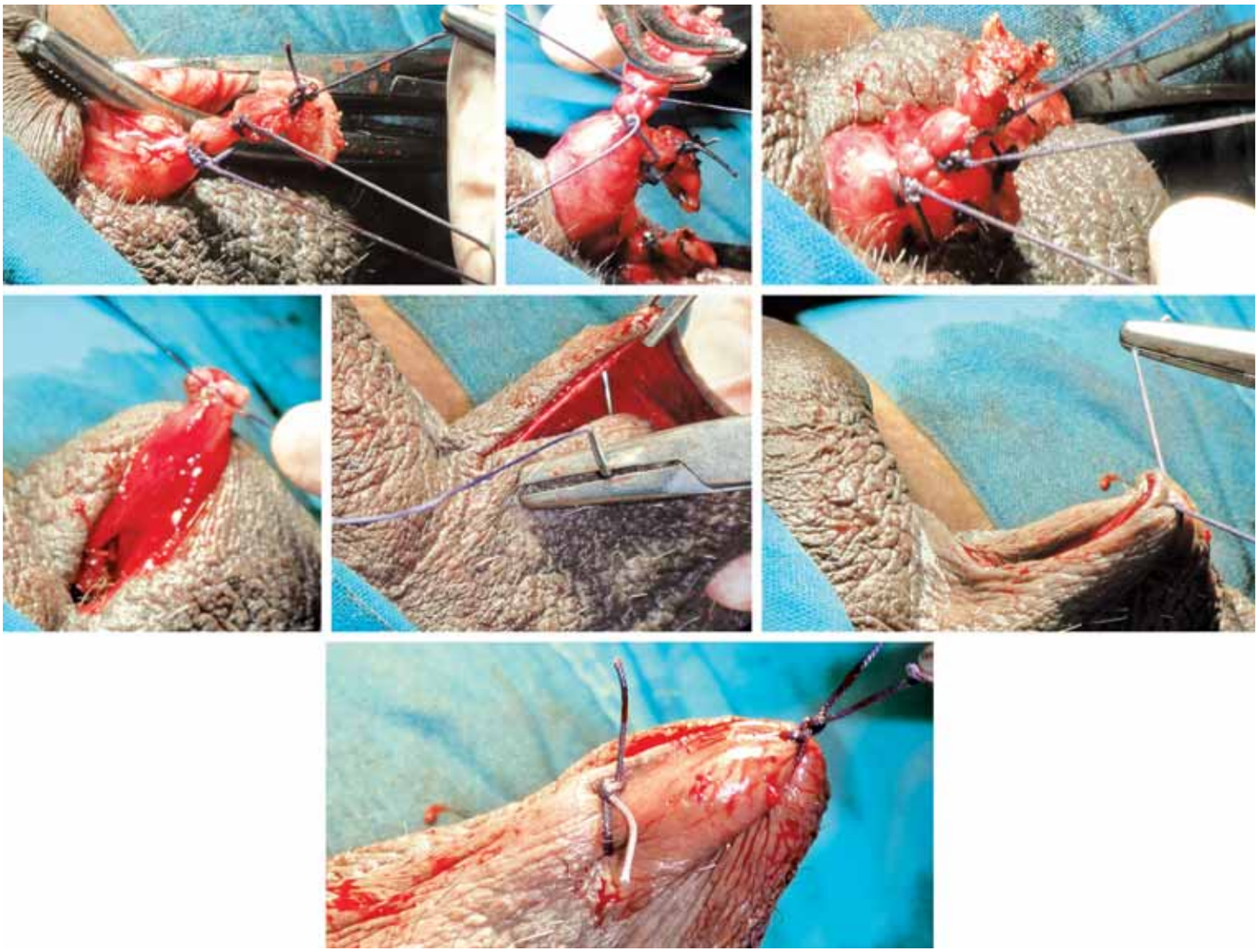
Fig. 31-45: Site of clamping for low orchidectomy.

Nonabsorbable suture material like polypropylene is not used as it may cut through the tissues. It is also not possible to dissect the cord structures to isolate the vessels and ligate independently. Clamps should not slip as if it happens vessels retract proximally into the groin causing torrential bleeding and it is difficult to identify the bleeder from the retracted vessel. Alternatively after mobilisation of the cord, first transfixation is done proximally using vicryl and clamps are applied to divide the cord which prevents retraction and possible bleeding of the vessel.

Corrugated or suction drain is placed which is removed in 48 hours. Skin with layers is sutured with interrupted sutures. Sutures are removed 7-10 days **(Fig. 31-46)**.



Figs 31-46(1)



Figs 31-46(2)

Figs 31-46(1 and 2): Low orchidectomy is done for pyocele; haematocele. In this old aged patient while doing hydrocoele surgery, firm lesion was found in the testis and so through scrotal approach only low orchidectomy was done. Biopsy report was inflammatory mass. Ideally scrotal wound should have been closed; new separate inguinal incision should have been made through which testis with cord is delivered into the groin high up to deep ring and cord is ligated at deep ring to achieve high orchidectomy. On table ultrasound will be very useful.

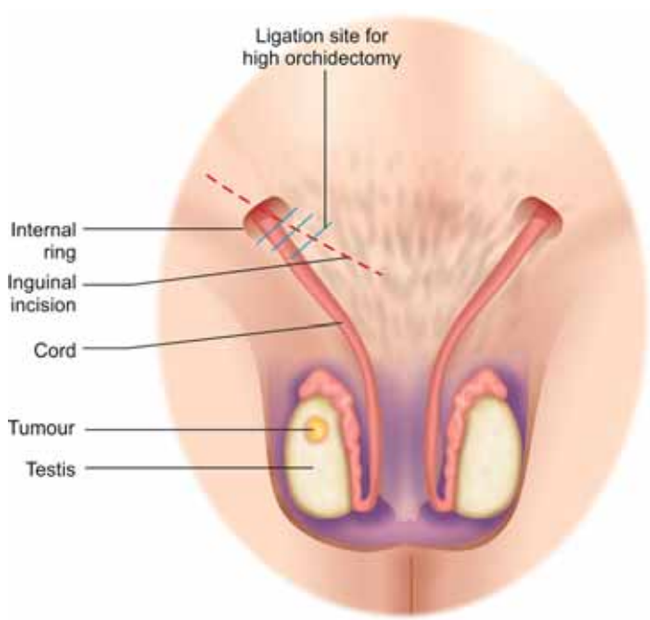


Fig. 31-47: Site of ligation in high orchidectomy (Chevassou maneuver).

High Orchidectomy

It is done classically for testicular tumour. It is also done in undescended testis. Lengthy inguinal incision is placed. Inguinal canal is opened. Testis with cord is dissected, mobilised fully up to or proximal to the internal ring. A soft occlusion clamp is placed over the cord at internal ring level. Testis is palpated for confirmation of the tumour. Often it is transected partially and seen; biopsy is done from the suspected area and confirmation is done by frozen section. If biopsy is negative then testis capsule is sutured back and testis is placed in the scrotum **(Fig. 31-47)**.

Once frozen section confirms the malignancy, clamp is not released; transfixation of the cord is done just proximal to the clamp using silk or vicryl and distally cord is divided to complete the orchidectomy. Double ligation of proximal cord stump is needed. Wound is closed with a suction drain. Testis specimen should be sent for histology. Often it is practice to place prosthesis in the scrotum in young individual. It is also often practiced to do biopsy of opposite side as malignancy can be bilateral. But nowadays due to good imaging (ultrasound) this technique it is not practiced.

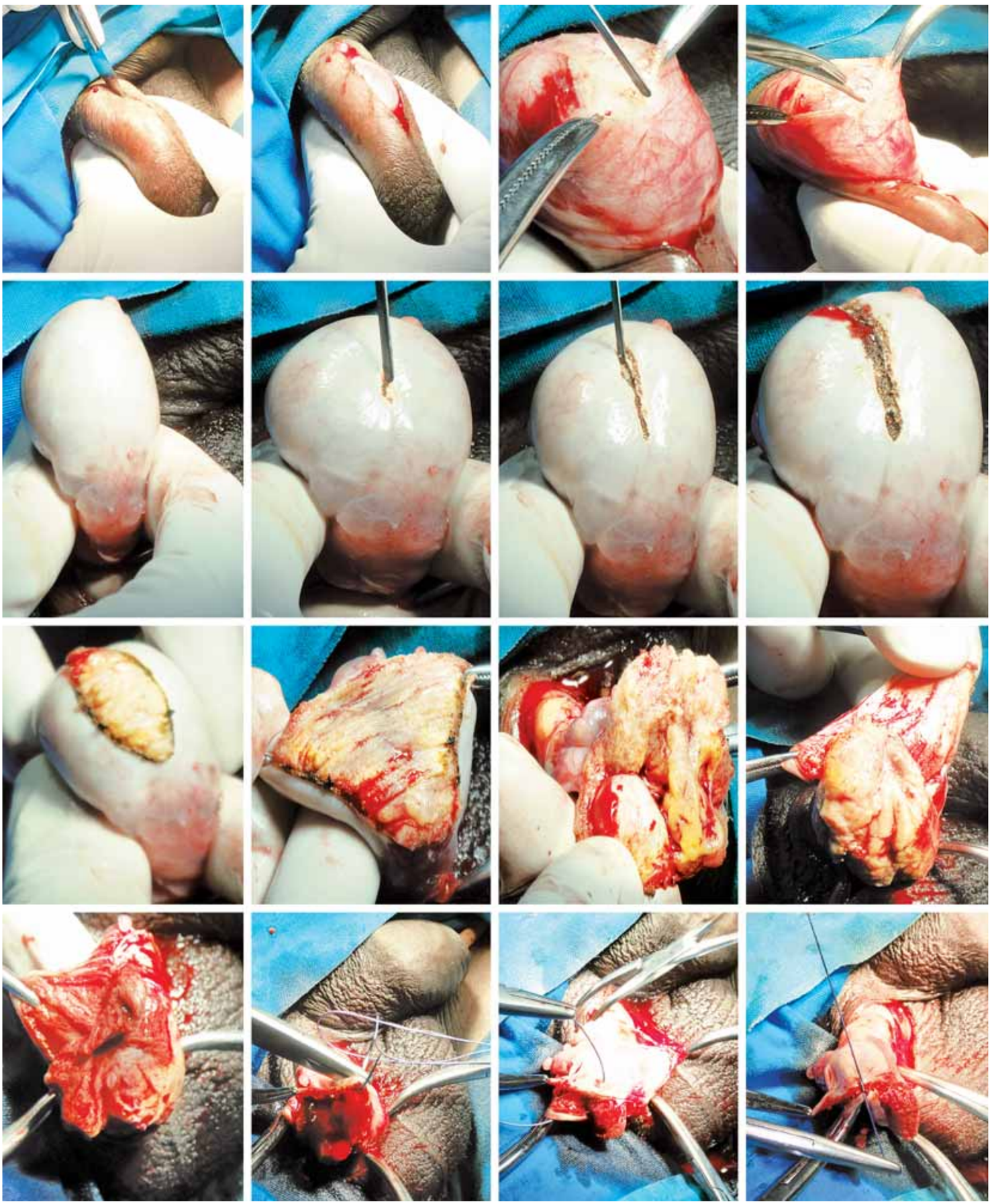


Fig. 31-48: Technique of subcapsular orchidectomy.

Subcapsular Orchidectomy

It is done in carcinoma prostate to achieve hormonal control. So it is done always bilateral. It is done under spinal anaesthesia or local anaesthesia. Single midline median raphe incision is sufficient. If surgeon is not comfortable then two separate vertical incisions one in each hemiscrotum may be placed **(Fig. 31-48)**.

Testis is reached; tunica albuginea is incised longitudinally using no 15 blade or cautery. All seminiferous tubules are removed using finger and scoop. Small bleeders in the inner wall of the testis are fulgurated using bipolar cautery. Tunica albuginea is sutured using 3 zero vicryl. Procedure is repeated on the other side. Skin wound is closed using nonabsorbable interrupted sutures. Presently urologists prefer to do low orchidectomy rather than subcapsular one.

Chapter

32

Basic Surgeries in Obstetrics and Gynaecology

General surgeons frequently encounter with gynaecological problems in females. Previously before the advent of ultrasound and CT scan there would be lots of confusion with diagnosis and the surgeon would be surprised with a gynaecological condition on table as the clinical features of some surgical conditions overlap with those of gynaecological conditions. Current investigative methods have reduced the surprises for the surgeons. But still it is wise for a surgeon to know common gynaecological conditions and their operative treatments.

SURGICAL ANATOMY OF FEMALE GENITALIA

Female genitalia are broadly classified into *external* and *internal genitalia*.

External Genitalia

It is also termed as *vulva* or *pudendum*. It is an ill-defined area bounded by *mons veneris* anteriorly, *labia majora* laterally and *perineum* posteriorly.

Mons veneris is a pad of subcutaneous adipose tissue over the pubis, covered by hair in adult females.

Labia majora consists of folds of skin with underlying subcutaneous fat extending on either side from mons in front to end in skin of perineum posteriorly. It is prominent in reproductive age group, covered with hair on outer aspect, whereas the inner aspect is hairless, moist and pinker than outer surface. Labia majora is covered with stratified squamous epithelium, contains hair follicles, sweat glands, sebaceous glands and a specialised sweat glands called apocrine glands whose secretions give the characteristic aroma. So presence of all these structures makes labia majora prone for folliculitis, boils, and sebaceous cysts. Labia majora are homologous with scrotum in males.

Labia minora are two thin folds of skin devoid of fat lying on either side within the labia majora, which divide anteriorly to enclose the clitoris forming *prepuce* on upper surface and *frenulum* on under surface; posteriorly unite together to form a fold of skin in midline called *fourchette*. It is devoid of hair follicle but contains erectile muscle fibres, numerous sebaceous glands, vessels and nerve endings.

Clitoris is cylindrical erectile body consists of a glans, covered by prepuce, analogue to the penis in male but here it is entirely separate from urethra, attached to the undersurface of symphysis pubis by suspensory ligament. It is extremely sensitive with numerous nerve endings, plays considerable part during sexual intercourse in inducing orgasm in females.

Bartholin glands are a pair of pea-sized glands situated on either side at the junction of middle and posterior thirds of labia majora deep to bulbospongiosus muscle. They are compound racemose type of glands, secrete abundant lubricating mucus during sexual excitement. Duct is 2 cm long, opens below the level of hymen at the junction of anterior 2/3 and posterior 1/3. It is lined by columnar epithelium but by stratified squamous epithelium near the opening. Gland which is otherwise not palpable becomes enlarged by inflammation. Pus can be expressed through the duct opening on applying pressure on the gland when infected in acute gonorrhoea.

The space between the anterior and inner aspect of the labia minora is the *vestibule* which is bounded posteriorly by the vaginal introitus. *Urethral meatus* lies in the midline just below the clitoris. *Vaginal orifice* lies posterior to the urethral meatus, bounded by a thin membrane called *hymen* in virgins, which contains an eccentrically placed opening. Hymen gets ruptured by coitus which may sometimes cause brisk haemorrhage. It is lined on either side by stratified squamous epithelium.

Vestibular bulb are bilateral elongated masses of erectile tissue that lies beneath the mucous membrane of the vestibule, on either sides of the vaginal orifice in front of the Bartholian gland, which may get injured during child birth resulting in brisk haemorrhage.

Arterial supply of external genitalia is by branches of internal pudendal arteries and femoral arteries. *Venous plexus* formed drain into internal pudendal vein, vesical venous plexus and long saphenous vein. Varicosities that occur in these venous plexus during pregnancy may spontaneously rupture or cause haematoma formation. *Nerve supply* is by cutaneous branches of ilioinguinal and genital branches of genitofemoral nerve and pudendal branches of posterior cutaneous nerve of the thigh. *Lymphatics* drain bilaterally into superficial inguinal lymph nodes, lymph node of Cloquet and external and internal iliac nodes.

Internal Genitalia

It includes vagina, uterus, fallopian tubes and ovaries.

Vagina is the channel that communicates uterus with the exterior at vulva. The canal is directed upwards and backwards making an angle of 45° with the horizontal in erect posture. Though, it is distensible its

diameter is wider at its upper part, narrow at its lower part. It is attached to the cervix slightly at a higher level on the posterior aspect making the posterior fornix deepest of the all. This part of the vagina is in direct contact with the peritoneum of the pelvic floor and is the thinnest area in whole of the peritoneal cavity. Pointing pelvic abscess can be drained through the posterior fornix. Herniation of coils of intestine or *enterocele* can occur through this fornix. Ureter lies 12 mm antero-lateral to the lateral fornix. Vagina is related to base of the bladder and urethra in front, ampulla of rectum and *pouch of Douglas* behind. Vaginal secretion is derived from cervix and from transudation across the epithelium. Its acidic nature (pH is 4.5) is due to the presence of lactic acid formed by the bacterial (*Doderlein*) activity on the glycogen of the epithelial cells which is also estrogen dependent. This acidic nature is protective and inhibits the growth of pathogenic organisms and also explains the growth of mixed organisms before puberty and in menopausal age group where the influence of estrogen is low. It is supplied by the cervicovaginal branch of uterine artery, branches of internal iliac artery, and middle rectal with internal pudendal artery. Vaginal veins form plexus that drain into internal iliac vein. Lymphatics from lower 1/3rd vagina drain along with external genitalia into superficial and deep inguinal lymph nodes; middle 1/3rd into internal iliac nodes upper 1/3rd into external iliac nodes.

Uterus is a pyriform shaped muscular organ that lies in the pelvis between bladder in front and rectum behind. It measures 8.5-9 cm in length 6.5 cm in breadth and 3.5 cm in thickness, flattened antero-posteriorly, lies in anteverted, anteflexed position, slightly deviated to right. It is divided functionally and anatomically into body and cervix with isthmus being the line of demarcation. It is at this level the peritoneum gets reflected from the bladder onto the body of the uterus and this loose peritoneal fold is called the *utero-vesical* fold of peritoneum. Uterine artery, at this level changes its horizontal course into vertical, along the lateral surface of the body. Uterus consists of corpus or the body and cervix. *Fundus* is that part of the body above the attachment of fallopian tubes. *Cornu* is the junction of attachment of tubes to the uterus. *Isthmus* is the constricted portion that lies between the body and the cervix that forms the lower uterine segment during pregnancy. *Cervix* is the cylindrical lower part of the uterus that opens into the vagina. The endocervical canal is 2-3 cm in length that continues with the endometrial cavity at the isthmus. The exocervix is lined by stratified squamous epithelium whereas the endocervix by mucus secreting columnar epithelium, their junction of transformation is the squamocolumnar junction which is the site of initiation of dysplasia.

Peritoneum covers most part of the uterus except over the anterior aspect of the cervix, and laterally at the sites of attachment of tubes, round ligament and ovarian ligament. Posteriorly the peritoneum covers whole of the uterus, supravaginal cervix, upper part of the vagina and then reflects onto the anterior surface of the rectum thus forming the *pouch of Douglas* that consists of coils of intestine. The two sheets of peritoneum form the *broad ligament* on either side of the uterus which extends to lateral pelvic wall. Fallopian tubes lies in the medial 3/4th of the superior free border, where the lateral 1/4th forms the *infundibulopelvic* ligament which contains the ovarian vessels. *Mesovarium* is a fold of peritoneum that attaches ovary to the posterior layer of broad ligament. *Round ligament* is attached to the uterine cornu reaches the internal abdominal ring. The *ovarian ligament* attaches inner poles of the ovaries to the uterine cornu below the fallopian tubes.

Fallopian tubes are a pair of hollow muscular tubes, 10 cm long, attached to uterine cornu at one end and opens into the abdominal cavity on the other end, the opening of which is surrounded by radiating fimbria, *ovarian fimbria* being the longest is attached to ovaries. Interstitial portion is the narrowest portion of the tube, ampullary is the widest.

Ovaries are paired gonadal structures measuring 5 × 3 × 3 cm, that is suspended in the pelvis by the infundibulopelvic ligament laterally and ovarian ligament medially; mesovarium attaches the hilar surface of the ovary to the posterior surface of the broad ligament. It receives blood supply mainly from branches of ovarian artery and also branches of uterine artery.

Uterine artery, the branch of anterior division of internal iliac artery, supplies chiefly the uterus, tubes, and vagina. Once it reaches the parametrium, it runs medially to reach the internal os, where after giving a vaginal branch it turns upwards along the lateral border of the uterus, running a tortuous course ends near the cornu after anastomosing with ovarian artery. Uterine artery during its course towards internal os crosses over the ureter where it pierces the Mackenrodt's ligament. The vaginal branch of the uterine artery reaches the lateral fornix traversing the parametrium, has to be separately ligated during hysterectomy, which otherwise may lead into severe postoperative haemorrhage.

Ovarian artery arises from the abdominal aorta below the renal vessels; enter the infundibulopelvic ligament, ends by anastomosing with the uterine artery after giving branches to tubes, ovary, broad ligament and uterus. Veins form plexus which lie between layers of broad ligament that drain into renal vein on the left side, into inferior vena cava on the right side.

Lymphatics from the fundus and adjoining uterine corpus drain into para-aortic nodes along the ovarian vessels, from the cornu along the round ligament into superficial inguinal lymph nodes, from the lower part of the corpus into external iliac nodes; lymphatics from the cervix drain into external and internal iliac group, obturator group, paracervical and sacral group of nodes. Lymphatics from these entire groups ultimately drain into para-aortic group of lymph nodes. The lymphatic vessels of the ovary drain in three directions. The main group accompanies the ovarian vessels in the infundibulopelvic ligament, eventually reaches the periaortic nodes near the kidney. Other lymphatic channels communicate with channels of the opposite ovary by crossing the fundus of the uterus through the ovarian ligament. Some channels drain through the ovarian and round ligaments into the superficial inguinal lymph nodes in the groin.

Anatomy of Pelvic Floor

Pelvic floor consists of all structures from the skin of perineum below to the facial covering of the levator ani muscle above. It is pierced from before backwards by the urethra, vagina, and anal canal. Pelvic floor not only supports these canals but also the pelvic organs. Normal physiological function of the pelvic organs depends on the anatomic integrity of this pelvic support. Pelvic organ prolapse, urinary and anal incontinence sexual voiding and defecatory dysfunction can result defect in pelvic support. A proper knowledge of the pelvic support helps to treat pelvic floor dysfunction.

Pelvic Floor Supports

1. Levator ani muscle support
2. Perineal membrane
3. Perineal body
4. Pelvic connective tissue

Levator ani is a paired muscle that forms the main muscular component of the pelvic floor. It is also called as *pelvic diaphragm*

and is composed of 3 components—iliococcygeus, ischio-coccygeus, pubococcygeus. Normally levators maintain a constant state of contraction, thus an active floor is provided that supports the weight of the abdominopelvic organs against the forces of intraabdominal pressure. This helps to prevent excessive strain over the ligaments. Type1 muscle (slow twitch) fibres are predominant in these levators which bring about this normal resting contraction of these levators. This helps to keep the urogenital hiatus closed and draw the distal urethra, vagina and rectum towards pubis. The reflux contraction of these muscle elicited by the sudden increase in the intraabdominal pressure is brought about by the type 2 muscle fibres. Relaxation of the levators occurs for a brief intermittent period at the time of voiding, defecation and parturition. Other muscles which form the important component of pelvic floor are bulbospongiosus and ischiocavernosus, superficial transverse perineal muscle of superficial perineal pouch, sphincter urethrae and deep transverse perineal muscle of deep perineal pouch, and external anal sphincter. Levators receive efferents from S_2—S_5 nerve roots; the urethral and external anal sphincters by pudendal nerve.

Mass of dense connective tissue between the distal third of the posterior vaginal wall and the anus below the pelvic floor formed primarily by the connection between the halves of the perineal membrane in the midline forms the *perineal body*. It supports the distal vagina and rectum.

Uterus is supported in its position of anteversion and anteflexion in the pelvis by uterine ligaments, pelvic floor and pelvic cellular tissues. *Endopelvic fascia* is the connective tissue covering of the vagina, supravaginal cervix, uterus, bladder, urethra and rectum. *Pelvic cellular tissue* is the loose areolar tissue that acts as a packing material filling the space between the pelvic peritoneum and the fascia covering the pelvic floor. It condenses into bands that radiate from these organs to lateral pelvic wall laterally, sacrum posteriorly and pubic bones anteriorly. The anterior band which is attached to the anterolateral aspect of cervix, anterior vaginal vault and back of pubic bone is the *pubo vesico cervical ligament*. The lateral band called the *Mackenrodt's ligament* or *cardinal ligament* extends from the supravaginal cervix and upper part of the vagina to the lateral pelvic wall, consists of ureteric canal 1 cm lateral to cervix through which passes the ureter, supports the uterus preventing it to be dragged through the vagina when there is increased intra-abdominal pressure. The posterior band is the *uterosacral ligament* that extends from the uterine isthmus to the level of junction of 2nd and 3rd sacral vertebra, lateral to rectosigmoid, below the fold of peritoneum, acts as support of the uterus, maintaining it in its anteverted position. Mackenrodt's and uterosacrals constitute an important support (*level 1*) to the cervix and upper vagina, whose defects leads to post hysterectomy vault prolapse. The lateral walls of the midvagina are attached on each side to the pelvic walls. The anterior wall of the vagina is attached on its lateral aspect to arcus tendinosus and to the medial aspects of levator ani muscle (*level 2 support*). Clinical manifestation of defects in these support results in prolapse of anterior and posterior vaginal wall and stress urinary incontinence. The distal third of the vagina is attached to the urethra anteriorly, pubovaginalis muscle and perineal membrane laterally, to the perineal body posteriorly (*level 3 support*). Defect in these support results in distal rectocele or perineal descent. While treating genital prolapse it is very important to know and understand the integrity of these supports.

As pelvic cellular tissue extends into the gluteal region through sacrosciatic foramen, obturator region through obturator foramen, femoral triangle through femoral canal, perirenal region along the ureter, labia majus along round ligament, any inflammatory processes in pelvis can spread to any of these regions.

Anatomy of Pelvic Part of Urinary Apparatus in Females

It is important to know the *course of ureter* in pelvis as its course is altered in large broad ligament tumours or myomas. It needs to be dissected during Wertheim's operation. It crosses the bifurcation of common iliac artery beneath the peritoneum, to enter the pelvic brim where it is crossed by the ovarian vessels; and on left side also by mesosigmoid. It forms the posterior boundary of ovarian fossa, lies medial to the structures on the lateral pelvic wall along the anterior margin of greater sciatic foramen. It further progresses downwards, and at the level of ischial spine turns medially and forwards to enter into the ureteric canal in Mackenrodt's ligament, where it is crossed from above by the uterine vessels. After its exit from the canal it progresses forwards and medially to reach the bladder, where it lies from the cervix at a distance of 1-2 cm. Pelvic ureter is supplied from its lateral aspect by branches of internal iliac artery, vaginal artery, vesical and middle rectal arteries which form plexus on its outer fibrous sheath.

Urinary bladder is a hollow muscular organ, which when empty lies in the pelvis in front of vagina and uterus. When filled and gets distended rises above the pelvic brim to become palpable per abdomen. Uterovesical fold peritoneum lies above the bladder base at the level of internal os. Bladder is firmly attached to supravaginal portion of cervix at its base above and to the middle of the anterior vaginal wall at its neck below, but bladder base is separated from the upper part of anterior vaginal wall by a loose areolar tissue that forms the plane of cleavage between the two. It is through this plane where the bladder is separated off the cervix and anterior vaginal wall during hysterectomy and caesarean section. Bladder is supplied by superior and inferior vesical branches of internal iliac arteries. Veins form plexus around bladder neck that drain into internal iliac veins.

Urethra from the base of the bladder passes downwards and forwards behind the symphysis pubis, measures 3.5 cm in length, opens out at the *external urinary meatus* below the clitoris. There is pair of *paraurethral gland of Skene* along the floor of the urethra, the duct of which opens near the external meatus, can get infected to form an abscess or cyst.

SURGERIES IN FEMALE GENITAL TRACT

Preoperative Preparation

Minor surgical procedures of vulva and vagina, dilatation and curettage, cervical biopsy which are done under local anaesthesia can be done as outpatient procedures. Major surgeries of vagina, abdominal operations, needs admission one or two days prior to the procedures.

Patient is assessed by taking detailed history pertaining to her menstruation, pregnancy and postpartum period, other medical illness like hypertension, diabetes, bronchial asthma and epilepsy, tuberculosis, and any surgeries done in the past.

In detail, medical examination is done before major surgeries to rule out hypertension, diabetes and ischaemic heart disease. Chest X-ray is taken in case of chronic cough to rule out emphysema, tuberculosis. ECG and ECHO are done to assess the cardiac status.

Antihypertensives are started for hypertension, insulin for diabetics, antibiotics sometimes with bronchodilators for chest infections. Bleeding tendencies are ruled out by doing bleeding time, clotting and prothrombin time. Blood grouping is done and required amount of blood is kept ready for transfusion. Anaemia with HB% <10 gms needs preoperative transfusion of blood or packed cells in emergency. Urine routine examination is done to rule out urinary tract infection which has to be actively treated prior to surgery. Renal functions are assessed by doing blood urea and serum creatinine levels. Caries tooth and gum sepsis must be managed.

Preparation of the part—The operating site over the abdomen, vulva and perineum must be shaved for all major surgical procedures. Shaving is done with a sharp disinfected razor blade using soap or cream to prevent any injuries to the skin. Vaginal douche must be given for few days prior to abdominal surgeries and vaginal surgeries. For minor surgeries, no vaginal preparation or shaving is required.

Preparation of the bowel is essential for all major abdominal and vaginal surgeries. Bowel wash or enema may be given on the previous day evening. Minor vaginal procedures require no enema. Patient kept fasting for 8 hours for all major surgeries done, with light food intake on the previous day.

Premedications like inj Pethidine 50 mg inj. Phenergan 25 mg with inj. atropine or any other drug is given 1 hour prior to the surgery as per anaesthetists instructions. Preoperative antibiotics are given 1 hour prior to surgery.

Patient is made to empty the bladder prior to minor surgeries. But for major abdominal surgeries catheter is inserted and left *in situ*. For vaginal procedures bladder is initially catheterised and later left *in situ* after the surgery.

Informed consent of the patient is taken for all major and minor procedures explaining the nature of the procedures, its after effects and care.

Patient is placed in Trendelenburg position for abdominal surgeries and in lithotomy position for vaginal surgeries.

For abdominal surgeries vagina is initially cleaned with iodine preparation and later abdomen is painted with iodine preparation and spirit from mid chest to mid thighs. For vaginal surgeries whole of perineum, thighs and lower abdomen is painted with antiseptic solution. Later vulva is initially swabbed followed by vagina. Later the painted area is draped with sterile linen, except the area to be operated is exposed.

Routine bimanual examination under anaesthesia is very beneficial in all vaginal and abdominal surgeries.

DILATATION AND CURETTAGE (D & C)

It is done for diagnostic purpose:
- As a part of investigation and treatment of menstrual disorders
- As a part of initial workup in infertility
- In postmenopausal bleeding.

As a part of treatment in:
- Dysfunctional uterine bleeding
- To remove retained products of conception
- To remove retained IUCD
- To remove endometrial polyps.

Only cervical dilatation done in:
- Cervical amputation
- For intrauterine radium insertion
- For insertion of LNG-IUCD
- For drainage of pyometra
- For cervical cautery.

This procedure is deferred in the presence of active infections of vagina, cervix, fallopian tubes and endometrium.

D&C is done as an outpatient procedure with the patient instructed to fast for 4-6 hours. It can done under general anaesthesia, but doing under local paracervical block and IV sedation (petidine/diazepam and fortwin along with atropine) would be ideal. Prior to the procedure preparing the local area by shaving is not an absolute necessity. Patient is asked to void urine just before the procedure. Patient is placed in the lithotomy position with buttocks protruding slightly beyond the edge of the table. Vulva, vagina and perineum is cleaned with suitable antiseptic lotion (savlon). Bimanual examination is done to assess the position of the uterus, size of the uterus, its mobility, and to assess any other pelvic pathology. Labia is gently drawn apart and *vaginal speculum* (Sim's or Auvard's) of appropriate size is inserted into the vagina. Anterior lip of cervix is held with *volsellum*. If there is difficulty in visualising the cervix, one can use *anterior vaginal wall retractor* to lift up the bladder. The cervix that is held is drawn towards introitus by gentle traction. By doing this the endocervical canal is straightened thereby allowing easy passage of instrument into the uterine cavity. *Uterine sound* held lightly between thumb and fingers is passed gently through the cervix to note the utero-cervical length and also to confirm the position of the uterus whether retroflexed or anteflexed. This has to be done very carefully as any forceful introduction of sound will cause false passages in the endocervical canal.

Dilatation of Cervix

Cervix is now gradually dilated using *graduated metal dilators* (Hegar's or Hawkin's-Amblar's) starting from lowest size close to that of the sound. It is gently pushed into the cervical canal with steady pressure, the tip of which should go well beyond the internal os. The distance to which the dilator is pushed should not be beyond that of the utero-cervical length determined by the uterine sound. And the pressure to be used on the dilator comes by repeated practise. Uterine perforations are more common with smaller dilators than larger ones. The degree dilatation depends on the type of procedure to be done. For simple curettage it is sufficient to dilate up till 7 mm so to allow the passage of a *curratte,* whereas for suction in termination of pregnancy it can be dilated maximum up to 10 mm. Overdoing in nulliparous will cause damage to cervix leading to incompetence.

Curettage of Endometrium

A small sharp curette of 7 mm width is inserted into the uterine cavity. Holding its sharp concave edge firmly against anterior uterine wall curetting is started from 12 o'clock position in ante-clockwise direction with stroke done from fundus to the cervix. Pressure used should be optimum enough to scrape off the endometrium but not too excess to cause uterine perforation. This gauging of pressure comes only by practice. All the anterior wall, posterior wall, cornual ends and fundus must be optimally scraped and are collected on sterile gauze. Endometrial curettings that is scraped off is collected in a bottle containing 10% formalin saline and is sent for histopathological study. In *fractional* curettage, the samples collected from anterior wall, posterior wall, cornual ends and endocervix are separately collected and sent

in separate bottles with proper labelling. The sample has to be sent in normal saline to rule out endometrial tuberculosis.

The speculum is removed off the vagina after ensuring the haemostasis. After the patient recovers from anaesthesia she is discharged with a course of antibiotics and analgesics.

Complications

Cervical tear—common at the time of dilatation during earlier days. But now with the use of prostaglandins (vaginal misoprostol 400 mcg 3-4 hours prior to procedure) which aids in softening the cervix and help in favourable dilatation. If cervical tear has occurred it has to be sutured without fail. Sometimes the tear may extend upwards involving the descending cervical arteries causing profuse haemorrhage. This can be controlled by a deep lateral stitch on the cervix. It may sometimes necessitate opening the abdomen if there is a tear of the cervix involving the uterine artery above which needs to be ligated.

Uterine perforation—this can be produced by uterine sound, dilators or curette. Sudden loss of resistance while sounding the uterus, dilating the cervix or curetting the uterus should one suspect perforation. The procedure is abandoned at this point and laparoscopy is done to confirm the perforation. The perforation may be simple involving only the uterus or may injure the bladder, omentum, vessels and intestines. If it is simple uterine perforation without involving adjacent viscera, patient is admitted and observed for 24 hrs with antibiotics, monitoring pulse, temperature and respiration. If she is stable she may be discharged. Laparotomy is required when there is visceral injury, big uterine perforation, vessel injury and peritonitis. Uterine rent is sutured, bleeding vessel is ligated. Hysterectomy is done when there is extensive uterine injury with haemorrhage or broad ligament haematoma. Bowel is inspected from jejunum to rectum including omentem. Simple bowel perforation can be sutured in 2 layers using vicryl sutures. Bowel resection with end to end anastomosis is required in case of multiple perforations along with avulsion of mesentery. Bladder injury if present should be identified and sutured with 2 layers of 2-0 vicryl sutures and catheter should be left *in situ* for 7-10 days.

Infection—may be immediate or late; may be localised to pelvis and uterus or may extend to the general peritoneal cavity causing peritonitis. Local pelvic infection is treated conservatively with higher antibiotics. Generalised peritonitis require proper management of fluid and electrolytes, higher antibiotics, laparotomy, pus drainage, hysterectomy if necessary.

Remote complications are secondary amenorrhoea, infertility due to secondary sepsis.

MEDICAL TERMINATION OF PREGNANCY

Induced abortions in India are been liberalised and was brought under *Medical Termination of Pregnancy Act* passed by the parliament which came into force on April 1, 1971. The law specifies—

1. The condition under which pregnancy can be terminated.
   a. *Medical grounds* where the continuation of pregnancy (i) may endanger the life of pregnant woman ii) cause grave injury to the physical and mental health of the woman as in cardiac diseases (severe grade III and grade IV types, pulmonary hypertension, cardiac enlargement, left ventricular hypertrophy, ECG changes showing myocardial ischemia) renal diseases (CRF),uncontrolled hypertension and diabetes, ongoing psychiatric diseases (like schizophrenia, severe depression), malignancies of cervix or breast, severe degree of hyperemesis not responding to any conservative management.
   b. *Eugenic grounds* where there would be a risk of physical and mental disability in fetus when the mother has been exposed to teratogenic drugs, radiation, viral infections (rubella) , at the time of organogenesis (First 8 weeks of gestation); risk of chromosomal abnormalities (trisomy 21, 18) and inborn errors of metabolism in fetus picked up by amniocentesis done after 14 weeks, sonar study done at 18-20th week revealing neural tubal defects (spina bifida, anencephaly) in fetus.
   c. *Social grounds* to prevent grave injury to the physical and mental health of the pregnant woman, where the woman has to undergo an unplanned pregnancy resulted from contraceptive failure or rape.
2. The abortion procedure can be performed by:
   a. Registered Medical Practitioner who has assisted at least 25 MTP's in an authorised centre and having a certificate.
   b. One who had 6 months house surgeon training in obstetrics and gynaecology.
   c. MD/diploma holder in obstetrics and gynaecology.
3. This procedures can be done at government hospitals or places maintained by the government or at places approved by the government.

Written consent of only the patient is sufficient; in case of minor or lunatic consent of the parent or the legal guardian can be taken.

Termination is legally permitted up to 20 weeks, beyond 12 weeks opinion of two medical practitioners is necessary.

Methods of Termination

Prior to termination it is essential to assess Hb%, blood grouping and Rh typing, urine analysis and blood sugar estimation. If patient is Rh negative blood group it is essential to give inj. Anti-D 50 μg within 72 hours of the procedure. USG to confirm period of gestation.

First Trimester (up to 12 weeks)

Medical method

Mifepristone (RU486) and misoprostol—Mifepristone an analog of natural progesterone blocks its effect and misoprostol (PGE_1) helps in expulsion of conceptus by bringing about powerful uterine contraction. Recommended dose of 600 mg of mifepristone orally on day 1 followed by 400 mcg of misoprostol orally on day 3 is effective when used within 50 days of gestation. 200 mg of mifepristone orally with 800 mcg of misoprostol vaginally is also equally effective.

Problems:

- Incomplete expulsion (2-3%), confirmed by USG done after 2 weeks, needs surgical evacuation.
- Non-responders (1%), where the above protocol has failed to bring about abortion, requires surgical evacuation.

Other regimens:

- Methotrexate 50mg/m^2 IM followed by misoprostol 800 mcg vaginally after 7 days.
- Tamoxifen 20 mg orally for 4 days followed by 800 mcg of misoprostol vaginally.

Surgical Method

- Menstrual regulation
- Dilatation and suction evacuation
- Dilatation and curettage.
  - *Menstrual regulation:* This involves aspiration of uterine cavity within 2 weeks of last missed period without confirming the pregnancy. The contents of uterine cavity is aspirated using a special plastic syringe of 60 ml capacity with a non-return valve attached to a flexible plastic cannula (Karman) of 6-12 mm diameter. The syringe can be used 65-75 times and the cannula for 10-12 times.The vacuum created in the syringe is similar to that in an electrical apparatus, upto 660 mm of mercury. The procedure can be done as an out-patient procedure without anaesthesia but may sometimes require paracervical block.

    Under aseptic precaution, speculum is inserted into the vagina, cervix is visualised and held with Allis forceps or small-sized vulsellum. The cervix is dilated up to the required size. The cannula is inserted into the cavity. It is attached to the syringe. The valve of the syringe is closed and the piston is pulled back to create a vacuum before attaching it to the cannula. Once the cannula is inserted into the uterine cavity the valve is released. The cannula is moved to and fro gently until whole of the endometrial contents are aspirated or the syringe gets completely filled with contents. The cannula is detached from the syringe and the aspirated contents are inspected by pouring it over basin filled with water. The procedure may be repeated until no contents fill the syringe, or you see air bubbles in the syringe or when you feel the gripping sensation of the uterus and uterine cavity feels empty. The vacuum must be repeatedly created as mentioned above before attaching it to the cannula. *Problems*: The procedure may be inadequate in pregnancies beyond 7 weeks. There is risk of continuation of pregnancy (5%) and also a possibility of missing ectopic pregnancy. Other risks are uterine perforation (05%) though rare do can occur. Incomplete abortion, haemorrhage due to retained products of conception, cervical tear and perforations are the other problems that can be encountered.
  - *Dilatation and suction evacuation***:** This procedure involves sucking of products of conception with the help of a cannula attached to a suction apparatus.

    This method is useful in termination of pregnancy less than 12 weeks, in incomplete abortion, inevitable abortion, and molar pregnancy. It can be done as a outpatient procedure under paracervical block and IV sedation (inj diazepam 10mg and atropine 0.6 mg). General anaesthesia may be required in apprehensive patients.

    Prior to the procedure a gentle vaginal examination is done to note the size, position of the uterus with patient in lithotomy position, perineum is cleaned with any antiseptic solution. Draping is done. Posterior vaginal speculum of appropriate size is inserted. Cervix is visualised and held with vulsellum or Allis's forceps. Paracervical block given Uterine sound is inserted into the uterine cavity to know the uterocervical length and the direction of the uterine cavity. The cervix is dilated with the help of dilators as mentioned in the previous topic to a size less than the size of the cannula which has to be used. The dilatation can be made easy by the use of vaginal misoprostol 400 mcg 3 hours prior to the procedure or parenteral carboprost (15 methyl $PGF_{2\alpha}$). Once the dilatation is done cannula is inserted into the uterine cavity. Noting the uterocervical length it should not move beyond that length. With a help of rubber tubing or plastic tubing it is connected to a suction apparatus. The pressure of the suction apparatus is maintained at 400-600 Hg. Injection methergin 0.2 mg is given intravenous. By to and fro movements of the cannula the contents of the uterine cavity are aspirated which gets collected in the bottle of the suction apparatus. The suction can be regulated by placing a finger over the hole at the base of the cannula. The suction is said to be complete when no contents are aspirated from the uterine cavity, air bubbles are seen in the cannula, when one feels the gripping sensation over the cannula by the contracting uterus, and the typical grating sensation .The vacuum has to be broken by detaching the tubing before the cannula is removed. The cavity is gently curetted with a curette. The cannula may be re-inserted to aspirate any leftover contents. At the end of the procedure cervical os is examined for any bleeding. A sterile vulval pad is placed.
  - Problems:
    - » Cervical injury and laceration (already discussed in dilatation and curettage).
    - » Perforation (already discussed in dilatation and curettage). Can be minimised with the use of plastic cannula.
    - » Infection can be reduced and/controlled with the use of proper antibiotics before and after the procedure.
  - Drawbacks: Not beneficial in gestation beyond 10 weeks as the products are big to be sucked into the cannula.
  - *Dilatation and curattage:* The steps are similar as described before. But as the products of conception has to be removed the cervix needs to be dilated to 10-12 mm even for 8 weeks gestation,14-15 mm for 11-12 weeks gestation.The cervix needs to be softened prior to the procedure by vaginal misoprostol (inseted 3 hours before) or intramuscular carboprost (given 2 hours before). Dilatation must be carried out gently and smoothly to avoid cervical tear.

    As the pregnant uterus will be soft intravenous methargin 0.2 mg has to be given once the dilatation is complete and curettage is begun in order to contract the uterus and make it hard. Alternatively oxytocin 5U can be given intravenously as methergin causes undesirable vomiting.

    Uterine sound is passed to know the uterocervical length. Sponge holding forceps or ovum forceps of appropriate size is inserted through the dilated cervix and advanced towards fundus. The sac is ruptured allowing the fluid to flow out. The blades of the forceps is opened and the products are held with the blades and gently pulled out through the cervix. The procedure is repeated until all products are pulled out. Undue traction should be avoided while pulling out the products. If resistance is felt then the products are pulled in small bits until the cavity is felt empty. A blunt curette can now be inserted into the cavity and curettage is done to loosen the tissues. The ovum forceps is re-inserted to remove any more bits left especially from the cornual ends. Cavity can be curetted gently until you feel the grating sensation of endometrium and no blood trickles through the cervical os ensuring the completeness of the procedure. Antibiotics are always given for 5 days to prevent any infection.

Second Trimester Termination

- *Surgical evacuation:* Dilatation and evacuation, aspirotomy
  It is suitable up to 13-15 weeks of pregnancy.
- Intra-amniotic instillation of drugs: Hypertonic saline, urea, prostaglandins.
- Extra-amniotic instillation of drugs: Ethacridine lactate, prostaglandins and hypertonic saline.
- Hysterotomy.

Combining the use of oxyrocic drugs augments the myometrial activity and thereby help to shorten the induction-abortion interval. Vaginal misoprostol 400 mg can be used prior to the above procedure which will help in cervical softening and dilatation thereby preventing cervical tears.

Dilatation and evacuation: Patient is in lithotomy position. Vulva is cleaned with antiseptic solution and draped with sterile clothes. Posterior vagina is depressed with Sim's speculum. Cervix is visualised and held with sponge holding forceps or vulsellum. Paracervical block given. Cervix is dilated as described before up to no.12. Sac is ruptured and the liquor amnii is aspirated with a large-bore suction cannula. A special forceps called the aspirotomy forceps which has long blades, strong jaws measuring 7-12 mm across and no ratchet is inserted into the cavity. The fetal parts are crushed with it and extracted out through the cervix. Injection methergin 0.2 mg IV is given at the time of evacuation to contract the uterus so as to make it hard to avoid perforation and also to minimise the bleeding. Placental parts are also removed with the forceps. Cavity is curetted with blunt curette.

With expert hands this method helps to evacuate the uterus with minimal bleeding and no hospitalisation.

Intra-amniotic instillation of drugs: This method is employed beyond 16 weeks up to 20 weeks. It requires hospitalisation. Drugs instilled into the amniotic cavity may be $PGF_{2\alpha}$ alone or combination of PGE_2 and hypertonic urea solution or hypertonic saline solution. USG is necessary to confirm the placental site. Coagulation profile, cardiac and renal status, are checked.

The prostaglandin solution to be injected is freshly prepared before use by diluting 40 mg of $PGF_{2\alpha}$ in 20 ml syringe containing physiological saline. Combination of hypertonic urea solution and PGE_2 is prepared by dissolving 80 g of 40% urea in 150 ml of physiological saline and mixing it with 10 mg of PGE_2 in 50 ml syringe. 2 mg of 15 methyl $PGF_{2\alpha}$ (carboprost) can also be used with urea solution. Amount of hypertonic saline required is 10 ml per weeks of gestation.

Patient is placed in dorsal position after emptying the bladder. 5ml 1% lignocaine is used to infiltrate the skin over the chosen site far away from placenta. 19-gauge needle is used to inject the local anaesthetic agent into the rectus muscle and peritoneum. An 18-gauge spinal needle or Tuhey needle is inserted into the uterus with the tip in a clear pocket of amniotic fluid. About 20 ml of fluid is withdrawn to ensure the correct placement. If blood comes out of the needle, then probably the needle placement may be incorrect or it may have pierced some blood vessel. The needle is withdrawn and reinserted in another site till clear amniotic fluid is aspirated.

The drugs to be instilled are injected slowly through this needle. As the volume injected may lead to over distension of uterus causing discomfort to the patient, sufficient amount of amniotic fluid (at least 50 ml) must be aspirated prior to instillation. When hypertonic saline is used it is safer to infuse by means of drip set taking at least 5-10 minutes to infuse it. Vital signs should be recorded immediately after the procedure. Patient should be under close observation at least for 2 hours. Antibiotic coverage is given.

The patient may feel severe pain if the drug is injected into the myometrium or into the peritoneal cavity at when the procedure may be abandoned. When hypertonic saline is used as the instillating agent the patient may experience severe thirst, headache, flushing hypertension, chest pain, bradycardia, apnoea, tingling of fingers and severe pain, if the solution is accidently injected into the blood vessel. The procedure should be immediately abandoned and 1000 ml of dextrose solution should be rapidly infused with intravenous diuretics. This may sometimes also cause anuria, cerebral oedema.

Uterine contraction usually commences within 2-6 hours. If at all no satisfactory contraction is seen then the dose of prostaglandins can be repeated without urea solution. One should withhold the use of syntocin infusion to avoid uterine hyperstimulation, cervical laceration and rupture uterus and fluid overload.

Induction-abortion interval is 36-48 hours in 95% of cases when hypertonic saline is used; whereas it is 13-16 hours in 90% of cases when the combination of urea and prostaglandins are used.

Complications

- Nausea, vomiting, diarrhoea (more when PG's are used).
- Intense abdominal pain due to hyperstimulation of uterus.
- Cervical tear and laceration leading to profuse haemorrhage.
- Incomplete expulsion with retained products of conception which might require exploration and evacuation under anaesthesia.
- Intrauterine infection leading to severe sepsis which can be checked with proper usage of higher antibiotics.
- Hypernatraemia due to accidental infusion of hypertonic saline into a blood vessel.
- Uterine necrosis, rupture, pulmonary and cerebral oedema, consumption coagulopathy, and renal failure are hazards more common with hypertonic saline infusion.
- Accidental infusion of saline into bladder wall or myometrium or peritoneal cavity or ovaries can cause severe irritation and tissue necrosis.

Contraindication:

- Hypertonic saline is better avoided in pre-existing cardiovascular disease, hypertension, sickle cell anaemia, renal disease and severe anaemia (as hypernatremia can cause haemolysis).
- PG's are better avoided in patients with known history of bronchial asthma.

Late sequelae: Menstrual disturbances due to chronic endometritis, secondary infertility due to cervical incompetence and tubal block, chronic pelvic inflammatory disease, ectopic pregnancy.

Exta-amniotic instillation of drugs: Drugs used—0.1% ethacrydine lactate (10 ml per week but maximum is 150 mL) $PGF_{2\alpha}$ 200-500 µg or PGE_2 200 µg.

Patient is placed in lithotomy position after emptying the bladder. After cleaning with antiseptic lotion, perineum is draped. Vagina is cleaned with antiseptic solution, cervix is visualised with the help of Sim's speculum and held with tenaculum. A no. 16 Foley's catheter is pushed through the cervix well beyond the internal os up to 10 cm between uterine wall and membranes. The balloon of Foley's is inflated with 10 ml saline or distilled water. This will fit at the internal os there by preventing the fall of the catheter.

Now the drug either ethacrydine lactate or prostaglandins is injected to the extraamniotic space through this catheter. The required dose of prostaglandin is taken and dissolved in physiological saline to make 100 ml solution. This solution is injected through the catheter to the extraamniotic space. The dose of prostaglandins can be repeated every 2 hrs or can be be given as a continuous infusion through the catheter. Usually contraction starts within 1-2 hours and induction – abortion interval is around 16-18 hours in 90% cases. Patient should be monitored continuously for vital signs, uterine contraction and cervical dilatation. The catheter gets expelled with dilatation of cervix followed by expulsion of the fetus. Placenta is frequently retained which needs to be evacuated under anaesthesia.

Complications

- Infection due to indwelling catheter. So some prefer to remove the catheter within 4 hours. Antibiotics coverage should be started at the earliest.
- Intolerance to prostaglandins—fever, severe nausea, vomiting, diarrhoea, uterine hyperstimulation.
- Cervical tear and laceration leading to profuse bleeding.
- Expulsion of live fetus giving a uncomfortable feeling.
- Retention of placenta needing evacuation under anaesthesia.
- Menstrual disturbances due to chronic endometritis, secondary infertility due to cervical incompetence and tubal block, chronic pelvic inflammatory disease are the late sequelae.

Hysterotomy

This is not routinely done for medical termination of pregnancy. It is done if all the other methods for midtrimester abortion fails and is usually combined with tubal sterilisation whenever necessary. The procedure is usually done through abdominal route but can also be done vaginally.

The patient is prepared as for any abdominal surgery. The procedure can be done under general or spinal or epidural anaesthesia. The abdomen is painted with antiseptic lotion, draped with sterile drapes. Abdomen is opened by Pfannenstiel incision. After opening the peritoneum uterus is drawn out of the incision and the abdomen is packed with sterile mops to prevent the spillage of uterine contents into the peritoneal cavity (to prevent scar endometriosis). The loose uterovesical fold of peritoneum is opened and bladder is pushed down. A vertical incision of 5 cm is made on the myometrium as low as possible, deepened until the membranes are visible. As the isthmus is narrow in early pregnancy, transverse incision may cause injury to uterine vessels. Inj. Methergin 0.2 mg is given intravenously. The products of conception are gently removed from the uterine cavity. Cavity is cleaned with a gauze gently.The uterine incision is closed by apposing the muscle in 2 layers by continuous sutures, with 1-0 chromic catgut in round bodied needle.

Alternatively, uterus can be opened in the upper segment without opening the UV fold of peritoneum, but the incision is made as low as possible. This approach is usually followed by tubal ligation to prevent rupture uterus in future pregnancy.

Abdominal packs are removed. Abdomen is closed in layers after a peritoneal wash with saline.

Patient is kept nil oral till the bowel movements are heard. Hydration is maintained with IV fluids. Sepsis is prevented with proper antibiotics. Patients is watched for vaginal bleeding, and sepsis. Patient is discharged on 5th day from the hospital.

Complications

Sepsis peritonitis, uterine bleeding, anaesthetic hazards are the immediate complications. Menstrual irregularities, scar endometriosis, rupture of hysterotomy scar in future pregnancy are the delayed complications.

Vaginal Hysterotomy

Patient is placed in lithotomy position. Cervix is exposed with Sim's speculum and anterior wall retractor. It is held with vulsellum. Anterior vaginal skin above the cervix is infiltrated with 10 ml 1:200000 adrenaline to reduce the bleeding. A horizontal incision is made on the vaginal epithelium at its junction with the cervix. Bladder is identified and pushed up with finger and guaze to expose the cervix and the lower segment. Uterine wall is incised 3 cm on the lower segment; products of conception are removed with ovum forceps. Later the uterine wall is closed followed by the closure of the vaginal epithelium.

This procedure avoids all the hazards of abdominal procedure.

BARTHOLIN CYST AND ABSCESS

Bartholin's cyst is a rounded swelling on the inner aspect of labium majus at the junction of anterior 2/3rd and posterior 1/3rd due to blockage of duct orifice following chronic inflammation. Cyst is asymptomatic but may cause slight vulvar discomfort, dyspareunia.

Cyst may sometimes rupture spontaneously which then may require sitz bath and a course of antibiotics. Persistent cyst needs excision which can be done under general anaesthesia with the patient placed in lithotomy position. Vulva and perineum is painted with antiseptic lotion and draped. A vertical incision is made over the outer aspect of the cyst not extending upwards too much as it may cause damage to vestibular bulb containing venous plexus. A plane of cleavage is dissected between the cyst wall and the vaginal mucosa and skin. As the cyst is thin walled and the tissues around the cyst wall are thickened and vascular, the cyst is likely to rupture during the dissection. Sharp dissection helps to enucleate the cyst completely. Duct also should be removed along with the cyst. Bleeding vessels has to be cauterized or ligated. Cavity is obliterated with interrupted sutures. A silastic drain can be kept in the cavity if there is excess oozing. The skin is trimmed and closed with interrupted sutures. Drain may be removed on the 2nd day. Patient is discharged with a course of antibiotics **(Fig. 32-1)**.

Acute inflammation of the Bartholin gland leads to bartholinitis and abscess formation. Abscess is very painful causing the patient difficult to sit, and walk. Incision and drainage of the abscess is done under general anaesthesia. A vertical incision is done on the outer aspect of the abscess. Pus drained is sent for culture and sensitivity. Finger is inserted into the cavity and explored. Gauze plug soaked with betadine solution is kept in the cavity. Daily dressing is done till cavity heels. Antibiotics are given. Alternatively *marsupialisation* can also be done for bartholin abscess. Under general anaesthesia a vertical incision 2.5 cm is made over the vaginal aspect of the labium. The skin is separated from the underlying abscess. The abscess cavity is opened with scalpel. Pus drained is collected and sent for culture and sensitivity. The edges of abscess cavity and skin is trimmed and apposed with 3-0 interrupted catgut sutures. No drain is required. Even though it is practiced to suture the skin if infection is severe, pack can be kept and dressing can be done. As if it is severely infected area, it will not granulate if sutured. Non suturing may lead into wide scar. When healing occurs a small permanent opening will remain **(Fig. 32-2)**.

ECTOPIC PREGNANCY

It is an abnormal pregnancy where the fertilised ovum implants and develops outside the normal uterine cavity.

Sites of Ectopic Pregnancy

Fallopian tubes—98% (ampullary portion commonest)
Ovaries—0.15%
Abdominal cavity—1%
Cervix

Clinical Features

Patient with ectopic pregnancy presents with variable degrees of abdominal pain (may be severe, acute or dull aching type); short

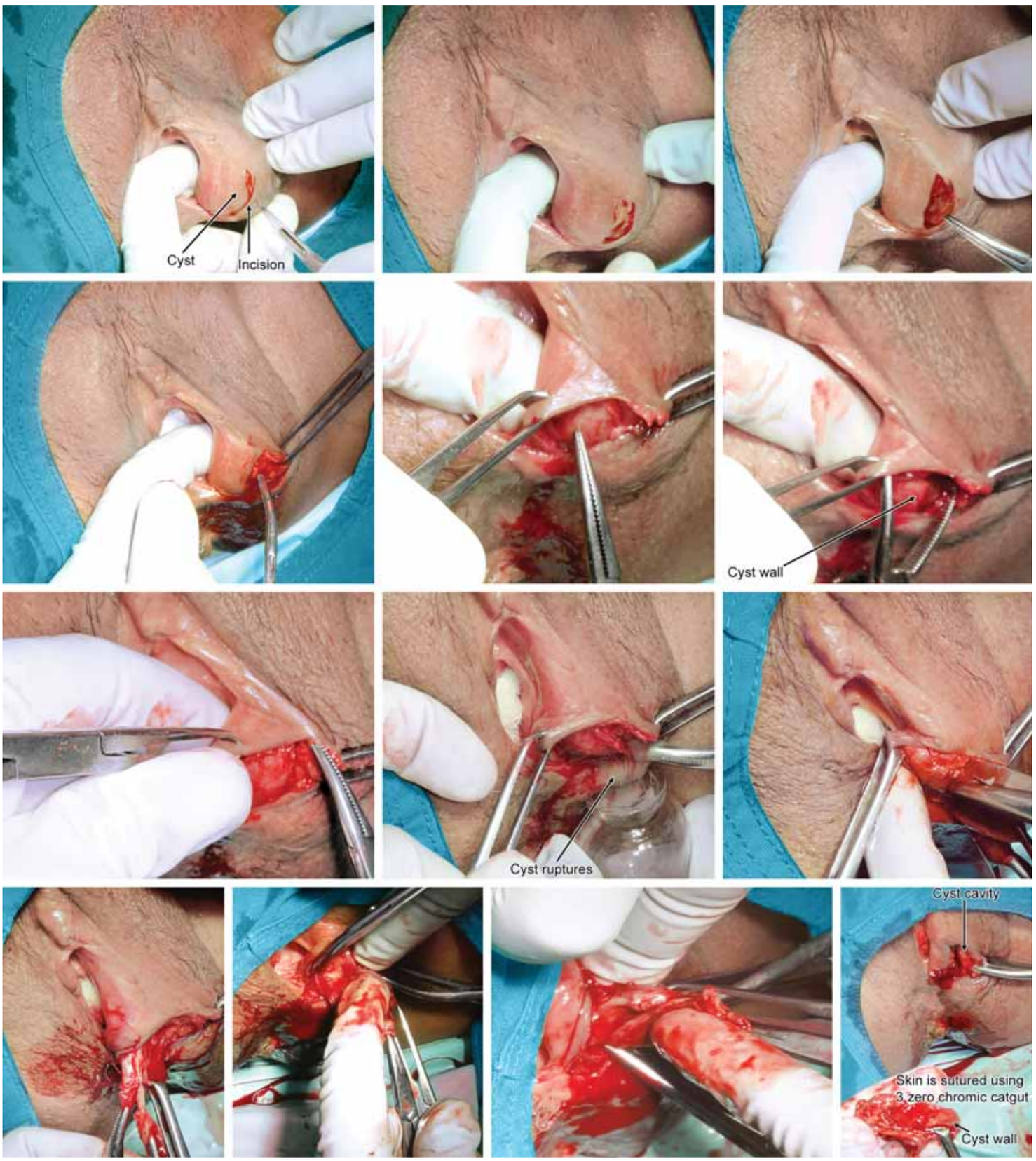


Fig. 32-1: Bartholin cyst excision—technique.

period of amenorrhoea (may or may not be present, may have on and off spotting); fainting episodes (typical of ectopic), feeling of nausea and vomiting with pain. Some patient may present with profound shock with a characteristic pallor out of proportion to visible vaginal bleeding. Tenderness in lower abdomen and the typical tender uterine movement, raised serum β-HCG, ultrasound abdomen and pelvis may show free fluid in pelvic cavity along with absence of intrauterine gestation with presence of gestational sac outside the uterine cavity—all help in coming to a diagnosis. In doubtful cases laparoscopy can be done to diagnose and proceed with ectopic gestation.

Fig. 32-2: Bartholin abscess drainage.

Surgical Aspects in Ectopic Pregnancy

Once the diagnosis is confirmed patient is immediately taken up for surgery. Patient in shock is initially resuscitated with IV fluids. Minimum 2 points of blood is arranged as there may be significant intra-peritoneal haemorrhage. IV antibiotics are given.

Abdomen is opened by a large incision either by Pfannenstiel or lower midline so as to have adequate access to ectopic site and also there may be adhesions which may have to deal with. Blood in the peritoneal cavity is cleared off with suction. Ectopic site is identified.

In tubal ectopic gestation, *salpingectomy* is done when future fertility is of no concern, when there is rupture with major intra-peritoneal haemorrhage, or when the tube is extensively damaged. One pair of long haemostatic clamps (Kocher's long and straight clamp) are placed on the medial end of the fallopian tube including the mesosalpinx close to the tube so as to conserve the ovarian vasculature. Second pair is placed on the lateral aspect on the mesosalpinx. The tips of the clamps should be approximated. If the adjacent ovary need to be removed the second pair of clamp is placed over the infundibulopelvic ligament. The divided pedicles are transfixed and ligated with 1/0 vicryl sutures before releasing the clamps. The excised tubes are sent for histopathological examination.

Partial salpingectomy/segmental resection is done when one wants to conserve the tube for fertility. Only that part of the tube damaged by ectopic pregnancy is removed, leaving behind considerable amount of tube for reanastomosis in later period. Clamps are applied on either side of the ectopic. Before applying clamps it is essential to note vessel free area in the mesosalpinx which appears transilluminant. The tips of the clamps should be placed close to each other. This will avoid bleeding from any blood vessels when sutures are applied. The pedicles include the cut end of the tubes and mesosalpinx. If the patient does not wish for future fertility tubal ligation (by *Pomeroy's method*) is done on the other tube.

Conservative Surgery in Ectopic Pregnancy

Salpingostomy/Salpingotomy: In case of un-ruptured ectopic pregnancy, this procedure can be done to conserve the tube. The tube is held on either side of the ectopic gestation with Babcock's forceps. A linear incision on the antimesenteric border, running parallel to the tube is done with knife/needle tip cautery/laser, at the site of ectopic gestation for about 2/3rd of the length of the swollen part. Prior to the incision over the tube, inj. vasopressin may be given to the tube so as to reduce bleeding. Products of conception are flushed out with suction irrigator or removed with non-toothed dissecting forceps. Bleeding points are ligated with fine sutures or cauterized. Lavage of the tube with Hartmann's solution may help in identifying the bleeding points. If the tube is not very healthy with fimbria partly occluded, it is left open (*salpingostomy*) without suturing to heel by itself, which usually occurs in 3-6 weeks. The incision may be closed in one layer with fine 6/0 prolene if the tubes look healthy (*salpingotomy*).

The success of conservative surgery depends on—

- One should not use catgut as it may cause inflammatory reaction in the tube leading to decreased fertility.
- Tubes are to be handled gently using atraumatic instruments and sutures.
- Peritoneal cavity must be cleared off blood clots so to reduce the adhesion formation. Proper haemostasis should be ensured.

Laparoscopic surgeries for ectopic pregnancy is done in haemodynamically stable patient, is now becoming immensely popular as the healing time is quicker with minimal adhesions. Salpingectomy, salpingostomy or segmental resection can be done laparoscopically. In salpingectomy, the tubal segment to be removed is coagulated with bipolar forceps. The meso-ovarium is coagulated and cut close to the tube. The specimen can be retrieved by a small suprapubic stab incision. Haemostasis can be obtained with diathermy.

Chronic Ectopic

Here the patient has passed the acute phase of the ectopic presentation. Due to continuous slow bleed from the ectopic site haematoma is formed which organises to form a mass in the lower abdomen with significant adhesions with the adjacent bowel, omentum and bladder.

Ovarian Pregnancy

Ectopic pregnancy in ovaries is diagnosed when the gestation occupies the region of ovary and that side tube is normal. As rupture is an inevitable phenomenon *oophorectomy* is done. Presently many have advocated cystectomy as the procedure of the choice. Only the portion of the ovary involved by ectopic is removed either by laparotomy/laparoscopy.

Cervical Pregnancy

When the implantation occurs in cervix it leads to cervical pregnancy. It mimics inevitable abortion. But here the uterine size is smaller for the gestational age with internal os closed. Uterine curettage shows no placental tissue. When suction curettage is done to evacuate the pregnancy, one may encounter with mild to severe haemorrhage. This can be dealt with either by uterine packing or by placing lateral cervical suture to ligate the lateral cervical vessel. Cervical encirclage or applying tamponade with Foley's catheter or angiographic embolisation are other methods tried to control bleeding. In severe cases one may need hysterectomy.

Abdominal Pregnancy

It can be *primary* (when the implantation of the fertilised ovum exclusively occurs in the peritoneal cavity) or *secondary* (when the fertilized ovum escapes into the peritoneal cavity either following tubal abortion or through utero-peritoneal fistula). Amniotic sac with the fetus is found within the peritoneal cavity. Placenta may be attached to any of the organs receiving blood supply from it. Empty uterine cavity with abnormal position of the fetus on ultrasound will help one to come to a diagnosis. Laparotomy is done immediately once the diagnosis is made. Fetus is removed out after clamping and cutting the cord close to the placenta. Placenta can be removed if its vascular supply can be identified and ligated. But severe bleeding can occur wherein case sterile packs are kept for 24-48 hours and closed. Angiographic embolisation can be tried to stop the bleeding. Alternatively or in case the vascular supply cannot be identified or the placenta is stuck to a vital organ, it is left *in situ* and abdomen is closed. Higher antibiotics are given to prevent infection. Follow-up with serial ultrasound and serum β-hCG is done to look for the shrinkage of the placenta which can occur by aseptic autolysis. Bowel obstruction, sepsis and fistula formation are the likely complications.

CAESAREAN SECTION

It is an important operative procedure where in fetus after 28 completed gestational week is removed from the uterine cavity by an incision over the abdominal and uterine walls.

When it is done for the first time it is called as *primary caesarian section*, when done on subsequent pregnancies it is called *repeat caesarian section.*

Types

Classical caesarian section—Where the incision made over the uterus is in the upper segment.

Lower segment caesarian section—Where the incision made over the uterus is in the lower segment.

Although caesarian section started as the 'classical type' it is now been totally replaced by 'lower segment caesarian section', as postoperative complications like adhesions, peritonitis and sepsis are more with classical type and also because of the poor integrity of the scar in classical type giving high chances of rupture uterus. Now classical type is totally out of practice.

Emergency caesarean section—When an unforeseen complication arises either during pregnancy or during labor that may endanger mother's or baby's condition, an emergency section is resorted to.

Elective caesarean section (Planned C-section)—The caesarean is planned and done on a specific date during pregnancy (patient not in labor) chosen by the patient and the doctor after assessing the maturity of the baby.

Indications

Elective indication:

- Previous caesarian section done for a recurring cause like contracted pelvis, CPD
- Previous 2 caesarian section
- Malpresentations
- Severe degrees of placenta previa
- Severe diabetes mellitus, severe hypertension, severe degrees PIH, cardiac disease not fit for induction of labour
- Bad obstetric history
- Elderly primigravida
- Fetal macrosomia with birth weight >4 kg
- Advanced carcinoma cervix
- Pelvic tumours, impacted ovarian cysts not allowing a vaginal delivery
- Previously repaired VVF
- HPV infection in mother
- Maternal request.

Emergency indication:

- Complications of labor—prolonged labour or a failure to progress (dystocia)
- Fetal distress
- Cord prolapse
- Uterine rupture
- Increased maternal blood pressure after amniotic membrane rupture
- Maternal or fetal tachycardia after amniotic membrane rupture
- Placental problems (placenta praevia, placental abruption or placenta accreta)
- Failed labour induction
- Failed instrumental delivery (by forceps or ventouse)
- Umbilical cord abnormalities (vasa previa, multilobate including bilobate and succenturiate-lobed placentas, velamentous insertion).

Preoperative Preparation

For elective caesarian section it is advisable to keep the patient fasting for 6 hours. But if the patient is in labour as for emergency C section, it is not possible to keep the patient fasting. To prevent acid aspiration injection ranitidine 150 mg, antiemetic metoclopramide is injected an hour before the surgery. Abdomen and perineum up to mid-thigh is shaved. Inj. atropine 0.6 mg is administered IV. Bladder is catheterised. Before giving anaesthesia it is always advisable to hear the fetal heart sound and do a pelvic examination (especially in patients who were in labour). Some indications like placenta previa, placenta accreta, previous caesarian section, twin pregnancy, rupture uterus require cross-matched blood to be kept ready. Pediatrician should be called for to attend the baby soon after extraction.

Anaesthesia

It may be general/spinal/epidural. It depends on the indication and the experience of the anaesthetist. Most of the elective C section is preferably done under epidural/spinal. General anaesthesia is given when spinal anaesthesia is contraindicated or not possible.

Positioning of the Patient

Patient is positioned in dorsal position with left lateral tilt of 15° to avoid *supine hypotension syndrome*. Under anaesthesia due to direct pressure of the gravid uterus over the inferior vena cava, there would be fall in cardiac output and uterine perfusion which can be prevented by giving a 15° tilt on the lateral aspect with a sandbag or firm pillow.

Antiseptic cleansing with iodine or savlon solution is done followed by draping of the abdomen.

Incision

Before putting an incision over the abdominal wall the lie, presentation of the fetus is confirmed.

The incision may be midline or paramedian or *Pfannenstiel. Midline incision* extends from upper border of the pubes to 2 cms below the umbilicus. But its extent depends on the fetal size or configuration of the abdomen. The incision is deepened through the rectus sheath. Peritoneum is opened in the upper third so as to avoid injury to the bladder. Alternatively *Pfannenstiel* incision is used which is now very popular and in wide use, as the wound healing is better and postoperative discomfort, wound disruption is less with this incision. This transverse skin incision is approximately 12 cm long, placed 2-3 cm (2 fingers breadth) above the symphysis pubes. *Joel-Cohen* incision is another transverse incision that could be alternatively used, placed slightly higher, 3 cm below the line joining the anterior superior iliac spine. The incision is deepened through the subcutaneous tissues, haemostasis is obtained with diathermy. Rectus sheath is incised in midline and the incision is extended laterally with scissors. Rectus sheath held with Allis forceps or Lane's tissue holding forceps and dissected upwards. Bleeders are secured with diathermy. The parietal

peritoneum is identified, held with two artery forceps and opened with knife or scissors after confirming that there is no structure in the underlying the peritoneum. The peritoneal incision is extended upwards; downward extension must be done carefully due to the presence of bladder which may have displaced unexpectedly high.

The lateral recesses of the wound may be packed with taped abdominal packs to prevent the soiling of the peritoneal cavity with liquor or meconium. Free packs should be avoided as they may get lost in the abdominal cavity leading to medicolegal issues and other complications.

Any rotation (*dextrorotation* commonly) in the long axis of the uterus is noted by the position of the round ligament. This is very important, as if not corrected now; when the uterine incision is done there will be unnecessary lateral extension into the uterine vessels causing bleeding.

Exposing the Lower Uterine Segment

A Doyen's retractor is inserted on the pubic side of the incision. Lower segment is identified. This may not be well formed if is preterm gestation. The loose utero-vesical fold of peritoneum is identified. It is held with non-toothed forceps and opened with scissors. It is extended transversely all along the fold. And the bladder is pushed down away gently by fingers from the site of uterine incision. Fingers are kept towards uterine side rather than bladder. In case of previous caesarian section where there is adhesion of bladder to the lower segment one may have to do sharp dissection with scissors or else it may result in bladder injury. The retractor is advanced further to retract the bladder away from the lower segment.

Uterine Incision

A small transverse incision is made over the lower segment, deepened carefully till one sees the amniotic membrane. The level of the incision depends on the level of the head, such that its widest diameter can be easily brought out. It is usually put 2-3 cm above the bladder base. In unengaged floating head, when the lower segment has not formed and thick as in preterm pregnancy it is better to put the incision slightly higher or else it may extend laterally into the base of the broad ligament involving the vessels. Alternatively low midline, ⊥ shaped or J shaped incision is used. When caesarian section done in advanced stages of labour where the lower segment is stretched incision is placed slightly higher or else the incision may extend into the bladder or into the vagina. It is also better to put a stay stitch in the midline so that the lower uterine flap will not get lost behind the bladder and will help to identify during subsequent suturing.

If the amniotic membrane is not ruptured during uterine incision, it is done and the gushed out fluid is sucked out with the suction. The incision is widened on either side by stretching it with forefingers. This may give ragged edges thereby suturing the uterine edges may give poor quality scar. So, some prefer to widen the uterine incision using scissors, keeping the index and middle fingers underneath the incision for guiding and protection.

Extraction of the Fetus

Four fingers of the hand are inserted below the presenting part. In cephalic presentation the head is gripped with the fingers. The Doyen's retractor is removed. The head is delivered out through the incision which is assisted by the pressure applied over the fundus by the assistant. If the head is deeply jammed in the pelvis, it has to be pushed up by an assistant with sterile gloved hand inserted into the vagina. Once the head is out the secretions in the mouth and nostrils are cleared with hand suction. Shoulders are delivered by insinuating fingers in the axilla; meanwhile the assistant has to retract the upper uterine flap. Once the shoulders are freed the baby will come out freely. The cord is clamped with two artery forceps and cut between the two. Baby is handed over to the pediatrician. Meanwhile inj. Methergin 0.2 mg is given to the mother either IV or IM at the time of delivery of the shoulders to prevent postpartum haemorrhage. Alternatively 5 units of oxytocin may be used in the infusion fluid to prevent bleeding.

In case of high floating head where the delivery of the head through the incision is difficult, one can use outlet forceps or ventouse to extract the head.

In case of breech presentation, the breech is first extracted first through the incision later followed by shoulders and head.

Removal of Placenta

Once the baby is delivered out, the lateral angles of the uterine incision is secured with Green-Armytage clamps. The uterine incision is observed for any bleeding sinuses which are secured with the clamps. Identifying the lower margin of the incision is important as most of the time it gets retracted below and behind the bladder, getting hidden by the pool of blood. It is traced from its lateral angle and held up with Green-Armytage clamps. The stay sutures applied before uterine incision will now come into role to identify the lower margin.

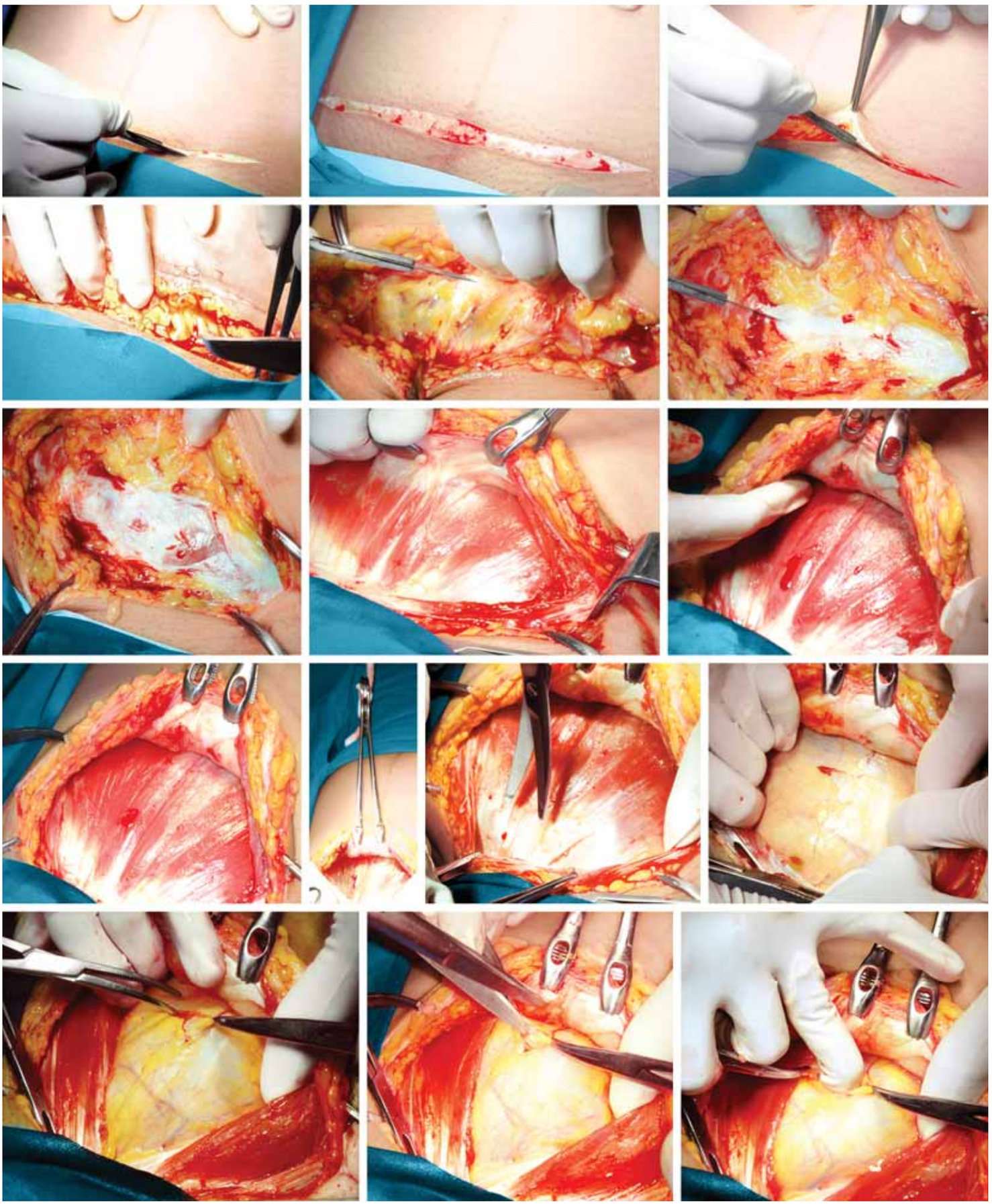
It is always better to wait for placental separation rather than forceful extraction. Once the placenta is found to have separated it is extracted by controlled cord traction, meanwhile applying pressure over the fundus in upward direction. Along with the placenta the membranes are to be carefully stripped off, even from the lower uterine segment. This may require the clamps applied to the margins and the angle to be removed and reapplied.

Complete removal of placenta is ensured by observing for the cotyledons. The uterine cavity may be cleaned gently with sterile gauze. If the patient was not in labor the cervical canal may need to be widened with finger for the outflow of uterine discharge **(Fig. 32-3)**.

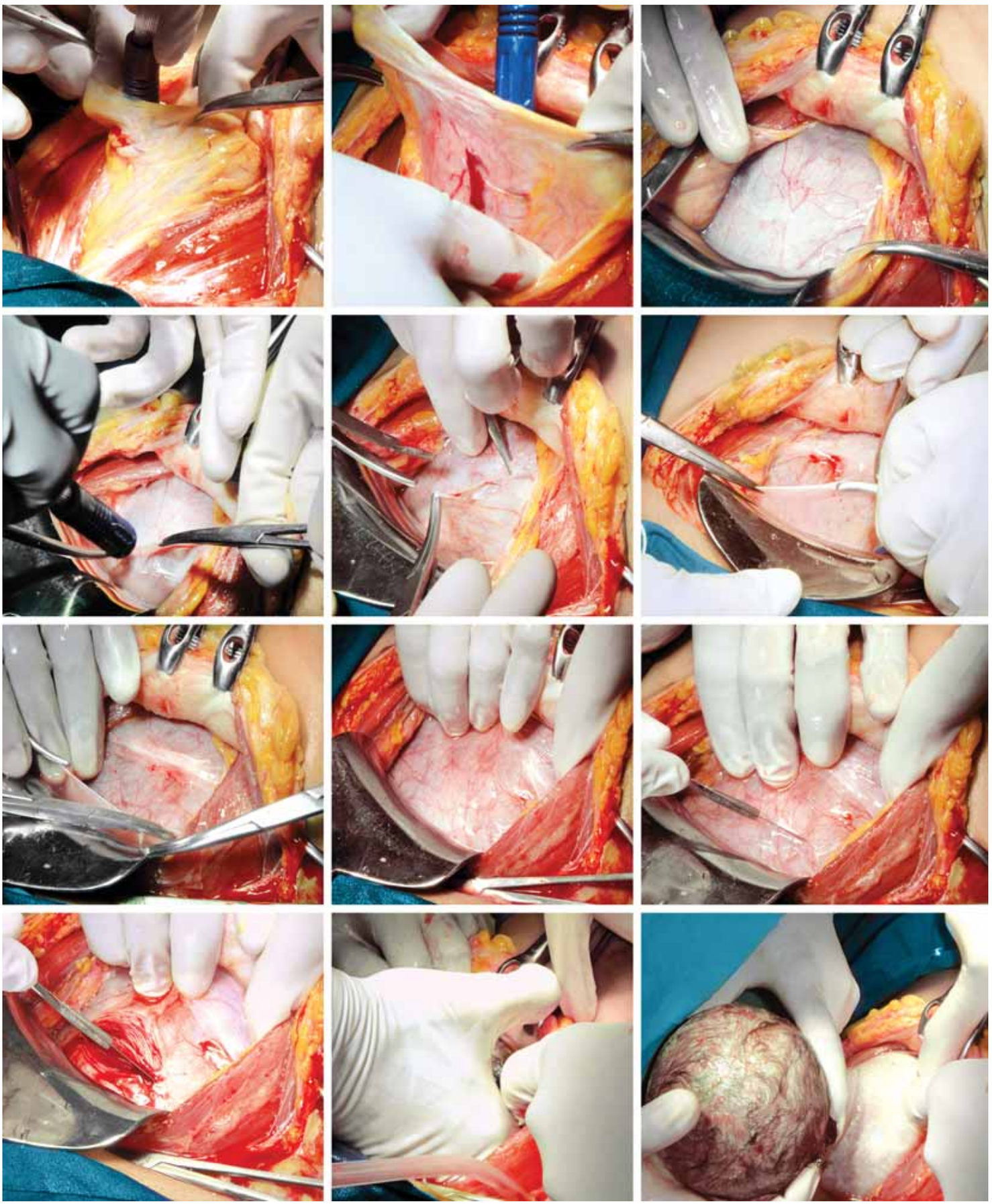
Closure of the Uterine Incision

Uterus is closed with atraumatic round bodied needle using 1/0 chromic or 1/0 vicryl needle.

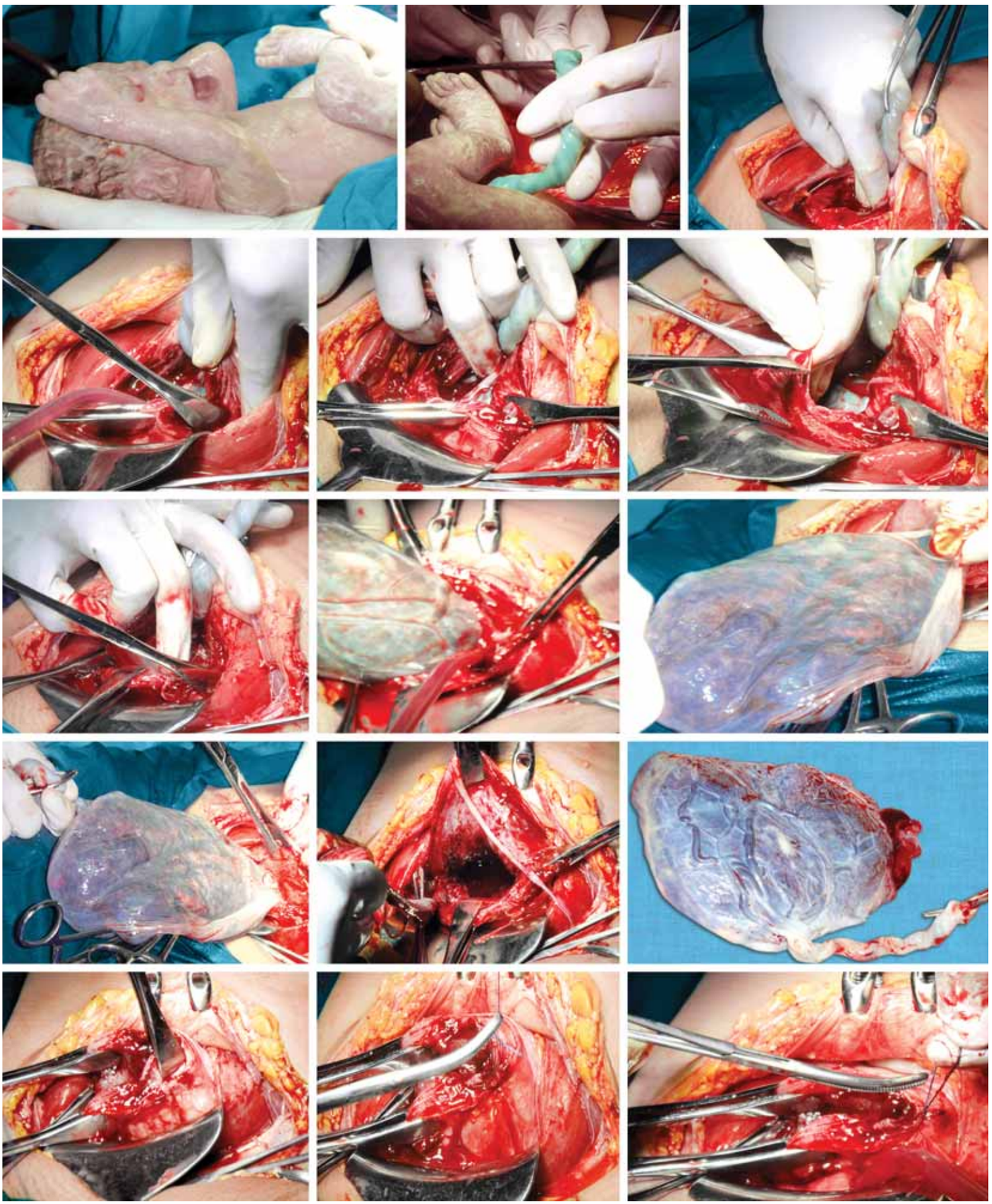
Uterine wound is well visualized. Doyen's retractor is re-inserted to retract the bladder. The suturing is started from the angle far from the operator. The first stitch is taken slightly beyond the angle so as to secure the vessels near the angle. This stitch is very important as sometime the incision may extend laterally tearing the uterine vessels. The suturing is continued taking full thickness of uterine muscle excluding the decidua. Continuous locking suture are used to secure haemostasis. Need of second layer suturing has become a controversy. Some prefer to put a second layer of continuous suture to invert and strengthen the first layer. If haemostasis is well maintained with one layer suturing, then some prefer to avoid second layer suturing. The uterus is palpated to see whether it has contracted or not. Sometimes it may require continuous massage to make it contract and become hard as a cricket ball. UV fold of peritoneum is usually left as such as spontaneous healing is known to occur. Any major bleeding from the bladder base is identified, may need securing with sutures. Ovaries and tubes on both sides are visualised for any abnormalities. The



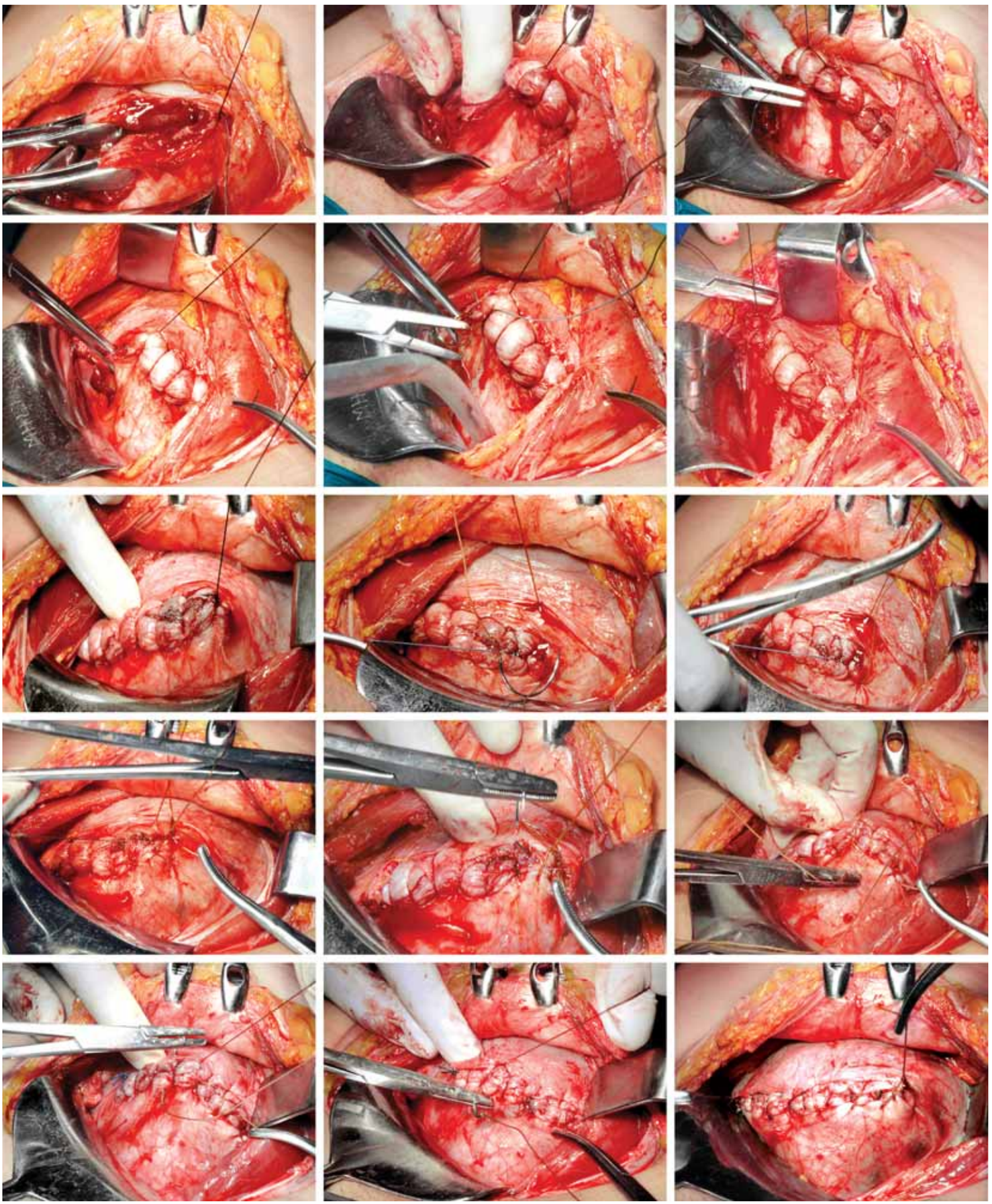
Figs 32-3(1)



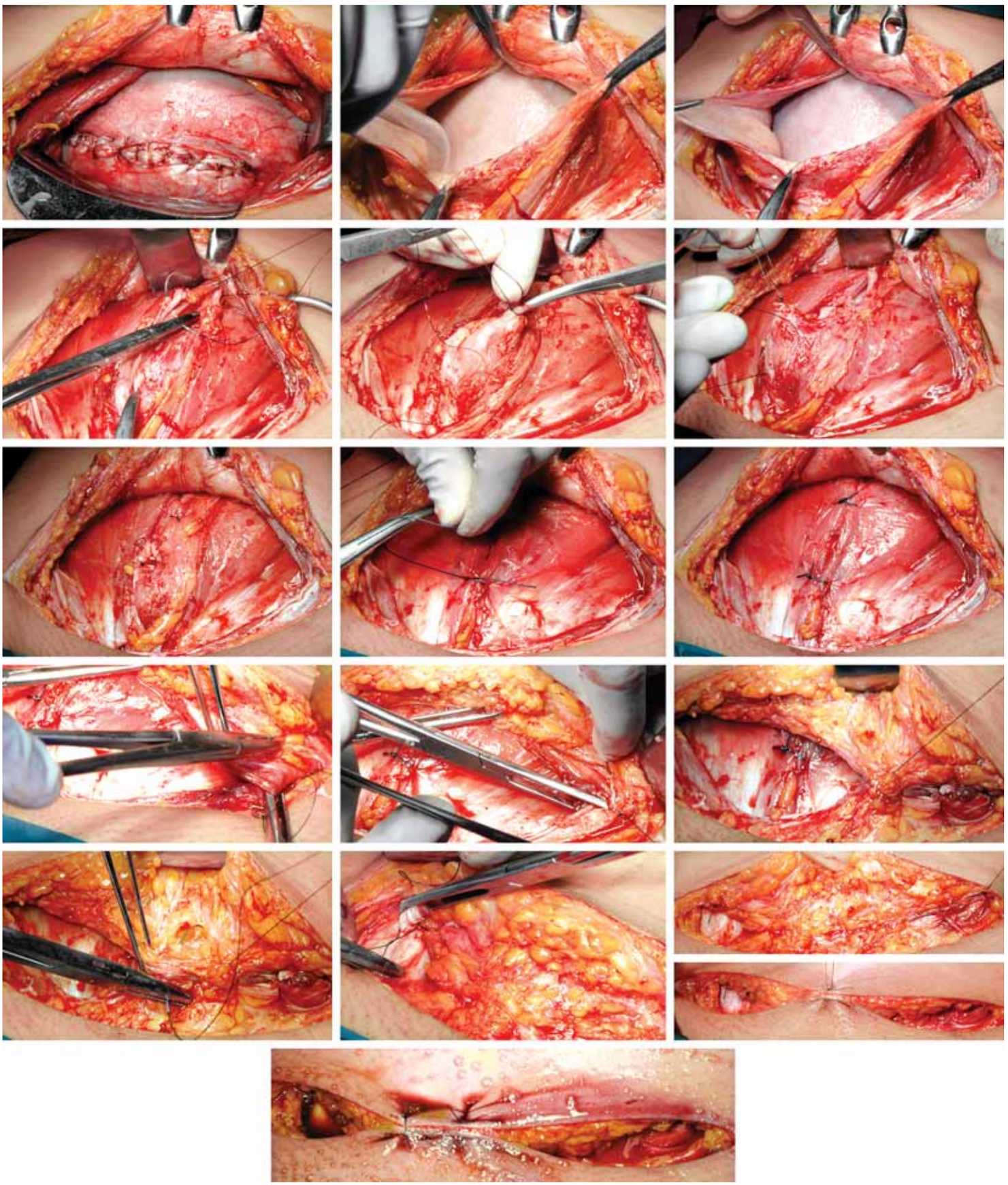
Figs 32-3(2)



Figs 32-3(3)



Figs 32-3(4)



Figs 32-3(5)

Figs 32-3(1 to 5): Lower segment caesarean section – technique.

abdominal packs if kept prior to the procedure are removed. The paracolic gutters are cleared off clots, and meconium. Irrigation with saline may be used if needed.

Closure of the Abdomen

Once haemostasis is ensured, instruments and mop count are cleared from the theatre nurse; the abdomen is closed in layers. Initially peritoneum with continuous 1/0 vicryl sutures, followed by the rectus sheath with continuous 1/0 vicryl sutures. The subcutaneous fat if thick may need to be sutured with 2/0 plain catgut or 3/0 vicryl. The skin is closed with subcuticular sutures with 3/0 monocryl or 2/0 ethylon or with clips.

- Vagina is cleaned off clots.
- Catheter is placed *in situ* for 24 hours.
- Patient is kept nil oral for 18-24 hours.
- Breastfeeding of the baby is started as soon as possible when the mother is able to hold it against the breast.
- Parenteral antibiotics given for 24-48 hours followed by oral preparation.

Complications of Caesarean Section

Maternal Complication

a. *Haemorrhage:* It is common in emergency caesarean section done in patient who was in labour for long hours, multiple pregnancy, and placenta previa, placental abnormalities (increta, percreta, and accreta).

It may be primary or secondary. Primary haemorrhage is due to bleeding from placental bed, uterine sinuses, uterine vessels, or atonic PPH. Bleeding from lacerated uterine vessels and sinuses can be controlled by taking appropriate stitches. Bleeding from placental bed is controlled by giving bimanual uterine compression with warm mops. Occasionally may require figure of eight sutures. When caesarean section is done for placenta previa, where the placental attachment is over the lower segment whose retraction is not sufficient to control the bleeding, careful application of simple or box stitches or figure of eight sutures over the bleeding sinuses will control the bleeding. Compression sutures of lower anterior and posterior segment can be tried. Alternatively lower segment can be packed with a sterile pack; the end of it should be passed through the cervix into the vagina so that it can be pulled out after 18-24 hours. In *atonic PPH* intramyometrial injection of prostaglandin can be tried after parenteral uterotonics. Continuous bimanual compression is tried. If by bimanual compression the bleeding gets controlled then this patient will benefit with B-Lynch sutures.

Technique of B-Lynch suture: With vicryl no.1 or monocryl mounted on 70 mm round bodied needle the uterus is punctured 3 cm below the right lower edge of uterine incision 3 cm from right lateral border. The suture is brought out from within the uterus puncturing at a point 3 cm above the right upper edge of the incision, 4 cm from the right lateral margin. The suture is now passed above the fundus 3-4 cm from right corneal border. Sutures can be fixed here so as to prevent the slippage of the sutures. The suture is pulled back posterior under moderate tension. It is now brought into the uterine cavity piercing the posterior uterine wall at the same surface points as that of anterior. The suture is then brought back to the posterior aspect of the uterus piercing the posterior wall 4 cm from its left lateral margin. It is passed round the fundus 4 cm from the corneal end. The suture is brought near the left side of the uterine incision in similar fashion as on the right side. With the assistant giving bimanual compression of the uterus the sutures are tightened. One has to confirm that the vaginal bleeding has stopped. Once it is confirmed that bleeding has stopped the uterine incision is closed as explained before.

This procedure will save the uterus from unnecessary hysterectomy. But this procedure will help only if bleeding reduces by bi-manual compression. This procedure can also be done in atonic PPH following vaginal delivery, but the uterus need to be opened as in lower segment caesarean section.

Uterine artery ligation: Ligation of uterine artery on both side will reduce the bleeding by 90%. Uterus is grasped and held to expose the vessels in the broad ligament. With vicryl 1/0 on a round bodied needle uterus is pierced 2 cm below the lateral end of the incision. The needle should pass though the full thickness of myometrium so that both uterine artery and vein should be included in the ligation. Then the needle is passed from behind through an avascular portion of broad ligament and tied anteriorly. Effective ligation will result in blanching of the uterus.

Uterine artery embolisation may be tried to occlude the uterine vessels. Meanwhile blood test for coagulation profile is done. Replacement of blood volume with packed cells and FFP is done.

b. *Injury to bladder, ureter, intestines:* Bladder wall may get opened while opening the peritoneum due to upward pull of the bladder as seen in prolonged labour or obstructed labour or previous history of caesarean section. It may also get injured while pushing the bladder away from the lower segment. When caesarean section is done in 2nd stage of labour, bladder is likely to be injured during extraction of the foetus. The damaged area is identified and sutured with vicryl 2/0 in two layers. Catheter is kept for 7-10 days.

Ureters are likely to get injured or ligated while suturing the uterine incision. This occurs quite commonly when the pelvic architecture is distorted as in previous surgeries. Complete ligation is rare. Ureter may get kinked due to placement of suture into the paraureteral tissue or partially ligated if the suture passes though its wall partially. When the ureters are kinked due to placement of suture in paraureteral tissue, ureterolysis is done; but one has to be assured that one stays out of the adventitia. If the ureters are partially or totally ligated, the ligatures are removed. Viability of the ureters is checked by looking for peristalsis, absence of blanching and discolouration. In case of doubt on viability, that particular segment is resected and re-anastomosed with 3/0 vicryl sutures. J-stent has to be kept *in situ* which is removed after 6-12 weeks through cystoscopy.

Intestine injuries are rare during caesarean section but do can occur. The caecum on right side and sigmoid colon on left may get injured. If injury is small it is sutured with 3/0 silk or vicryl with a drain in the peritoneal cavity. If the injury is large it requires diversion colostomy for sigmoidal injuries, ileostomy for caecal injuries. Though, these injuries are rare, prompt recognition and early treatment is very essential to prevent sepsis, fistula formation, renal failure and so on.

c. *Sepsis:* Infection in the urinary tract, lungs, abdominal wound, uterus, and peritoneum is known to occur. Usage of appropriate prophylactic antibiotics have reduced their incidence. Postoperative atelectasis (partial lung collapse) can sometime occur in CS. Postoperative peritonitis, wound dehiscence, burst abdomen

is quite common, often associated with premature rupture of membrane, severe anaemia, poor nutritional status. The incidence of wound infection in caesarean section is high (2.5%—16%) which needs active management.

d. *Amniotic fluid embolism:* Though extremely rare, is known to occur which has 60—80% mortality. The amniotic fluid, foetal cells, hair enter maternal circulation through placental bed trigger an allergic reaction in the mother resulting in cardiorespiratory collapse and DIC.

e. *Anaesthetic hazards:* As most of the time when patient is taken up for emergency caesarean section, she is unlikely fasting for 6 hours.This can lead to aspiration of stomach contents especially when under general anaesthesia leading to atelectasis, aspiration pneumonitis.

f. *Thromboembolism:* Thrombus is more likely to occur in lower limb and pelvic veins. Common in obese patients. If gets dislodged and can precipitate pulmonary embolism. Therefore, proper hydration in postoperative period, and early ambulation is necessary.

g. *Shock:* Due to haemorrhage, amniotic fluid embolism or sepsis.

h. *Paralytic ileus* –Control of sepsis, maintenance of electrolyte balance is necessary.

i. *Intestinal obstruction—due to adhesions.*

j. *Poor healing of the uterine scar leading to scar dehiscence and rupture in future pregnancy or delivery.*

k. *Increased risk of placenta previa, placenta accreta, placenta increta, placenta percreta in future pregnancy necessitating hysterectomy.*

Fetal Complication

Respiratory distress, prematurity, birth injury while extraction are some of the common problems seen in the babies born by caesarian section.

CAESARIAN HYSTERECTOMY

It is the removal of uterus at the time of caesarian section.

Indication

- Abnormal placentation—placenta increta, placenta percreta, placenta accreta.
- Atonic PPH—when all other methods (both medical and surgical) of arresting the bleeding have failed.
- Rupture uterus—where the damage to the uterus is beyond repair.
- Carcinoma cervix diagnosed during pregnancy.

It can be called as *postpartum hysterectomy* if done immediately after vaginal delivery.

After caesarian section, once hysterectomy is decided, the surgeon has to inform the anesthetist and the patient's relatives. Patient's consent should be taken in planned hysterectomy. In emergency situation when the patient is not in a position to give consent, the consent of the patient's husband or the close relative is taken.

Precaution

Pelvic architecture is altered in pregnancy. So it may not be as easy as in non-pregnant uterus. Blood vessels are engorged and tortuous and tissues are edematous. So, careful clamping and ligating the pedicles is necessary. The vessels may otherwise retract leading to severe bleeding which may be difficult to control. The pelvic anatomy may get distorted in conditions like rupture uterus. Proper identification of the structures followed by their repair, and control of bleeding is very essential.

Incision

If it is a planned hysterectomy, midline vertical is ideal as it gives good exposure and also helps to access the upper abdomen. But most of the caesarian section is started with *Pfannenstiel incision* where most of the time the exposure is not adequate enough for hysterectomy. One may need to put a vertical incision converting it into an inverted T-shaped incision which gives a cosmetically bad scar and more postoperative pain. A transverse incision can be converted into a *Cherney incision* by transecting the rectus muscle at its insertion which can provide adequate exposure. An alternative approach is division of the rectus muscle converting a standard Pfannenstiel to a modified *Maylard incision.*

Procedure

The fundus of the uterus is grasped, removed from the pelvis and placed on the abdominal wall. The uterus should be kept under upward traction so as to diminish blood loss by constricting the uterine vasculature.

The uterine incision may be closed with single continuous sutures before proceeding to hysterectomy as this will reduce the bleeding. In atonic PPH uterus may be packed with sterile gauze so as to prevent continuous bleeding from placental site till the hysterectomy is complete. In abnormal placental attachment like placenta accreta, percreta, severe bleeding will occur by forceful removal of placenta. So cord is cut short and tied and proceeded with hysterectomy without removing the placenta. When the uterus need to be saved placenta may be left back with cord cut short covering with higher antibiotics and methotrexate. Placenta is known to disintegrate by autolysis.

Standard hysterectomy procedure is started with identification of round ligament. A self-retaining retractor may be placed to improve visualisation. Round ligaments are clamped with Kocher's clamps, ligated and cut on both sides. Care is taken to see that tips of the clamps lies on an avascular plane of broad ligament so as to avoid unnecessary bleeding. With electrocautery the anterior leaf of broad ligament is opened and proceeded medially to the point where the vesicouterine peritoneum was dissected off the lower uterine segment to create the bladder flap. In postpartum hysterectomy the vesicouterine peritoneum is opened along with the anterior leaf of broad ligament and the bladder is then pushed away and down from the lower uterine segment. Posteriorly, the broad ligament is incised laterally and parallel to the infundibulopelvic ligament to expose the retroperitoneum. The loose areolar tissue is carefully dissected parallel to the course of the ureter so as to allow proper visualisation of the retroperitoneal space and the course of the ureter.

An avascular area is identified in the posterior leaf of the broad ligament and perforated with electrocautery. Straight Kocher's clamp is placed on the cornu of the uterus, the utero ovarian ligament which attaches the adnexa (tubes and ovary) to the uterus are included in this clamp. A second clamp is placed lateral to this clamp, avoiding ovarian tissue. The tissue between the medial and lateral clamps is divided, and the pedicles are ligated by a transfixing suture using 1/0 vicryl or chromic catgut. Double ligation may be

done to reinforce the first ligature. The lateral clamp is then removed. The clamp on the uterine cornu is left in place for traction and to control back bleeding. This procedure is repeated on the other side also.

Next, the uterine arteries are identified and ligated. The uterine arteries are palpable, grossly enlarged due to the pregnancy. The parametrial tissue surrounding the uterine vessels is delicately "skeletonised" anteriorly until the uterine arteries are identified. Curved clamps (Heaney or Kocher's) are placed such that the curved end is perpendicular to the vessels at the level of internal os. Care should be taken to see that the uterine artery is clamped properly and entirely. Some prefer to use two clamps but it is always better to use one to reduce the chances of ureteral injury. A straight clamp (Kocher's) may be applied on the medial aspect of the above clamp close to the uterus to prevent the back flow of blood from uterines when they are cut. The uterine artery is cut and ligated (double often) with 1/0 vicryl sutures. The suture is passed beyond the tips of the clamp and tied behind the clamp. A portion of the leaves of broad ligament is incorporated with the pedicle so as to prevent the retraction of the vessel. Alternatively, Haeney's ligature can be used to secure the pedicle. The curved clamp on the lateral aspect is removed. The procedure is repeated on the other side.

A second clamp may need to be placed medial to the previous pedicle moving down the parametrial tissue and hugging the cervix, which will allow ligation of any branches of the uterine artery not ligated with the first clamp.

Now decision is to be made whether to do a supracervical/subtotal hysterectomy or total hysterectomy. In emergency condition where the patient has bled a lot, further prolonging the surgical procedure is not suitable for her general condition; supracervical/subtotal hysterectomy is commonly done as a life-saving procedure. The uterus is amputated with a scalpel or cautery, cutting superiorly to the ligated uterine arteries proceeding medially and downward, thus allowing removal of an inverted cone of the cervix, which will facilitate approximation of the edges of the cervical stump regardless of the degree of dilation. Once amputated, the cervical stump can be approximated in an anterior-to-posterior fashion using interrupted figure-of-eight ligatures. Special care should be taken to avoid the bladder injury.

If the patient's conditions are favorable and when it is a planned procedure then total hysterectomy is done. But the problem here is identification of cervix. If the patient was in late stages of labour with cervix fully dilated and effaced it becomes difficult to identify it from vagina. Some surgeons prefer to "mark" the cervix, either by placing a ring forceps on the anterior lip of the cervix or placing a suture on the cervix. If total hysterectomy is decided then bladder has to be pushed further down. Extreme care should be taken as the bladder wall is extremely soft and friable and likely to get damaged. When the cervix is not dilated its level can be felt through the vaginal wall. The clamps are applied to the cardinal ligaments, cut and ligated. Sometimes, the uterosacral ligaments are quite prominent and may need to be individually clamped and ligated. Clamps need to be reapplied medial to the previous pedicle, and thus proceed downwards till the surgeon reaches the external os. Suture line approximating the uterine incision may be released now and the cervix can be palpated from within the uterus. Now the vagina is opened and cervix is amputated with curved scissors. Allis forceps can be used to maintain traction on the anterior, posterior, and lateral angles of the vaginal wall. The vaginal epithelium is very friable and must be handled gently.

Closure of vaginal cuff begins with supporting angle sutures that incorporate the lateral vaginal angles, the lower cardinal ligament pedicles, and the uterosacral pedicles. The vaginal cuff may be closed with continuous locking or interrupted sutures. Or the cuff may be left open putting continuous nonlocking suture to the anterior and posterior cuff edges to secure hemostasis which allows drainage of any discharge until spontaneous reperitonealisation occurs.

Pelvis is irrigated with warm saline. All pedicles are inspected for any bleeding. Vaginal cuff must be inspected for any bleeding. In supracervical hystectomy, amputated cervical stump is inspected for any bleeding. Cystourthroscope can be done per operatively to exclude any bladder or ureteric injury. Indigocarmine dye can be injected intravenously to the patient. Both ureteric orifices are visualised. Gush of blue dye through the ureteric orifices confirm ureteral patency. Also staining of the operative site indicates bladder injury which needs to be identified and closed with 2/0 or 3/0 vicryl in two layers. Continuous bladder catheterisation is done for 7-10 days. In case of placenta percreta there may be placental intrusion into the bladder wall. In such cases excision of that portion of the bladder wall with bladder wall reconstruction should be done by an urologist.

Abdomen is later closed after taking the count of instrument and mops.

Complications

a. Sepsis: Quite common. It can be in the pelvis, urinary tract, abdomen, or in the wound. Seroma, wound infection, cuff hematoma and cellulites, pelvic haematoma and abscess are often seen. It is due to excessive handling of the genital tract as it occurs in PPH, bleeding. Higher antibiotics have to be started before hand as the patient may quietly slip into septicemia.
b. DIC: It is mainly due to excessive bleeding that has lead to hysterectomy or due to sepsis. Transfusion of blood, platelets, FFP, and cryoprecipitate is done.
c. Deep venous thrombosis: Thrombosis in pelvic veins and leg veins are likely to occur with the risk of pulmonary embolism. Early mobilisation, use of compression stockings will reduce the risk of thrombosis.
d. Bladder injury/ureteric injury: If not identified and repaired can lead to vesicovaginal fistula and ureterovaginal fistula.
e. Psychological impact of hysterectomy in young women has to be dealt by proper counseling and support.
f. Prolonged hospital stay:

TUBAL STERILIZATION PROCEDURES

It is the procedure where the fallopian tubes are occluded so that the woman will not be able to conceive and become pregnant in the future. It is a permanent method of contraception normally done in women who feel that they have completed their family.

Approach: It can be done by minilaparotomy or along with caesarian section or by laparoscopic approach.

Timing: It can be done along with caesarian section as mentioned before or abortion (*concurrent*) or within 24-48 hours of normal delivery (*puerperal*) or any time after 3 months of delivery or abortion (*interval*). It is commonly done in the immediate postmenstual period.

Anaesthesia: It can be done under general or spinal anaesthesia or local anaesthesia (1% lignocaine infiteration) with IV sedation (Inj. Pethedine 50 mg + inj. Phenergan 25 mg).

Informed consent of the couple is taken after proper counseling regarding the irreversibility of the procedure and also informing about the chances of failure (due to tubal recanalization).

Procedure

Minilaparotomy

Patient is kept fasting for 6-8 hours. Abdomen is shaved. There is no compulsory bladder catheterisation. Patient is made to void urine just before the procedure.

Incision—When done in immediate postpartum period where the uterus is palpable below the umbilicus, the incision of ½"-¾" is made two fingers breadth below the fundal height; whereas in interval period it is done two fingers breadth above the symphysis pubis. It can be midline, paramedian or transverse incision.

The abdomen is opened in layers as usual. Once the peritoneum is opened small specialised retractors are used to retract the incision while delivering the tube out.

The surgeon now introduces his index finger into the abdomen, goes behind the uterus, feels for the tubes and delivers it out hooking it with fingers. An instrument inserted through the vagina to lift the uterus would be useful especially in interval sterilisation to draw the tubes towards the incision. It is identified by the fimbrial end of the tube. It is held with Babcock's forceps at the junction of proximal and middle third portion **(Fig. 32-4)**.

Methods of tubal occlusion

- *Pomeroy tubal ligation*—Here part of the tube is elevated to create a loop or knuckle. An absorbable ligature (1/0 chromic catgut) is tied around the base of the elevated segment tightly, and the tubal segment (approx 1 cm) is cut out. The cut ends of the fallopian tube separate as the ligature dissolves. Within a few days, the peritoneum grows over and covers the cut ends of the tubal segments. It is the most commonly used method.
- *Madlener procedure*—Similar to the above procedure but here a loop of tube is elevated and crushed before ligation.
- *Parkland tubal ligation*—Involves tying two non-absorbable ligatures around the fallopian tube in its proximal to middle segment and then cutting out the tubal segment between the ligatures. The end result is similar to the Pomeroy method of tubal ligation.
- *Irving's tubal ligation*—Two ligatures are placed around the fallopian tube in its proximal to mid-segment and the tubal segment between the two ligatures is removed. Using blunt dissection, a tunnel is made within the substance of the uterine myometrium on its posterior aspect and the proximal tubal segment is pulled into this tunnel and sutured. And the distal tied end is buried in the substance of the broad ligament.
- *Fimbriectomy*—A portion of the fallopian tube closest to the ovary is removed, thereby eliminating the tubal ability to capture eggs and transfer them to the uterus.
- *Bipolar coagulation*—This method uses electrical current to cauterise sections of the fallopian tube, commonly used in laparoscopic female sterilisation.
- *Tubal clip*—Involves application of permanent clip to the tube (*Filshie Clip or Hulka Clip*) thereby blocking the transference of eggs from the ovary.
- *Tubal ring*—Involves application of a silastic band to the fallopian tubes.

The last three procedures are used in laparoscopic tubal ligation.

Tubal ligation is done on both sides. The resected tubal segment is sent for biopsy. The peritoneum is closed by purse string suture. The abdomen is closed in layers. The patient can be discharged in 24-48 hours.

Complications

- Preoperative—Bladder injury, bowel injury, broad ligament haematoma, uterine perforation.
- Postoperative—Sepsis, wound infection, haematoma, peritonitis.

Laparoscopic tubal ligation: Usually done as an outpatient procedure.

Anaesthesia: General anaesthesia or local (done in camp).

Position: Patient is placed in lithotomy position, with 15° Trendelenburg tilt. Both abdomen and vagina is cleaned with antiseptic solution. Uterine sound can be inserted to manipulate the uterus **(Fig. 32-5)**.

Procedure: Through a small skin incision of ½"below the umbilicus, Verres needle is inserted into the abdominal cavity at a 45° angulation, tip directed towards the pelvis. The abdomen is inflated with gas (carbon dioxide). The needle is removed and trocar with cannula is introduced through the incision by twisting movement. Laparoscope is introduced through the cannula. The pelvic organs are visualised. Through another small incision laterally placed either on left or right side another trocar with cannula is inserted. Through this cannula either bipolar forceps or *ring applicator* loaded with silastic ring is introduced. Ring applicator needs no sized 7 trocar as ring applicator is 7 number sized. The tube is grasped 2-3 cm from uterotubal junction. It is either cauterised with the bipolar till 1 cm of the tube blanches or the silastic ring is slipped to the base of the loop of tube that was picked up and drawn into the cylinder of applicator. The procedure is repeated on the other side. The tubes have to be visualised to see that the rings are placed properly and there is no bleeding. After confirming haemostasis laparoscope is removed. Abdomen is deflated and skin incisions are sutured.

Complications

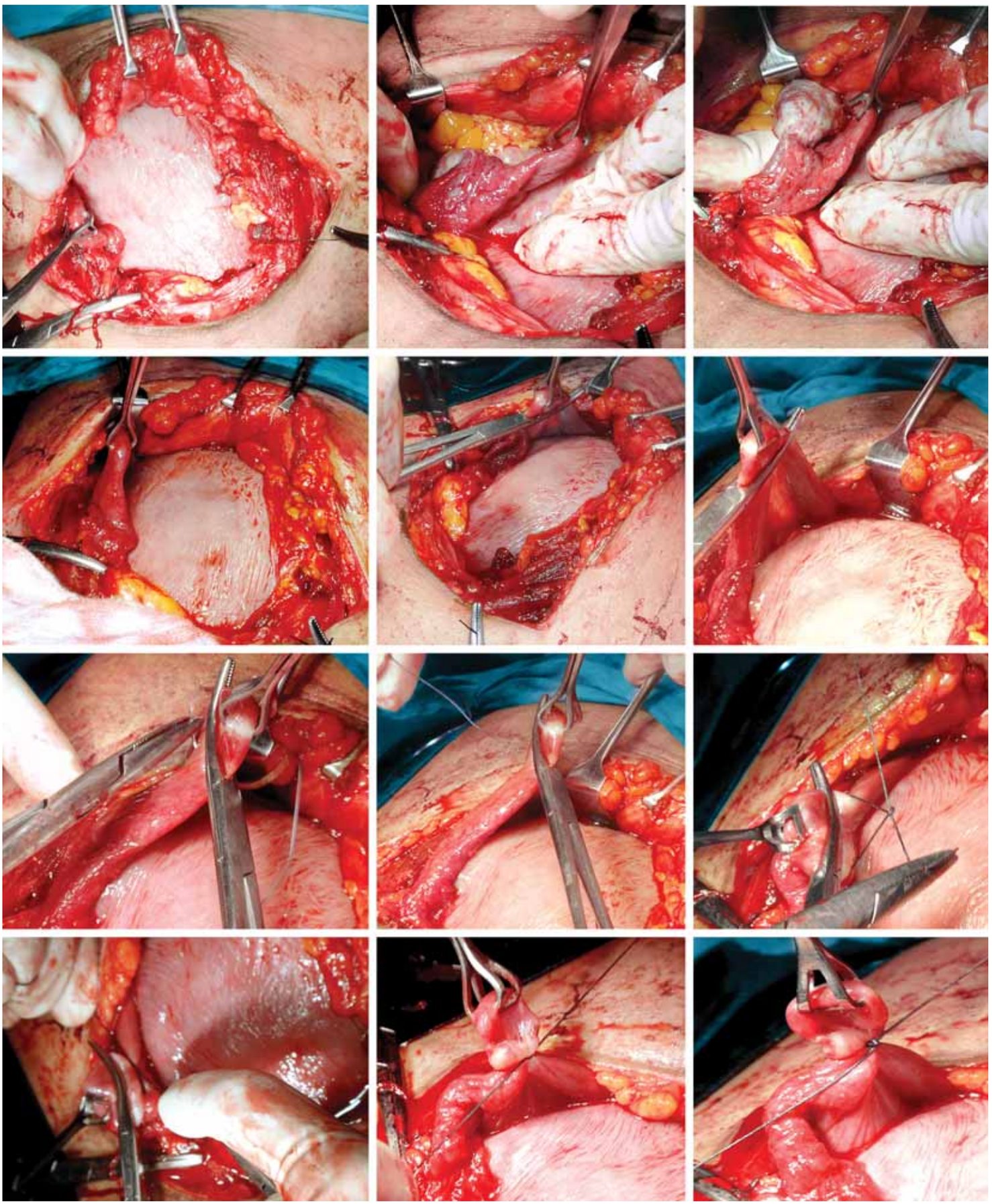
- Bowel and bladder perforation
- Vessel injury
- Cardiorespiratory embarrassment

SURGERIES FOR OVARIAN PATHOLOGY

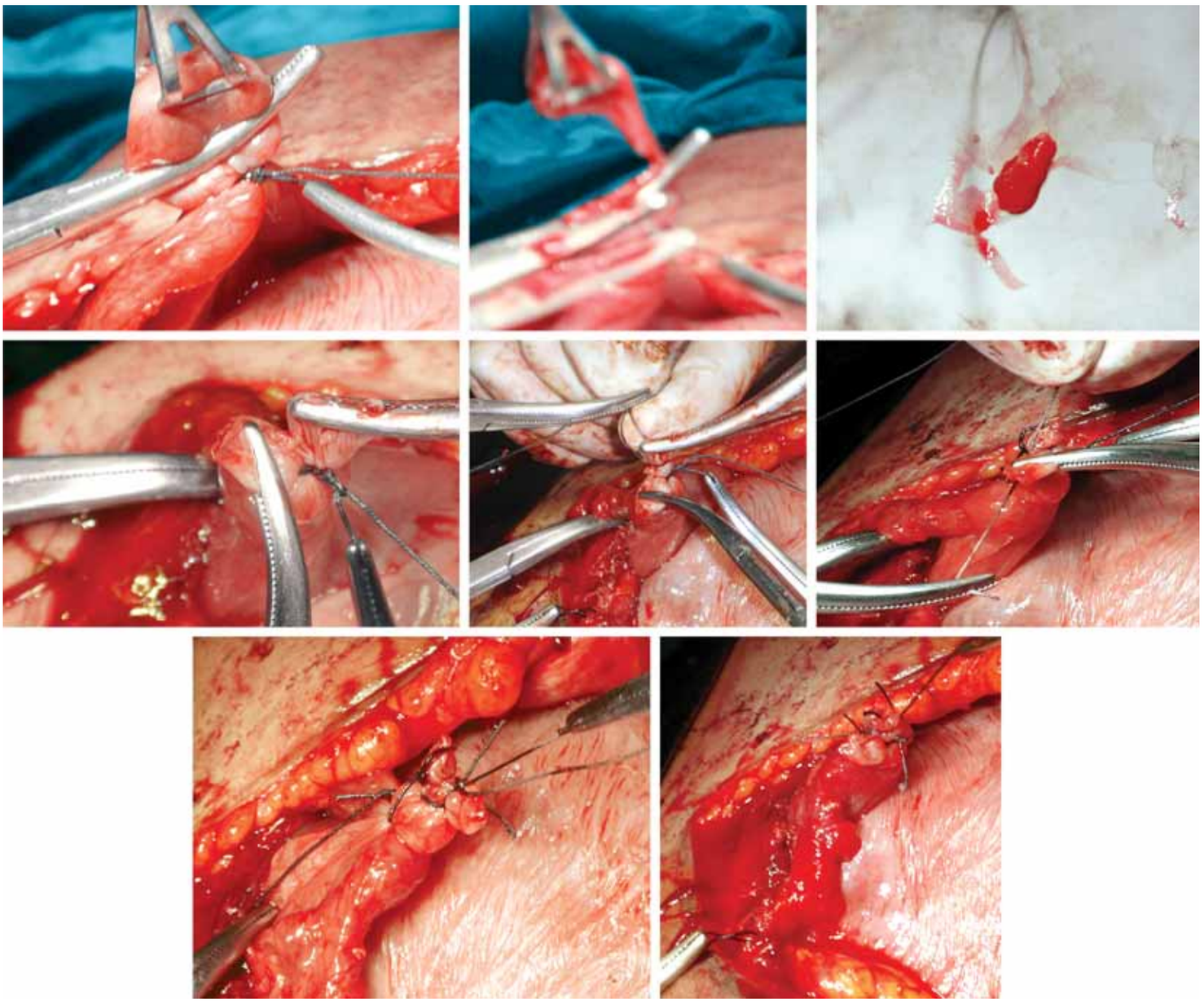
Many ovarian tumours are cystic, but some cysts are not tumours and some tumours are not cysts.

Their simplified classification:

- *Benign:*
  - Functional cysts of the follicles and corpus luteum.
  - Benign serous or mucinous cystadenomas.
  - Dermoid cysts (teratomas)
  - Endometriotic cyst (chocolate cyst)
  - Unclassified benign cysts (simple paraovarian cysts).
- *Malignant*:
  - Malignant serous or mucinous cystadenocarcinomas.
  - Metastatic carcinomas (from the gut, or breast)
  - Burkitt's lymphoma
  - Other rarer tumours.



Figs 32-4(1)



Figs 32-4(2)

Figs 32-4(1 and 2): Tubectomy is done during caesarean section after taking consent.

Pseudocysts are postinflammatory collections of fluid between adhesions in the pelvis, and are not true ovarian cysts; but the distinction is not always easy, even at operation.

The *uterine adnexa* consist of the ovaries, the fallopian tubes, and the uterine ligaments and any pathology arising from these structures are referred to as *adnexal pathology*.

An adnexal mass may be noted in cases of acute abdomen and the differential diagnosis should include adnexal torsion, ruptured hemorrhagic cyst, degenerating leiomyomata, ectopic pregnancy, unruptured tuboovarian abscess.

Some of the surgeries performed in the ovaries are ovarian cystectomy, oophorectomy, ovarian drilling, salpingo-oophorectomy.

Ovarian Cystectomy

It is done in benign conditions where the cyst *only* is removed leaving behind the functional ovary in place. She needs its endocrine function, regardless of possible fertility. Of the benign cyst functional cyst, dermoid cyst and endometriotic cyst are commonly encountered in clinical practice.

Indication

Symptomatic cysts, cysts > 6 cm size in premenopausal women/>3 cm size in postmenopausal women not showing resolution in 2-3 months of close observation or failed to resolve with 2-3 cycles of oral contraceptive pills, cysts with ultrasonic features deviating from being functional cyst, and bilateral cysts are removed by cystectomy.

However cystectomy is not advisable in postmenopausal women with large cysts >10 cm size, complex cyst with multiloculation, thick septa and solid components, and cysts with elevated CA-125 levels.

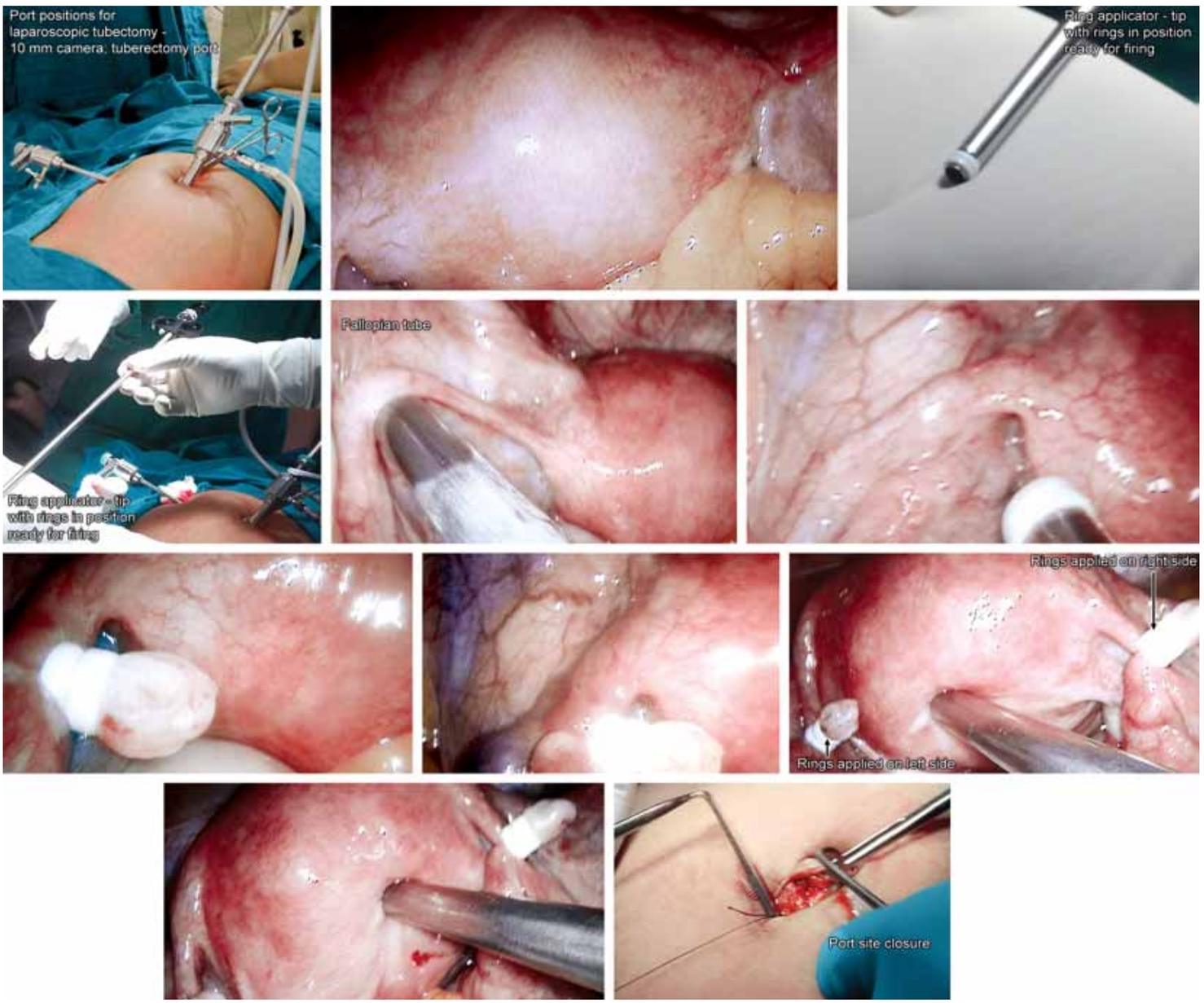

Port positions for laparoscopic tubectomy - 10 mm camera, tuberectomy port
Ring applicator - tip with rings in position ready for firing
Fallopian tube
Rings applied on right side
Rings applied on left side
Port site closure

Fig. 32-5: Laparoscopic tubectomy/sterilisation.

Anaesthesia

General or spinal for laparotomy with cystectomy, general anaesthesia for laparoscopic cystectomy.

Position

Dorsal lithotomy for laparoscopic cystectomy as it allows the use of uterine manipulator; supine position for laparotomy.

The abdomen, perineum, and vagina are surgically prepared.

Technique of Cystectomy by Laparotomy

In postmenopausal age or above it should be an infraumbilical midline incision for adnexal masses as the incidence of malignant disease is high in this age group and lower midline incision will give adequate access and exposure than the low transverse though it is cosmetically poor. Adequate exploration of the abdomen for a malignant ovarian process through a Pfannenstiel or transverse incision is difficult. A transverse incision or Pfannenstiel incision is adequate for younger patients in whom the chance of a malignant disease is quite low. If a malignant disease is encountered in this younger age group, the transverse or Pfannenstiel incision may be converted into inverted T incision.

After opening the peritoneum the abdomen is thoroughly explored. Any suspicious tissue in the upper abdomen (under surface of the diaphragm and surface of the liver) or along the aortic lymph nodes should be sent for a frozen section analysis. Ascites or any peritoneal deposits or papillary excrescences on ovarian surface are noted. In the presence of any of these features cystecomy is abandoned.

Uterus is pulled up towards the incision. Ovaries are indentified. Most ovarian cysts have few adhesions and can be easily drawn towards the incision. If adhesions are seen then it may be due to previous PID, malignant cyst in which the growth has already spread into the peritoneum, endometriotic/chocolate cyst, a cyst which has previously undergone torsion.

Cul-de-sac is packed with moist pack to prevent the pelvic contamination if there is a spill. The ovary is held with Babcock clamps

placing on the ovarian ligament. An elliptical incision is made with a scalpel through the thin ovarian cortex of a benign cyst the end of the knife handle can be inserted and develop a plane between the cyst wall and the ovarian cortex. Alternatively, fine-needle electrocautery or small Metzenbaum scissors can be used to separate the cyst wall from the ovarian cortex. After the cyst wall has been completely separated from its adherent attachments to the thin ovarian cortex, it can be shelled out without rupture. If proper plane is got, shelling out the cyst will be without difficult except near the base which needs to be cut with cautery or scissors. However, because of the friability of the cyst wall, rupture can occur even with the gentlest technique. So instead of having accidental rupture which will uncontrollably soil the peritoneal cavity, it is better to aspirate the cyst before shelling out its capsule. Aspiration of cyst will also facilitate the removal of large cysts through small incision and also it eases to release the paraovarian adhesion before cystectomy **(Fig. 32-6)**.

After the cyst has been removed, the dead space can be obliterated with fine 5/0 nonreactive vertical mattress sutures or figure-of-eight sutures. The ovarian surface is then re-approximated with 5/0 fine subcortical running suture. Interrupted sutures may be placed if cortex is friable. Alternatively the redundant cortex can be removed and the dead space is obliterated with an internal closure taking care that suture material does not penetrate the ovarian cortex. This prevents ischemia and adhesion formation. Some authors advocate leaving the ovary open after cystectomy.

Difficulties Encountered in Cystectomies

Extensive adhesions may be encountered in endometriotic cyst, post inflammatory cyst where the ovary cannot be freely moved above the pelvis. Forceful attempt to pull the ovary may injure the bladder, rectum, ureter and lacerate the veins. Adhesions have to be released slowly with both sharp dissections with scissors or gently with hands. In endometriotic cyst the thick chocolate coloured fluid is aspirated and sucked out, the friable cyst wall is removed as much as possible. Haemostasis is achieved with diathermy. Post inflammatory cyst is just aspirated and abdomen is closed giving her antibiotics. It is safer to leave a little cyst wall on her gut or the bladder, than to remove a little gut or bladder with the cyst wall.

Before closing the abdomen it is always good to give a thorough peritoneal cavity wash with saline so as to wash out the spilled cyst content. Abdomen is closed in layer. Usually no drain is required **(Fig. 32-7)**.

Complications

- Removal of large cyst may cause cardiorespiratory failure in immediate postoperative period.
- Supine hypotension syndrome while removal of large cyst due to its pressure over the veins, this can be prevented by giving lateral tilt during the surgery.
- Injury to bladder, ureter, bowel in presence of dense adhesions.
- Infertility due to adhesion.

Fig. 32-6: Bilateral large ovarian cysts are removed through laparotomy.

Fig. 32-7: Specimen of simple cyst of the ovary.

Laparoscopic Cystectomy

This is becoming very popular now as adhesions are less, so fertility will not be affected much. Postoperative recovery is faster. Endometriotic cysts are better tackled with laparoscopy than laparotomy.

Port site—periumbilical for telescope and camera. Two lateral port in the lower abdomen, one 5 mm another 10 mm. Additional ports can be used based on the requirement.

The ovarian capsule is incised with scissors or monopolar hook. The ovary is stabilised with a contralateral grasping forceps holding the suspensory ligament. The ovarian capsule is dissected/teased away from the cyst wall either by hydrodissection or a probe. Cyst is thus completely freed from the ovary. Bleeding points on the ovarian cortex is cauterised with bipolar forceps. The cyst sometimes ruptures while dissecting away from the ovarian capsule. The fluid can be aspirated and thorough wash to the pelvis is given later **(Figs 32-8 and 32-9)**.

Alternatively in case of large cyst, it has to be aspirated by passing a 18 guage needle through a trocar. Fluid is aspirated with 20 cc syringe or aspiration system. Fluid is sent for analysis. Pelvic wash is given. After draining the fluid, hole is made in the capsule of the ovary. The cyst wall is pulled away from the ovarian capsule. Contralateral traction is given with 5 mm grasping forceps. Complete capsule can be removed if the right plane is achieved. There may be some adhesions near the base which needs to be separated with monopolar hook or scissors. Resected area is thoroughly irrigated. Any bleeding points are coagulated with bipolar forceps. If stripping of the capsule cannot be achieved completely as in endometriosis, the residual part must be destroyed with laser or electrocautery. Suture of the margins are reserved for large cysts or when more than incision is done. This will restore the shape of the ovary thereby reducing adhesion **(Fig. 32-10)**.

The resected cyst wall is removed through 10 mm trocar. If the cyst is intact without rupture, a plastic bag may be inserted into the peritoneal cavity so that the cyst may be passed into it and retrieved though a small suprapubic incision or through an incision over the pouch of Douglas. Alternatively the cyst when inside the bag can be aspirated and the size reduced so that it can be brought through the 10 mm trocar **(Fig. 32-11)**.

Oophorectomy

Oophorectomy is the surgical removal of an ovary or ovaries. Some call it also as *ovariectomy*, but this term has been traditionally used in basic science research describing the surgical removal of ovaries in laboratory animals.

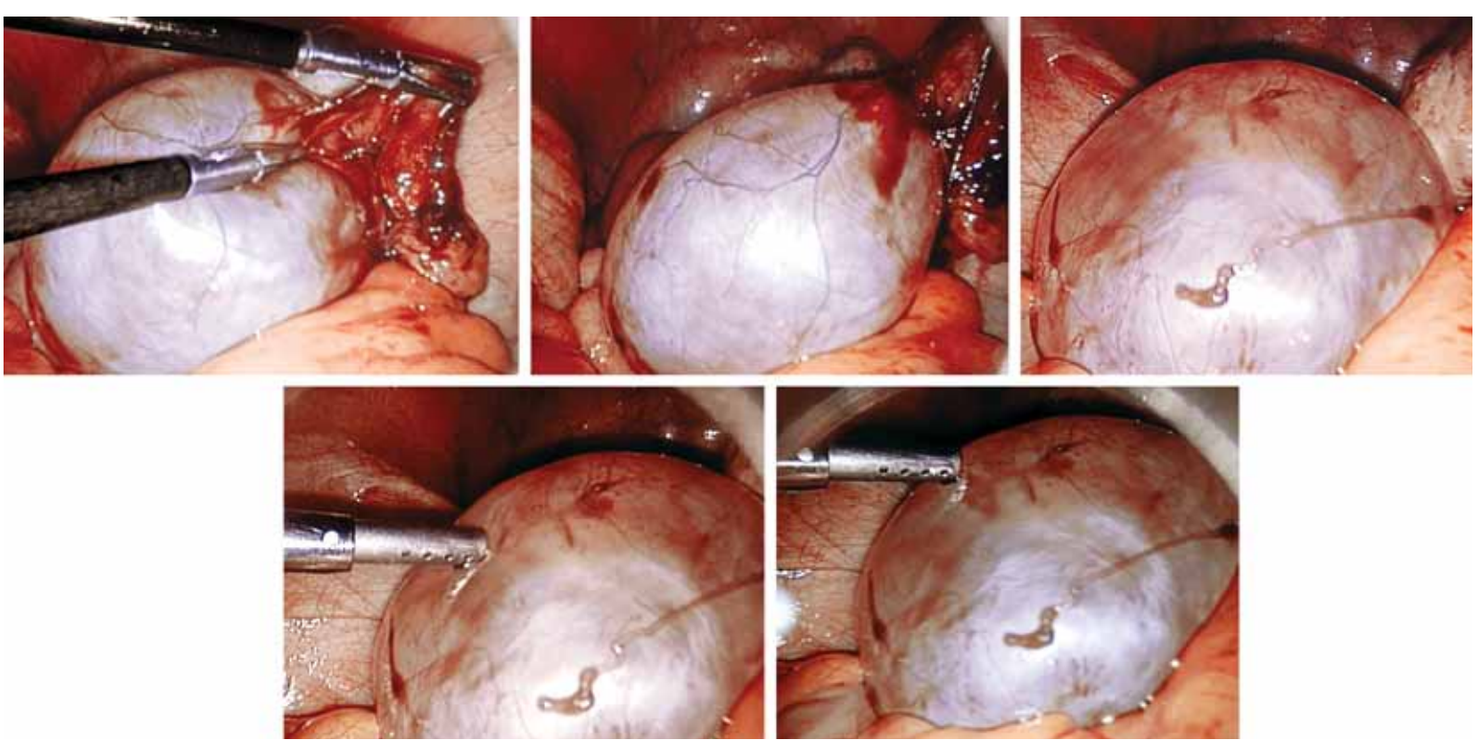


Fig. 32-8: Laparoscopic removal of simple cyst of the ovary.

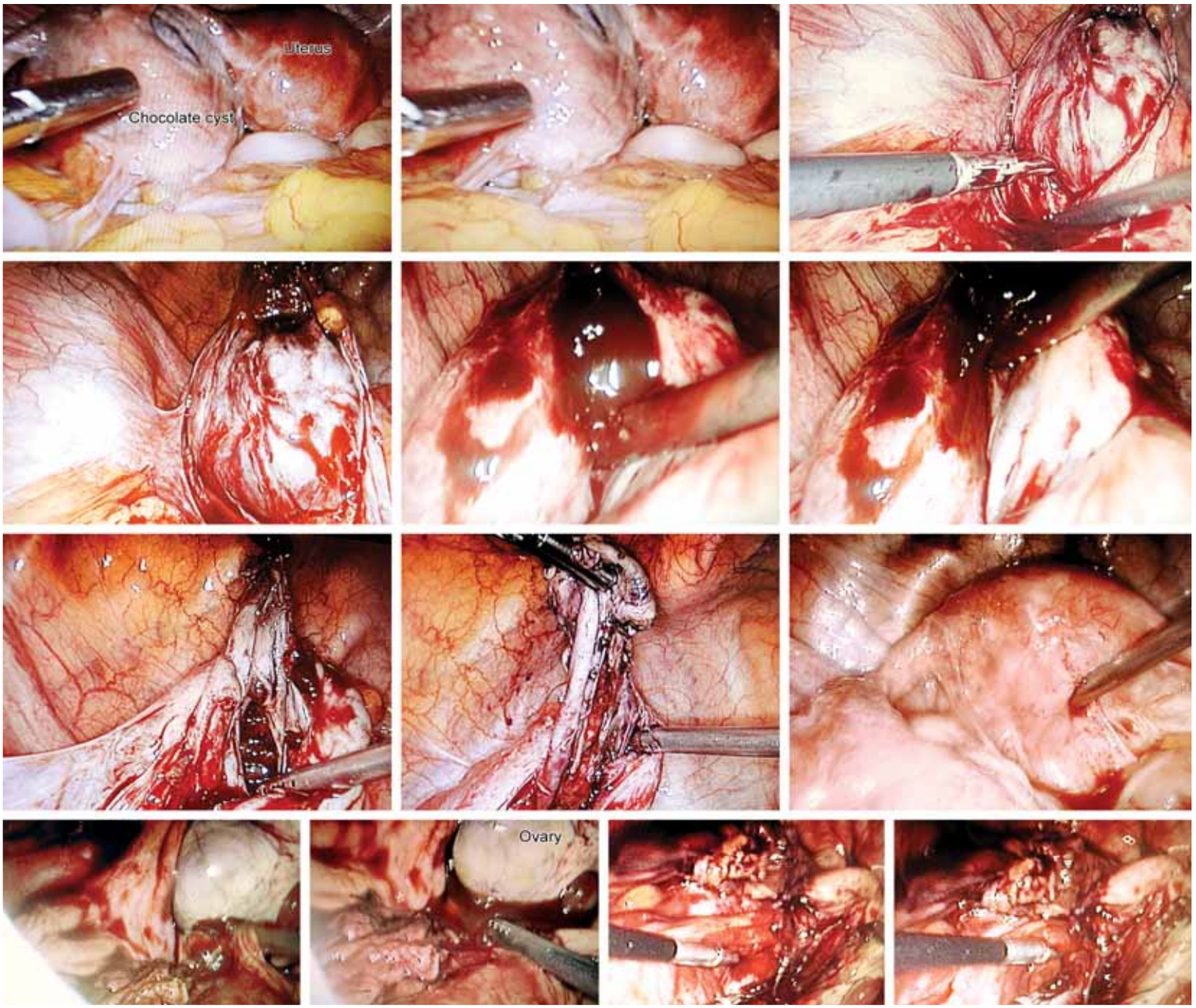


Fig. 32-9: Laparoscopic chocolate cyst removal.

Indication:

- Ovarian diseases—ovarian cyst, cancer
- Endometriosis
- As prophylaxis to reduce the chances of developing ovarian cancer or breast cancer
- In conjunction with removal of the uterus **(Fig. 32-12)**

Procedure:

Informed consent of the patient is a must before the ovary is removed.

Anaesthesia, exposure, positioning as in ovarian cystectomy.

The pedicle consists of the infundibulopelvic ligament and ovarian vessels, the ovarian ligament, and portion of the broad ligament. If the pedicle is wide clamp it with several clamps, taking bite not more than 2.5 cm in each of them. It will be less likely to slip if the pedicle is cut at some distance from each clamp. The pedicle in each clamp is transfixed with 1/0 vicryl sutures, taking care to avoid the plexus of veins when the needle is inserted. The stump is checked for any bleeding before cutting the ligatures short. Ovary thus removed is sent for biopsy. It is sometimes done on both sides **(Fig. 32-13)**.

Laparoscopic Oophorectomy

The ovary is stabilised with a grasping forceps over the ovarian ligament from contralateral port. The infundibulopelvic ligament is cauterised with bipolar forceps and cut with scissors. Alternatively harmonic scalpel or seal can be used. The ovarian ligament is cauterised and cut. The ovary can be retrieved using a plastic bag through 10 mm portal site.

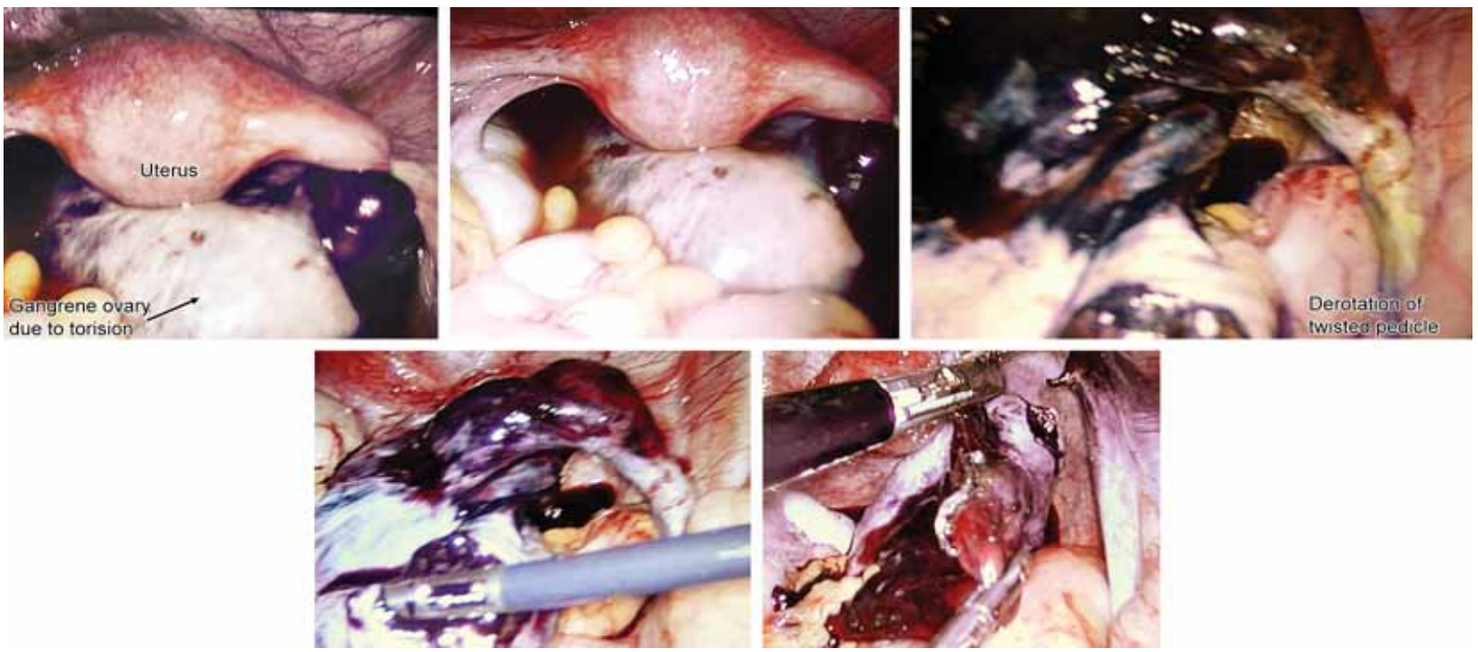


Fig. 32-10: Gangrene ovary due to torsion of ovarian cyst; it is removed through laparoscopy.

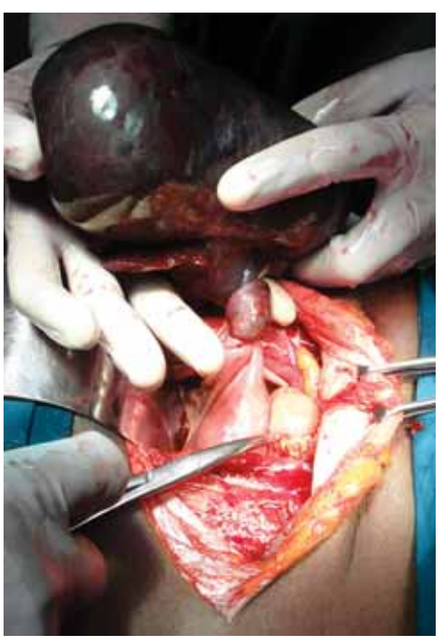


Fig. 32-11: Twisted ovarian cyst showing the twisted torsion pedicle.

Complications

- Greater risk of cardiovascular disease
- Increased risk of osteoporosis and bone fractures
- Significantly impairs sexual well-being
- Libido loss, difficulty with sexual arousal, and vaginal dryness
- Parkinsonism
- Decline in psychological well-being.

Salpingo-oophorectomy

It is removal of tube with along the ovary. It may be a unilateral procedure or bilateral which is often combined with hysterectomy.

Indication:

- Benign adnexal mass
- Adnexal torsion
- Tubo-ovarian abscess and pelvic inflammatory disease.
- Ectopic pregnancy
- Endometriosis
- Removal of normal appearing ovaries and tubes at the time of hysterectomy for benign disease, to decrease the risk of development of ovarian pathology in future and so the need for any procedures.

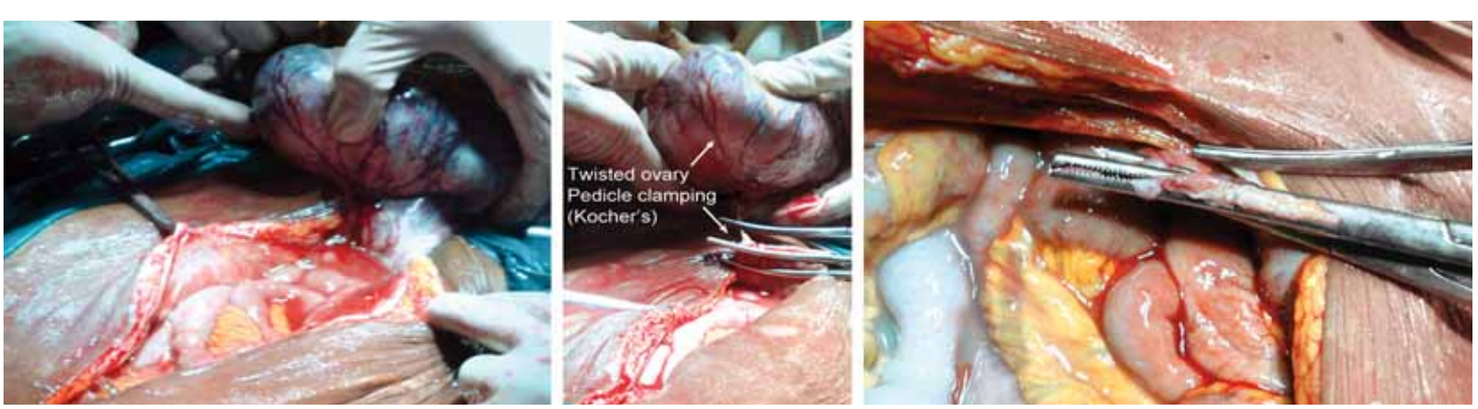


Fig. 32-12: Gangrene ovary with torsion of the cyst.

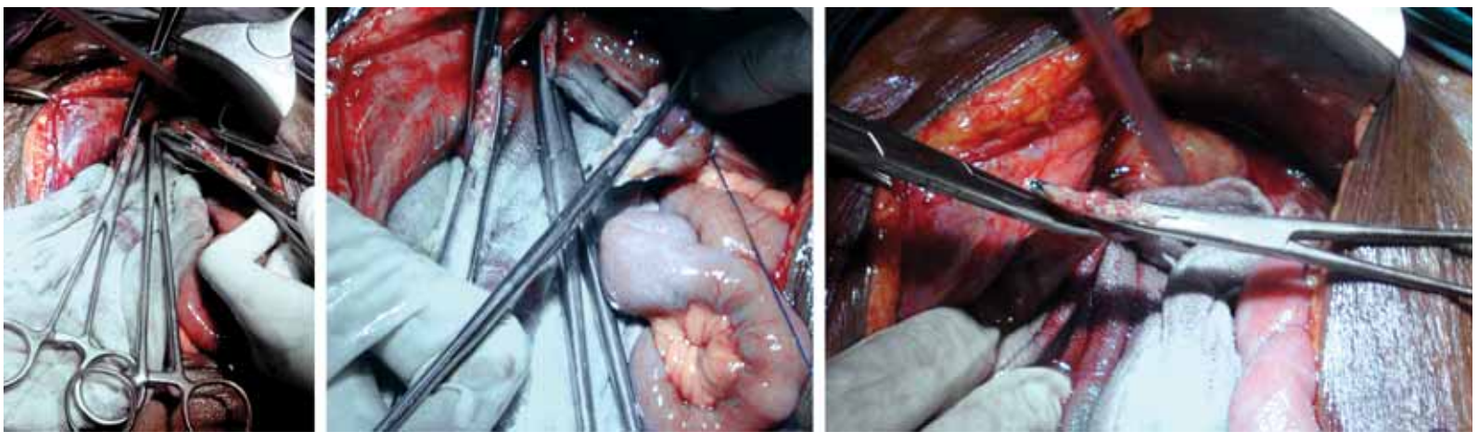


Fig. 32-13: Ovarian pedicle after removal of ovary.

- Malignancy—Ovarian cancer, uterine cancer, or metastases to ovaries from a distant primary malignancy (gastrointestinal, breast, lung carcinoma)
- Removal of ovaries and tubes in women genetically susceptible to ovarian cancer.

Sometime there may be extensive adhesions between tubes and ovary that it necessitates its removal with the ovary.

Procedure:

Approaching from below and behind, any adhesions between the ovary and broad ligament is carefully divided. Tube and ovary are raised and the infundibulopelvic ligament is identified. Ureter has to be identified before clamping the infundibulopelvic ligament so as to avoid injury to it. The IP ligament is clamped with 2 curved Kocher's clamp. It is cut between the two clamps. The pedicle is transfixed and ligated with 1/0 or 2 zero vicryl suture. Next ovarian ligament and uterine end of the tube is together clamped, cut and ligated **(Figs 32-14 and 32-15)**.

Complications

- Injury to ureter especially when there is severe adhesion as in endometriosis, PID.
- Injury to colon on left side while ligating the IP ligament.

MYOMECTOMY

Myomectomy is removal of myomas from the uterine wall. It may be intramural, subendometrial or subserosal. It causes infertility. Myomectomy is part of the treatment for infertility often.

Myoma can be removed either by open or laparoscopic method. Laparoscopic myomectomy needs more skill than laparoscopic hysterectomy.

Open Myomectomy

Bladder catheterisation is done. Patient with head down position is better to displace the bowel from the pelvis. It is done through Pfannenstiel incision. Site and size of the myomas should be assessed by preoperative imaging. Uterus is delivered/brought out of the abdominal wound. Often vasopressin injection into the uterus may be injected to reduce the bleeding; but its complications should be taken care of. Incision is made on the surface of the uterus directly on the myoma site. Myometrium is carefully separated using monopolar cautery or using no. 15 blade. Bleeding should be controlled. Well capsulated whitish yellow coloured myoma can be identified. Myoma screw is passed into the myoma which is manipulated to pull out the myoma off the uterine wound. Cautery, ligasure will also help from separating it from deeper plane. Once myoma is removed, bleeding points are fulgurated using bipolar cautery. Finger is inserted to confirm that endometrium is injured or not. If endometrium is injured it is sutured with 2 zero vicryl sutures. Myometrium is also sutured using 2 zero sutures. Parametrium is sutured similarly **(Fig. 32-16)**.

Laparoscopic Myomectomy

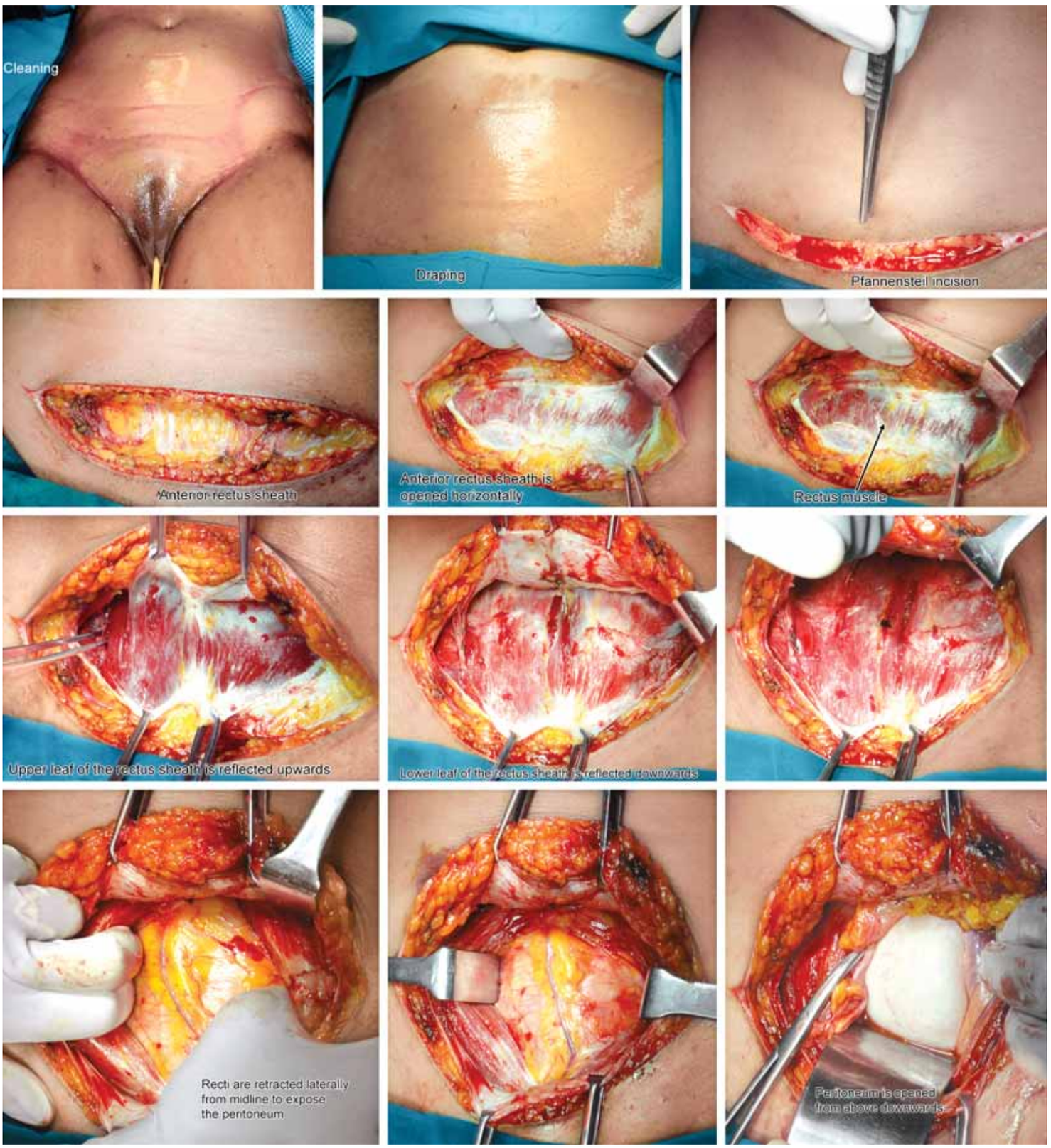
Bladder catheterisation should be done. It is done under general anaesthesia with head down and lithotomy position. 10 mm supraumbilical camera port is placed; 10 mm working port on one side in the iliac fossa; another 5 mm on the opposite iliac fossa; one more 5 mm port on the right side above the earlier 5 mm port which is used for myoma 5 mm screw to pass. Incision is made on the uterus on the myoma site using monopolar cautery. Once glistening avascular myoma capsule is identified, laparoscopic myoma screw is inserted into the myoma. Using the screw myoma is manipulated gently, gradually and progressively to retrieve it from myoma bed in the uterine wall. Bleeders should be addressed using ligasure or harmonic scalpel or bipolar cautery. Uterine wall is sutured with intracorporeal suturing. Difficulty is identifying the endometrial tear and suturing it. If difficulty arises conversion should be done. Absolute haemostasis should be achieved.

HYSTERECTOMY

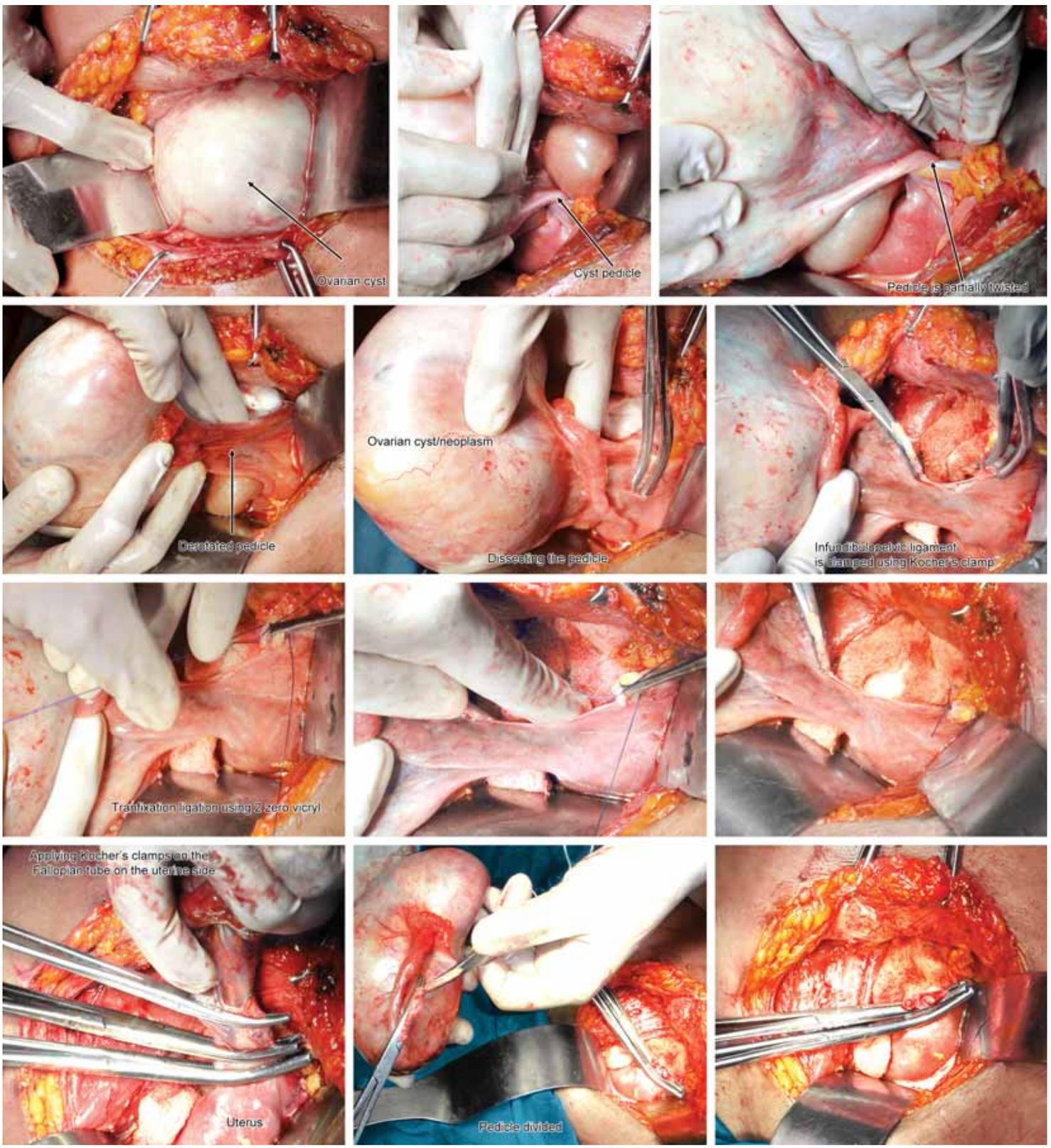
It is operative removal of the uterus. It is the most common gynecological surgical procedure.

Indications

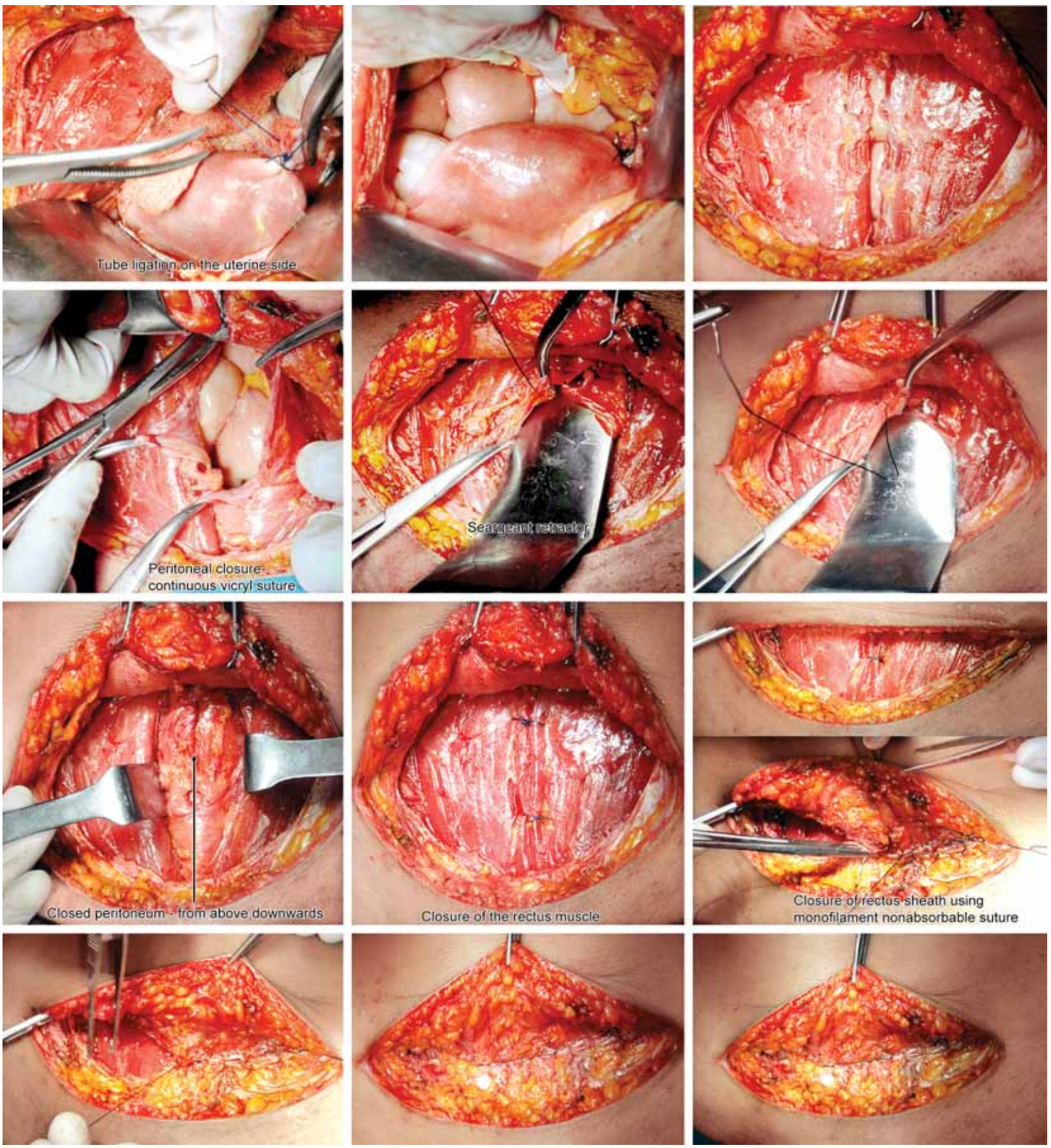
Benign condition	*Malignant condition*
• Dysfunctional uterine bleeding • Fibroid and adenomyosis • Bilateral ovarian cyst • Post menopausal bleeding • Endometriosis • Pelvic inflammatory disease • Pelvic organ prolapse • Obstetric causes like postpartum haemorrhage, rupture uterus, abnormal placentation	• Cervical intraepithelial neoplasia • Cancer of endometrium, ovary, fallopian tube • Gestational trophoblastic disease.


Cleaning
Draping
Pfannensteil incision
Anterior rectus sheath
Anterior rectus sheath is opened horizontally
Rectus muscle
Upper leaf of the rectus sheath is reflected upwards
Lower leaf of the rectus sheath is reflected downwards
Recti are retracted laterally from midline to expose the peritoneum
Peritoneum is opened from above downwards

Figs 32-14(1)


Ovarian cyst
Cyst pedicle
Pedicle is partially twisted
Derotated pedicle
Ovarian cyst/neoplasm
Dissecting the pedicle
Infundibulopelvic ligament is clamped using Kocher's clamp
Transfixation ligation using 2 zero vicryl
Applying Kocher's clamps on the Fallopian tube on the uterine side
Uterus
Pedicle divided

Figs 32-14(2)


Tube ligation on the uterine side
Peritoneal closure-
continuous vicryl suture
Seargeant retractor
Closed peritoneum - from above downwards
Closure of the rectus muscle
Closure of rectus sheath using
monofilament nonabsorbable suture

Figs 32-14(3)

Subcutaneous tissue closure
Subcuticular skin closure using monocryl
Specimen - dermoid cyst of ovary - other side ovary is normal
histology - benign dermoid cyst

Figs 32-14(4)

Figs 32-14(1 to 4): Salpingo-oophorectomy for benign dermoid cyst of the ovary—technique.

Fig. 32-15: Krukenberg tumour of the ovary.

Types

Total hysterectomy—uterine corpus with cervix removed.

Subtotal hysterectomy—only uterine corpus removed retaining the cervix.

Panhysterectomy—uterine corpus, cervix along with bilateral tubes and ovaries removed.

Radical hysterectomy—total hysterectomy, bilateral salpingo-oophorectomy, along with removal of parametrium, upper 1/3rd vagina and pelvic lymph nodes.

Routes of Removal

Uterus can be removed via abdominal, vaginal, or laparoscopic route.

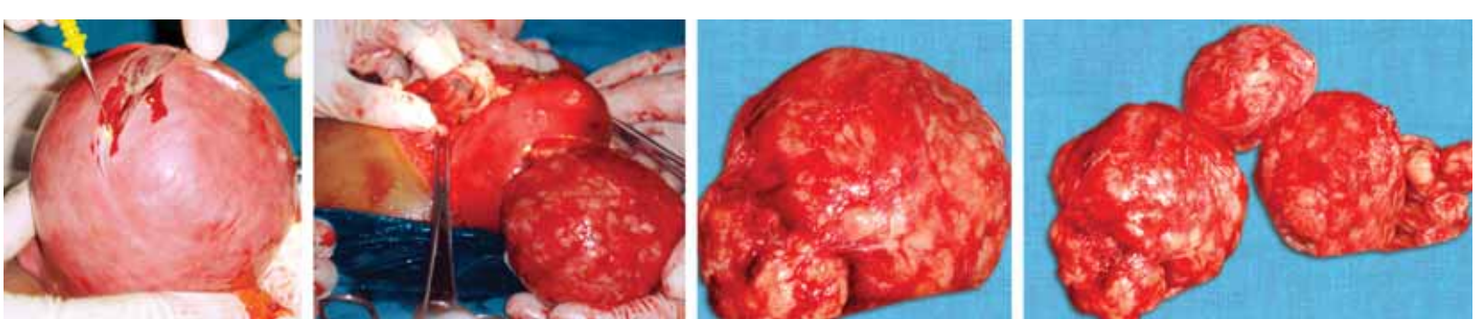


Fig. 32-16: Myomectomy – specimen – large and multiple.

Choice of this route depends on the uterine size, presence of pelvic pathology, uterine descent. Uterus up to 12-14 weeks size, with slight descent, with absence of any pelvic pathology like endometriosis, PID, pelvic adhesions due to previous surgeries, with absence of cervical hypertrophy/fibroid can be safely and effectively removed by vaginal route. Vaginal hysterectomy is less morbid and cost effective than abdominal hysterectomy. A diagnostic laparoscopy will clarify the situation and may allow the procedure to be converted to a laparoscopically assisted vaginal hysterectomy (LAVH).

Need of Oophorectomy During Hysterectomy

It is decided on the age of the patient, and gross structure of the ovary. *Prophylactic oophorectomy* is the term used for removing clinically normal ovaries, often done in postmenopausal women or in women aged > 45 years to prevent the development of any ovarian pathology in future. Young women < 45 years with normal looking ovaries can be left behind.

Disadvantages of oophorectomy:

- Menopausal symptoms which may be so severe that may require HRT.
- Risk of osteoporosis, atherosclerosis, coronary thrombosis increases.

Advantages: Risks of developing ovarian cancer, cysts are reduced.

Anaesthesia

Can be done under general/spinal anaesthesia. However spinal anaesthesia is preferable for vaginal hysterectomy.

Abdominal Hysterectomy

Technique: The patient is placed in supine or modified lithotomy position with legs supported by the Allen universal stirrups. The latter position favours access to vagina. The vagina and perineum are cleaned with antiseptic solutions. Indwelling Foley catheter is inserted. A pelvic examination is routinely performed under anaesthesia. This examination helps to delineate the existing pathology and also in selection of the type of incision. The abdomen is then cleaned from the anterior thighs to the xiphoid with antiseptic solutions. Sterile drapes are applied.

Incision: Abdomen is opened either by a low transverse, Pfannenstiel (mostly preferred), or infraumbilical-midline/paramedian (when good exposure is required) incision.

Once inside the peritoneal cavity, the abdomen is explored and pelvic pathology is carefully evaluated. The surgeon should examine the appendix for any pathology. The upper abdominal organs, including liver, gallbladder, stomach, under surface diaphragm, and omentum should be palpated for any pathology. The retroperitoneal nodes in the pelvic and paraaortic area should be palpated. Mild Trendelenburg position will help in keeping the bowel out of the operative field **(Figs 32-17 and 32-18)**.

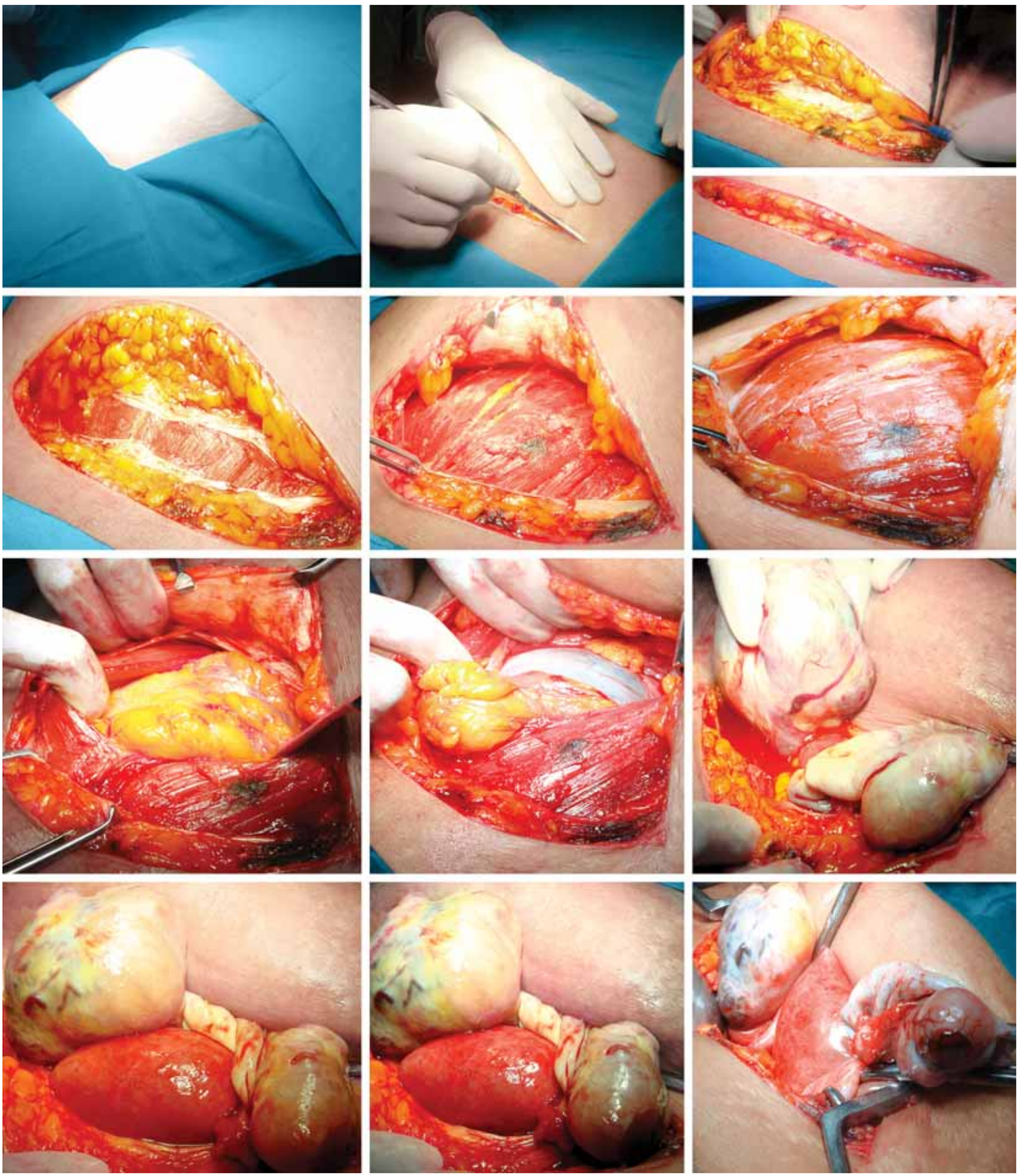
A self-retaining retractor may be used to retract the lateral abdominal flaps. The bowel packed superiorly with warm wet packs to afford good exposure of the pelvis. Any adhesions of the small bowel or rectosigmoid may need to be divided at this time so that the bowel

Fig. 32-17: Tissue forceps commonly used to hold the rectus sheath while raising the flap upwards.

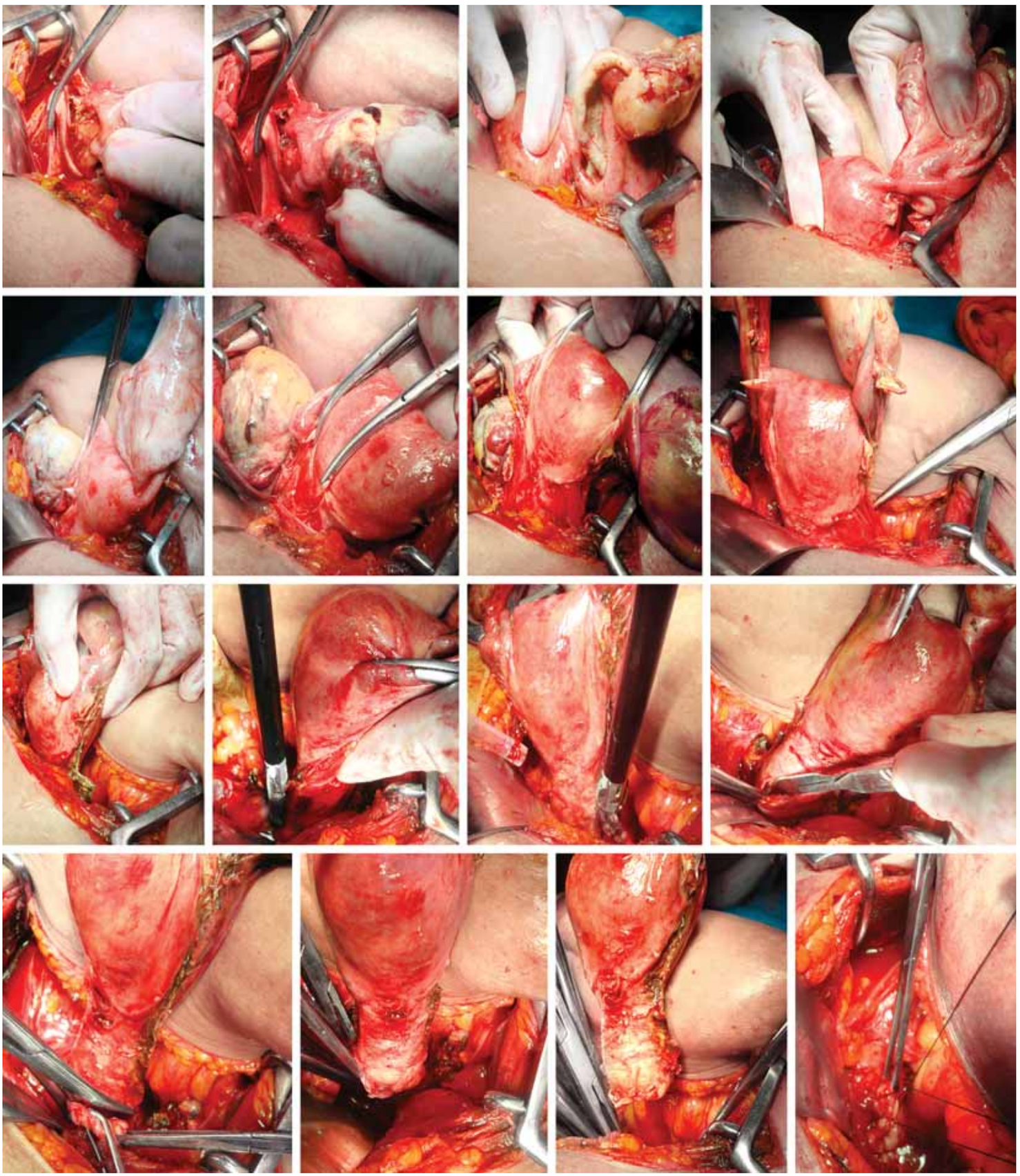
Fig. 32-18: Doyen's retractor is often used in pelvic surgeries.

can be mobilised out of the operative field. The uterus is elevated out of the pelvis with pair of Kocher's clamp applied on the uterine cornual end on each side which grasps the isthmic portion of fallopian tubes and mesosalpinx. Bilateral clamps in this position will allow for elevation, traction, and rotation of the uterus. Uterine mobility is restricted in cases of extensive inflammatory disease, endometriosis, malignancy, or very large fibroids, but uterine mobility is satisfactory in most benign conditions. Bilateral tubes and ovaries are carefully examined for any pathology **(Fig. 32-19)**.

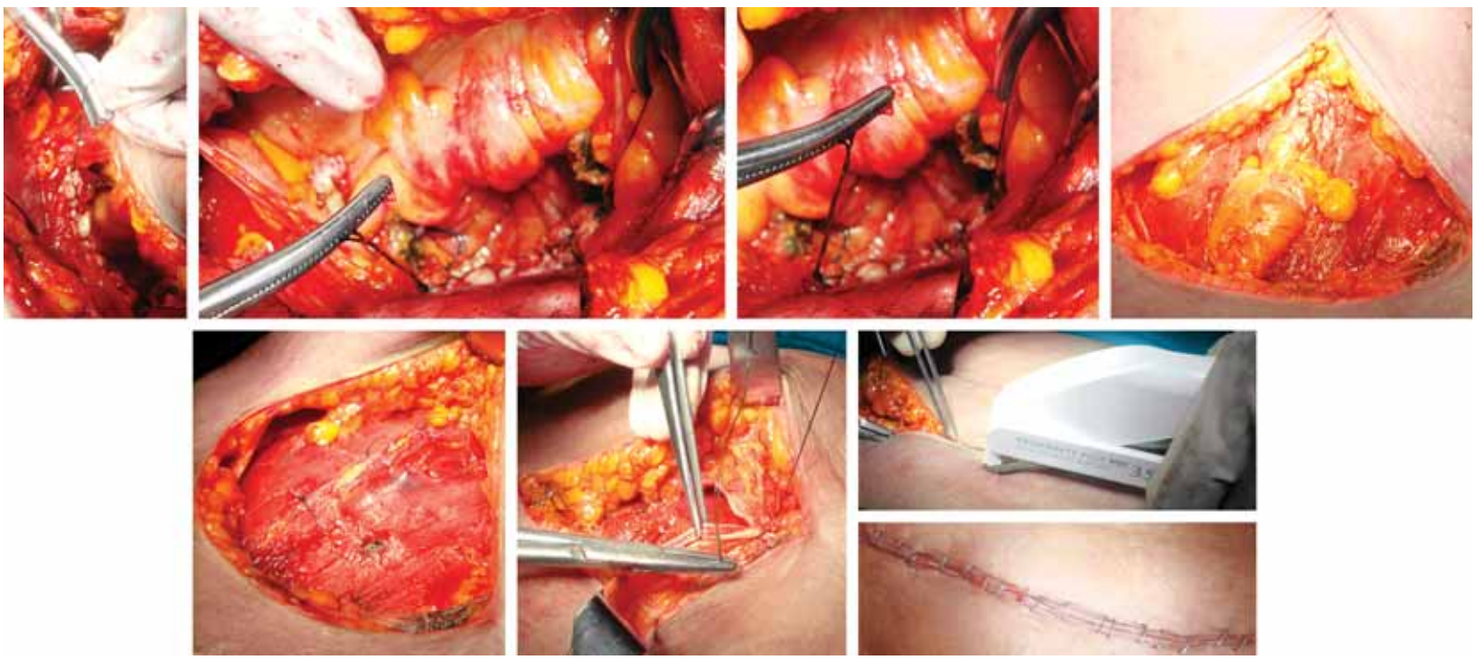
If the ovaries and tubes are healthy then *total hysterectomy* is done. The uterus is pulled to one side so that the opposite ovary and tubes are stretched and exposed. The round ligament is clamped midway with a pair of Kocher's clamp, divided and the clamps are removed after ligating with 1/0 vicryl sutures. This opens the retroperitoneal space, which is almost always a free space for blunt dissection, even in the patient with extensive tumor, inflammatory disease, or endometriosis. The loose areolar tissue of the retroperitoneum is divided with the index finger and the tip of the suction or the back of a tissue forceps. The external iliac artery on the medial surface of the psoas muscle is identified. Blunt dissection is done to expose superiorly to the level of the bifurcation of the common iliac artery. At this junction the ureter always crosses the pelvic brim and is identified easily. The internal iliac or hypogastric artery entering the pelvis at this location, parallel to the ureter is also identified. Identification of ureter and its course will prevent its injury during clamping and ligating of pedicles. This is especially important when pelvic anatomy is distorted as in pelvic inflammatory disease, endometriosis and malignancy. A window is made by sharp or blunt



Figs 32-19(1)



Figs 32-19(2)



Figs 32-19(3)

Figs 32-19(1 to 3): Technique of open hysterectomy.

way in the peritoneum beneath the fallopian tube between the uterus and ovary. A Kocher's clamp is used to clamp the tube and utero-ovarian ligament, its tip should lie in the window created in the peritoneum. The clamp that was initially placed at the corneal end of the uterus acts as a back clamp. The tube and utero-ovarian ligament are divided between the clamps and the pedicle is ligated twice. The procedure is repeated on the other side.

In *panhysterectomy* where the ovaries and tubes are to be removed, a hole in the peritoneum between the ureter and the ovarian vessels is made under direct vision. The ovarian vessels in the infundibulopelvic ligament are clamped with Kocher's clamp. A second back clamp is placed distally and the ovarian vessels are divided between the two clamps. Dissection done in the retroperitoneum will avoid the injury to ureter at this junction. The pedicles are transfixed and ligated with 1/0 vicryl sutures. The procedure is repeated on the other side also.

The uterus is now pulled upwards and backwards. Utero-vesical fold of peritoneum is exposed and is divided with sharp scissors just inferior (5 to 10 mm) to its attachment to the lower uterine segment. At this junction peritoneum is usually mobile, and this peritoneal division is carried from one side round ligament to the other. An avascular plane of loose areolar tissue can be identified between the posterior bladder wall and the anterior cervix. By giving constant upwards traction on the uterus and peritoneal fold of the bladder, the bladder is dissected away from the cervix either by sharp dissection with scissors or by blunt dissection with a gauze held with an Allis forceps. Care should be taken to see that scissors should rest lightly on the fascia overlying the cervix and this dissection should take place over the cervix avoiding to go far laterally as one may encounter bleeding due to injury to uterine vessels. With the thumb of one hand in front and fingers of the other behind the uterus the extent of this bladder dissection below the cervix is determined. As the bladder is advanced below the cervix, the thumb in front and the fingers behind come into closer opposition as they now have only the vaginal wall between them. Posteriorly, it is not necessary to dissect the rectum off the posterior cul-de-sac; but if adherent and prevents good exposure, it should be dissected free slightly by blunt dissection after the uterine vessels have been divided. The posterior peritoneum between the uterosacral ligament beneath the cervix is incised. By blunt dissection with fingers in the avascular plane which exists between the rectum and posterior cervix/vagina, will push the rectum backwards away from the operative field.

Next step is a crucial step of hysterectomy which is the ligation of uterine vessels. Any improper ligation or slipping of ligatures will cause the vessels to retract and result in torrential bleeding. Blind catching of the vessels with a hemostat in an attempt to stop bleeding will likely to damage the ureter that traverse close by. Uterus is pulled sharply to one side, and the loose fatty tissue adjacent to the lateral lower uterine segment on the opposite side is dissected. The uterine artery is usually found immediately adjacent to the uterus at the level of the internal cervical os. Skeletonising the uterine artery and vein allows them to be clamped more accurately. Less adjacent tissue means a smaller vascular pedicle, which allows more precise and more secure ligation. However excessive attempts to isolate the vessels may produce unnecessary bleeding. The exposed vessels are clamped with Heaney or Kocher's clamp adjacent to the uterus. The clamp must be applied at right angles to the vessels. A second clamp can be placed above the first for added safety. If the uterus is small, no back clamp is required. The uterine vessels are cut with scissors or a knife and the pedicle are doubly ligated with 1/0 vicryl sutures. The procedure is repeated on the opposite side.

It is once again made sure that the bladder anteriorly and the rectum posteriorly have been freed from the cervix. Giving upward traction on the uterus, the deeper portions of the broad ligament is exposed. By using a retractor bladder is retracted away and downwards and thereby pull the lower uterine segment away from the ureter. A straight Heaney or Kocher's clamp is now applied over the remaining portion of the broad ligament/parametrium close to the lateral portion of the cervix. Giving traction on the uterus towards opposite side, the cervix is freed from the parametrium with scissors. By staying close to the cervix the risk of damaging the ureter is minimised. The

clamps are removed after transfixing and ligating the pedicles with 1/0 absorbable sutures. Procedure is repeated on the opposite side. Maintaining good exposure, one or two pedicles are tied on each side, and then the procedure is repeated on the opposite side until the level of the cervico-vaginal junction has been reached. Once again, the bladder and rectum are checked and advanced if necessary to be sure that they are well clear off and the anterior and posterior vaginal walls are exposed. Haeney's clamps are then applied across the vagina below the cervix from either side, which should include the base of the cardinal ligaments laterally, the uterosacral ligament posteriorly, and anterior and posterior vaginal wall. With a knife or heavy, sharply angled scissors the vagina is divided above these clamps and below the cervix. This is closed technique of removing the cervix from the upper vagina which decreases the chance of spillage of vaginal contents into the abdomen. This technique decreases the risk of infection and the formation of symptomatic granulation tissue at the vaginal apex. Alternatively vagina may be opened by a stab incision with a knife below the cervix over the anterior vaginal wall and is cut circumferentially under direct vision. Full thickness vaginal edge is held with Allis forceps. Uterus thus removed is placed in a tray. Gauze may be introduced into the vagina from above and the vagina is cleared of clots. The lateral clamps are removed after transfixing and ligating the pedicles. Inclusion of the uterosacral and cardinal ligament in this pedicle provides excellent support of the vaginal apex. The vagina is closed with interrupted sutures or continuous locking 1/0 vicryl sutures.

Pelvis is irrigated with warm saline; the pedicles are inspected carefully to be sure that haemostasis is achieved. Cautery or excessive suturing at the bladder base should be avoided as it may predispose fistula formation because of necrosis. Any bleeding areas at the uterine vessels or cardinal ligament should be grasped with an Allis clamp and resutured within the suture line. The pelvis is not reperitonealised. New mesothelium arises from the subperitoneal connective tissue cells and occurs simultaneously in all exposed areas independent of the size of the defect. Attempts to cover areas of peritoneal injury may lead to increased adhesion formation at the sites of reperitonealisation by preventing autolysis of early fibrinous attachment and introducing reactive responses to suture material. The packs and retractor are removed. The anterior peritoneum is closed with delayed absorbable suture to prevent the development of future incisional hernia. The abdomen is closed in the usual way.

Difficult Hysterectomy

Difficulties are encountered in severe pelvic endometriosis, PID, malignancies large myomas where the pelvic anatomy is distorted. Dense adhesions cause great restriction in uterine mobility. By sharp dissection with scissors and blunt dissection with hand the adhesions are to be released and proceeded. In large cervical myomas the bladder may be pushed upwards into the abdomen which is likely to get injured while opening the peritoneal cavity. Often ureter may lie close to the myomas due to distortion of the anatomy. In cases of pelvic endometriosis or previous caesarian section it may be difficult to separate and advance the bladder from the cervix. In some cases adhesions are so extensive that an attempt to remove the cervix may cause trauma to bladder, rectum and ureter. In such cases one may have to resort to *subtotal hysterectomy* **(Fig. 32-20)**.

The *technique of subtotal or supracervical abdominal hysterectomy* is similar to abdominal hysterectomy until the ligation and clamping of uterine vessels. Care should be taken to see that the bladder and rectum have been advanced far enough so that the cervix can be clearly visualised both anteriorly and posteriorly. Upward traction is given to the uterine fundus and with electrocautery the cervix is cut anteriorly just above the level of uterine artery ligation. A shallow V-shaped incision is made on both anterior and posterior aspect until the uterine fundus is excised. Figure-of-eight sutures are used to close the upper endocervix in a hemostatic fashion. The top of the cervix is checked for any bleeding, and this cervical stump may be covered by the bladder peritoneum to minimise the risk of adhesions **(Fig. 32-21)**.

Postoperative Care

Foley's catheter inserted for bladder drainage is removed after 24 hours. Patient is hydrated with IV fluids for 24-48 hours. Once the normal bowel movements gets resumed oral diet is started. Parenteral antibiotics given for 48 hours, later switched over to oral preparation. Analgesics to control pain, initially inj.pethidine (50 mg) + phenargan (25 mg) later tramadol and paracetamol. Patient is motivated for early ambulation and respiratory exercise to avoid pneumonia and deep vein thrombosis. Skin suture are removed anywhere between 7th-10th postoperative day. If bilateral ovaries are removed in a young patient she may require hormone replacement therapy for certain period. Normal activities can be resumed in 2-3 weeks. Patient is advised to avoid lifting heavy weights and intercourse for 4-6 weeks. Driving and travelling can be resumed once the pain has completely reduced. Patient should consult the physician if there is any vaginal bleeding, fever, persistent nausea /vomiting, increase pain out of proportion to the postoperative period.

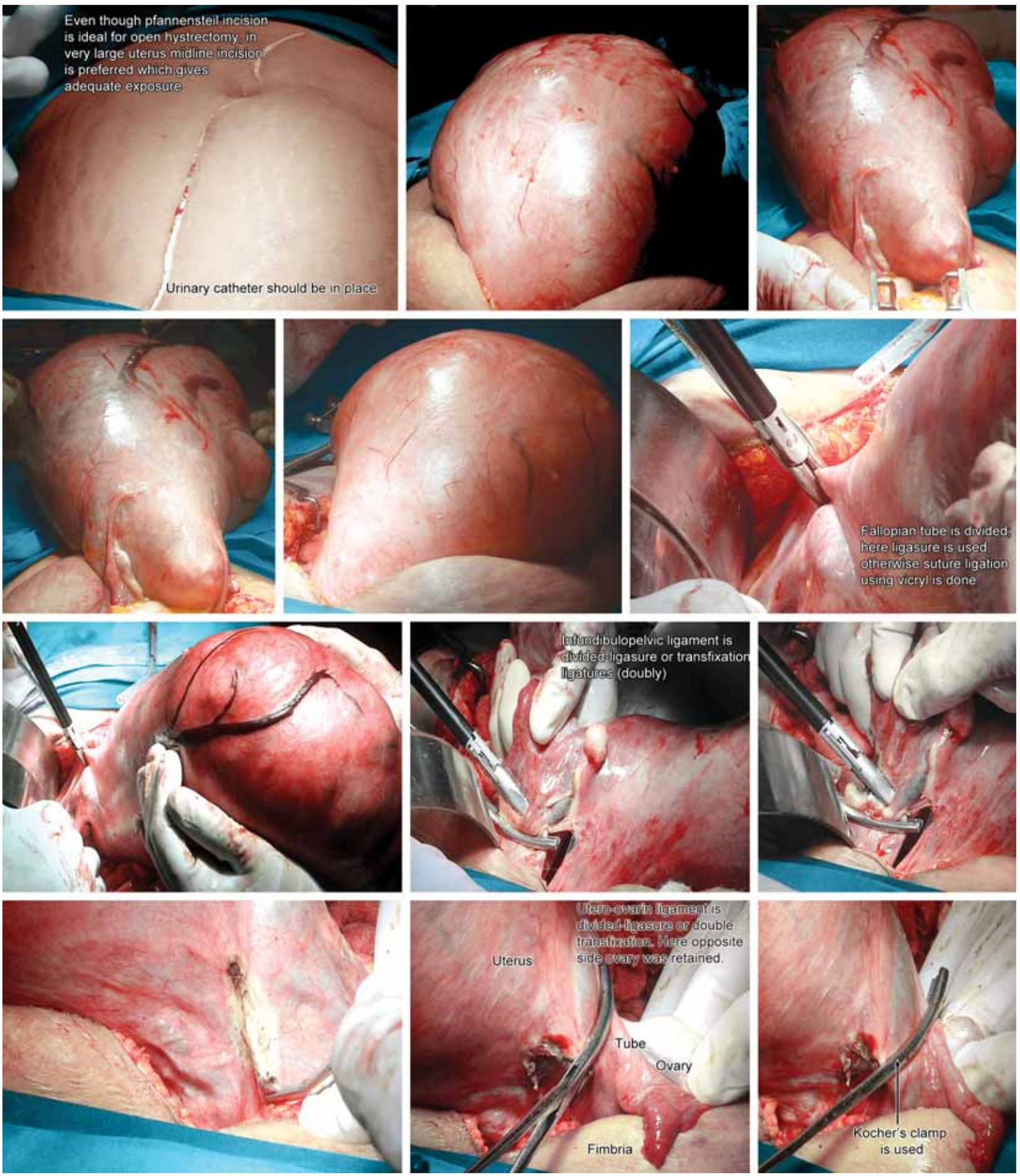
Complications of Hysterectomy

Intraoperative Complication

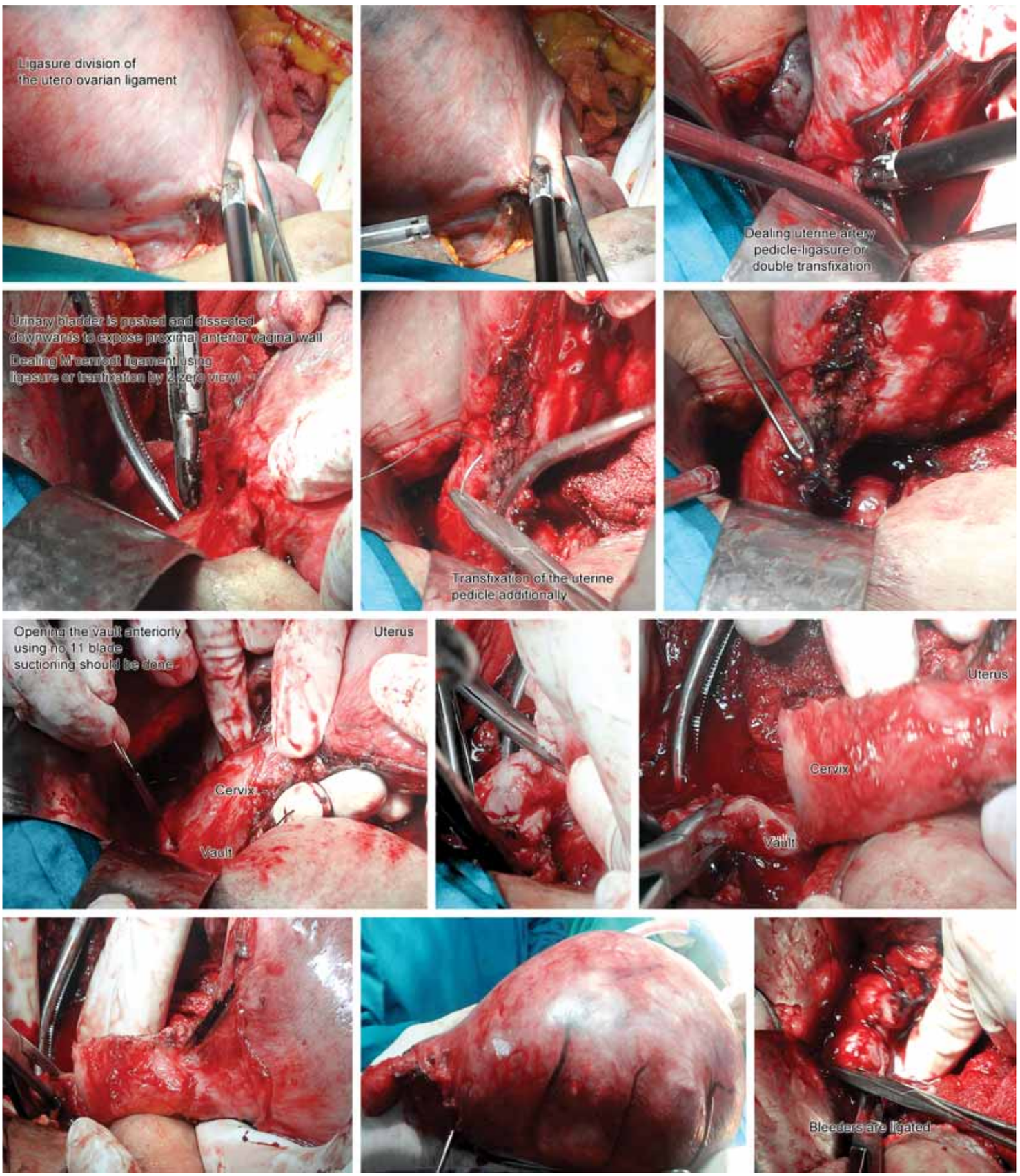
Ureteric injury: Common sites of ureteral injury during abdominal hysterectomy include the infundibulopelvic ligament where the ovarian vessels are ligated; the area of the uterine artery ligation and at the bladder base. It is wise to expose the ureter in the retroperitoneal space so that its injuries can be avoided. Despite proper precaution if there is a doubt of ureteric injury, *indigocarmine* dye is injected intravenously. Its spill through the ureteric orifices is seen either through cystoscopy or by making an incision over the dome of the bladder.

Bladder injury: Bladder may be unusually drawn up into the abdomen by large pelvic tumors, adhesions due to previous surgery leading to its injury while opening the peritoneum. Bladder may sometime be unusually adherent to the cervix due to previous caesarian section or pelvic endometriosis. So while advancing the bladder off the cervix or upper vagina its muscle fibres may get torn up. Apart from trigonal injuries bladder injury is repaired by 2 layer closure of continuous 3/0 vicryl sutures. Trigonal injuries are dealt by the urologist. Continuous bladder drainage by indwelling Foley's catheter for 7 days is done.

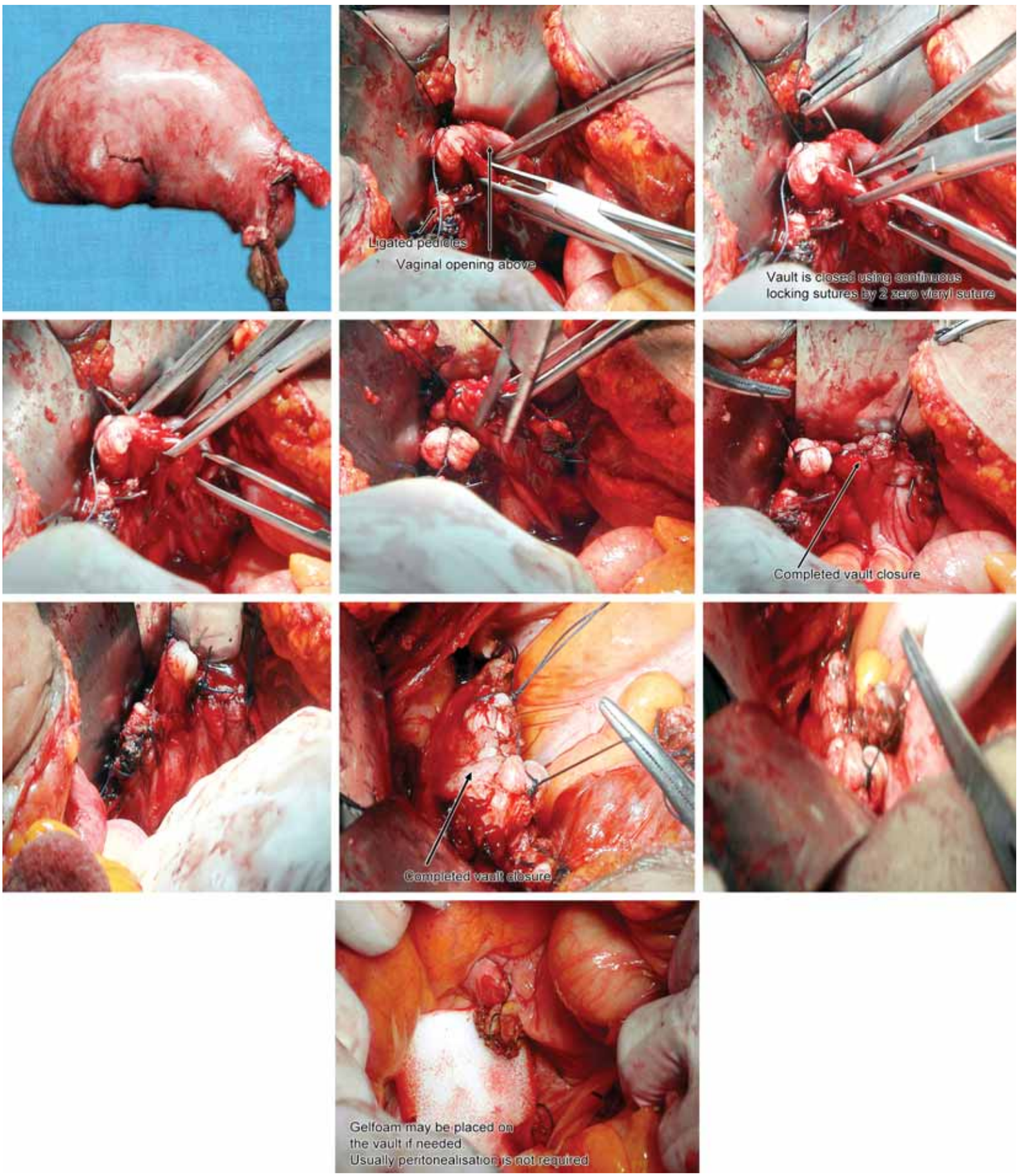
Haemorrhage: Often bleeding occurs from the slipping/loosening of ligatures from ovarian or uterine pedicles. Bleeding is also encountered near the bladder base. Blind application of haemostat should be avoided. Firm pressure is applied with a warm wet mop. By slowly releasing the pressure the bleeding vessel is identified,


Even though pfannensteil incision is ideal for open hystrectomy, in very large uterus midline incision is preferred which gives adequate exposure
Urinary catheter should be in place
Fallopian tube is divided here ligasure is used otherwise suture ligation using vicryl is done
Infundibulopelvic ligament is divided: ligasure or transfixation ligatures (doubly)
Utero-ovarin ligament is divided: ligasure or double transfixation. Here opposite side ovary was retained.
Uterus
Tube
Ovary
Fimbria
Kocher's clamp is used

Figs 32-20(1)


Ligasure division of the utero ovarian ligament
Dealing uterine artery pedicle-ligasure or double transfixation
Urinary bladder is pushed and dissected downwards to expose proximal anterior vaginal wall
Dealing Mcenrodt ligament using ligasure or transfixation by 2 zero vicryl
Transfixation of the uterine pedicle additionally
Opening the vault anteriorly using no 11 blade suctioning should be done
Uterus
Cervix
Vault
Uterus
Cervix
Vault
Bleeders are ligated

Figs 32-20(2)


Ligated pedicles
Vaginal opening above
Vault is closed using continuous locking sutures by 2 zero vicryl suture
Completed vault closure
Completed vault closure
Gelfoam may be placed on the vault if needed
Usually peritonealisation is not required

Figs 32-20(3)

Figs 32-20(1 to 3): Hysterectomy for a large uterine tumour through midline incision.

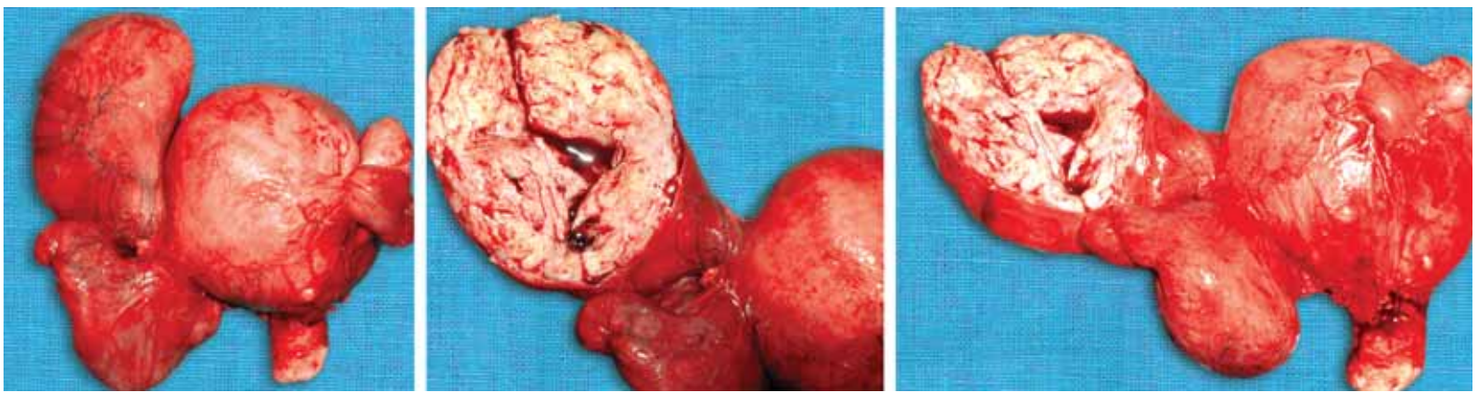


Fig. 32-21: Endometrial carcinoma specimen after hysterectomy.

clamped and ligated with suture. Bleeding from small vessels can be cauterised with electrocautery. Bleeding from denuded surface can be controlled by pressure, or application of topical agents like thrombin/collagen.

Bowel injury: Bowel injuries do can occur when there are extensive adhesions in the pelvis due to endometriosis, malignancy, pelvic inflammatory disease. When the defects are small not involving the mucosa in small bowel, it is closed with single layer of continuous/interrupted 3/0 silk sutures in direction perpendicular to the intestinal lumen. If the defect is large than resection and anastomoses is done. In rectum and sigmoidal injuries, if the defect is small not involving the mucosa it can be closed in similar fashion to small bowel. Large defect involving the mucosa requires diversion colostomy along with primary repair.

Postoperative Complication

a. *Hemorrhage*—It is a serious postoperative complication. It may present with vaginal bleeding or change in vital signs like, tachycardia, pallor, tachypnoea, hypotension some with a palpable mass over the abdomen. Fluids are transfused. Blood transfusion should be done. When vitals are stable then the patient is shifted to operation theatre and examined for any bleeding from the vaginal vault. If it is from the raw vaginal edges one or two re-enforcing stitches over the vault will stop the bleeding. In the absence of any vaginal bleeding and the patient's vitals are not satisfactory, and then exploratory laparotomy is done keeping enough points of blood ready for transfusion. The bleeding vessel is identified and ligated. Sometimes there may not be a intraperitoneal bleeding but from torn and retracted inferior epigastric vessels of the abdominal wall.
b. *Sepsis*—infection may be at the wound site, intraperitoneal, urinary tract, vaginal vault, lungs. *Wound infection* is the most common form of sepsis. Anaemia, poor nutrition, preoperative sepsis, malignancy, ineffective haemostasis leading to haematoma are some of the predisposing factors. Infection may be superficial to the rectus sheath or may be deep to it involving all the layers. It may involve full length of incision or restricted to a small segment. When all the layers are involved the wound may disrupt suddenly leading to burst abdomen which needs to be treated as an emergency. Under anaesthesia resuturing is done. In case of superficial infection it may lead to many discharging sinuses. The wound needs exploration under cover of higher antibiotics. Secondary suturing with deep mattress sutures using ethylon 2/0 is done which is removed only after 2 weeks. Mild superficial infection can be treated conservatively with antibiotics and regular dressing though it gives a bad scar.
   Fever in postoperative period can be due to urinary sepsis, pneumonia, bacteraemia, thrombophlebitis. Blood, urine are sent for culture. Chest X-ray is taken. Postoperative ultrasound will help to know any fluid collection in pelvis and abdominal cavity. Antibiotics are changed suitably. Sometimes the collection may localise in pelvis forming a pelvic abscess which may need to be drained vaginally. By thrusting an artery forceps followed by finger through the vault will help to drain the pus from the pelvis.
   Peritonitis though rare, do can occur following bowel injury or due to retained foreign body like gauze/mops. Ultrasound abdomen or CT scan is done. Some patient may require relaparotomy if bowel injury or retained foreign body is suspected.
   Pneumonia—quite common in elderly, obese ladies and those with history of chronic bronchitis. Postoperative respiratory exercises will help to prevent this.
c. *Oliguria/anuria*—in the presence of normal blood pressure, one should suspect ureteric ligation. Postoperative ultrasound will help to confirm this. Emergency nephrostomy may be done later, followed by exploration and reimplantation of the ureter.
d. *Paralytic ileus, intestinal obstruction*—electrolyte imbalance, sepsis are known to cause paralytic ileus. Proper hydration, higher antibiotics, nasogastric aspiration with Ryles tube will help to restore the bowel function normally. Persistent vomiting with colicky pain should one be suspicious of intestinal obstruction. Occasionally a loop of small bowel may get adherent to the vault. Laparotomy is done. Resection and end-to-end anastomosis is done.
e. *Thrombophlebitis and deep vein thrombosis*
f. *Pulmonary embolism*
g. *Early menopause*—Women who have undergone hysterectomy may experience menopause earlier than the average age of menopause (age 51). This may be due to an interruption in blood flow to the ovaries. Removal of ovaries also induces menopausal symptoms in the immediate postoperative period. Unless hormones replacement not started patient may develop severe symptoms that may affect the mental status.

Vaginal Hysterectomy

Indications: Common indications include abnormal or dysfunctional uterine bleeding, complex endometrial hyperplasia, leiomyoma (12-14 weeks size), adenomyosis, pelvic organ prolapse **(Fig. 32-22)**.

Fig. 32-22: Uterine prolapse.

Prerequisites for vaginal hysterectomy:

- Good uterine mobility that can be demonstrated with Valsalva manoeuvre
- Absence of adenexal pathology
- Pubic arch of 90° or greater with adequate vaginal canal, deep and wide posterior vaginal fornix will make the vaginal surgery easier to perform.

Proper selection of the patient is very important in vaginal hysterectomy.

Contraindication:

- Restricted uterine mobility
- Previous pelvic surgeries and caesarean section
- Severe endometriosis and pelvic inflammatory disease where there may be extensive pelvic adhesions
- Adenexal pathology—ovarian cysts and tumours, tumours of fallopian tubes
- Uterus enlarged beyond 12-14 weeks.
- Nulliparity
- Narrow pubic arch and narrow vaginal canal.

However vaginal hysterectomy can be successfully done in nulliparous women and women who have undergone caesarean as long as adequate access for division of the uterosacral and cardinal ligaments is obtained by the surgeon and the uterus can be sufficiently mobilised to allow vaginal extraction. Even when the uterus is enlarged beyond 12-14 weeks vaginal hysterectomy can still be accomplished safely by means of morcellation, uterine bisection, wedge debulking, or intramyometrial coring techniques.

Benefits of vaginal hysterectomy over the abdominal: Morbidity of abdominal procedure like, wound infection and disruption, blood loss, intestinal obstruction, paralytic ileus, adhesions, deep vein thrombosis is less in vaginal hysterectomy. Postoperative pain and discomfort is less in vaginal hysterectomy, so need of less analgesia and early ambulation is possible. Duration of hospital stay is less. So more cost effective than the abdominal procedure.

Prior to vaginal procedure adnexa can be tackled by laparoscopy, thereby converting the hysterectomy into a vaginal procedure which would otherwise be an abdominal (LAVH).

Preoperative Preparation

For better postoperative healing of the vaginal vault it is always advisable to give vaginal douche a day before and on the day of the surgery. This will help to clean the vaginal epithelium from any infection. The rectum is evacuated with an electrolyte purgative or fleet enema on the evening before surgery. Bowel cleansing evacuates solid stool from the rectum, reduces the bacterial load at the perineum, and reduces the incidence of postoperative ileus and constipation. Patient is kept fasting for 6-8 hours. Informed consent is taken.

Prophylactic broad-spectrum antibiotics are started before the surgery. The risk of postoperative infection can be reduced if antibiotics are given just before the surgery such that to be effective, the antibiotic must be in the tissue at the time of surgery.

Technique

Anaesthesia—It can be done under general, spinal or epidural anaesthesia. It depends on the condition and choice of the patient.

Positioning—The patient is positioned in the dorsal lithotomy position with the buttocks just over/well off the edge of the table. Type of stirrup used should take care to protect the vulnerable vascular, bony, and neurologic points of the lower limb. Use of adequate leg padding, avoiding marked flexion of the thigh, and avoiding pressure points, particularly laterally, where the peroneal nerve encircles the head of the fibula will prevent these injuries due to wrong positioning. In addition to this mild Trendelenburg (10–15°) positioning will help the surgeon to comfortably operate. Assistants need to stand inside the stirrups to see the operative field.

The vagina and perineum is cleansed with betadine or savlon lotion. In addition lavage of the vagina with saline will also help to reduce the postoperative infection. Bladder is drained with a metal catheter. The patient is then draped.

An examination under anesthesia is now performed, in dorsal lithotomy position, to assess descent of the pelvic organs, respective defects, mobility, and uterine size. The final decision is made at this time as to whether the procedure can be done vaginally or abdominally.

A heavy speculum is placed into the posterior vagina. With a right-angle retractor anterior vagina is retracted and the cervix is visualised. The anterior and posterior lips of the cervix are grasped with a single- or double-toothed tenaculum/vulsellum forceps. Sounding the uterus now will help to confirm the suspected size and contour of the uterus.

Gentle traction over the cervix with the vulsellum is given in all directions so that the surgeon can visualise the cervico-vaginal junction, the area where the initial incision has to be made. 0.5% lidocaine with 1:200,000 or a dilute solution of vasopressin may be injected into the paracervical tissue, the area around the uterosacral ligaments, the lower portion of the cardinal ligament, and the bladder pillars. This will help to decrease peroperative blood loss, and also to delineate the surgical planes. But the use of vasoconstrictive infiltration is not always necessary.

With adequate traction on the anterior and posterior lips of the cervix, a circumferential incision is made through the full thickness of vaginal epithelium at the cervico-vaginal junction. Anteriorly the junction is at where the vaginal rugae begin and the smooth cervical epithelium ends. As the incision is laid circumferentially, adequate counter-traction against the respective lateral vaginal wall will prove to be helpful. The full-thickness posterior vaginal mucosa is incised to meet the anterior incision. If this initial incision is made below the

level of cervico-vaginal junction close to the external os, a greater amount of dissection is needed to displace the vaginal mucosa and usually an increased amount of bleeding is encountered. And depth of the incision also should be adequate enough to involve only the full thickness of the vaginal mucosa, otherwise the dissection extends into the cervix leading to increased blood loss and technical difficulty. Now the vagina is dissected from the underlying tissue sharply with scissors or bluntly with the surgeon's sponge-covered finger. The bladder is dissected off the anterior lower uterine segment all the way up to the vesicouterine peritoneal fold. This step is frequently insufficiently performed for fear of entering the bladder. Entry into the anterior cul-de-sac is difficult if this dissection is not sufficiently carried up to the vesicouterine peritoneal fold. The bladder is elevated with a right-angle retractor placed under the vaginal mucosa and bladder. Strong downward traction is applied on the cervix held by vulsellum. This maneuver aids in identifying the vesicouterine peritoneal fold which appears as a white transverse line across the lower uterine segment. It is grasped with forceps and incised with sharp curved scissors. The edge of this incision is held with artery forceps and a finger is inserted to explore the area so as to be sure that one is in the peritoneal cavity and not the bladder and also to identify any unsuspected pathologic condition that was not identified before. A right-angle retractor is placed into the peritoneal cavity underneath the finger. If the patient had a previous caesarean section, the scar of this procedure can be readily visualised and identified separately from the bladder. Sometimes it is possible to dissect beneath the caesarean section scar to gain entry into the superior part of the vesicouterine space to identify the vesicouterine peritoneal fold.

With steep upward traction on the cervix, the cul-de-sac is exposed. Posterior vaginal cuff is retracted with forceps placing the peritoneum of the cul-de-sac on tension. The peritoneum of the cul-de-sac is incised with curved scissors. Care should be taken not to place this incision closer to the cervix in an attempt to prevent injury to the rectum, which results in retroperitoneal dissection ultimately pushing the peritoneum superiorly and posteriorly, thereby obscuring the identification of the peritoneum. Once the cul-de-sac is opened a finger inserted into the cul-de-sac and the area is explored for any unsuspected pathology. A right-angle retractor or weighted speculum is placed into the posterior cul-de-sac which will help to keep the rectum away from the operative site during the operation.

With the upward and lateral traction on cervix, a curved Heaney clamp is placed in the posterior cul-de-sac with one blade underneath the uterosacral ligament and the other over the uterosacral ligament, immediately lateral to the uterine cervix so that some carvical tissue is also included in this clamp. This prevents the possible ureteric damage during clamping of the uterosacral ligament. The uterosacral ligament is cut with curved scissors so that approximately 0.5 cm of tissue is distal to the clamp. A transfixion suture with 1/0 vicryl is placed at the tip of the clamp and tied. The procedure is repeated on the other side also. Next, the cardinal ligaments on both sides are identified, clamped, cut, and suture-ligated with 1/0 vicryl sutures in a manner similar to that previously described for the uterosacral ligaments.

Next the remaining portion of the broad ligament attached to the lower uterine segment containing the uterine artery is clamped, cut and suture ligated with 1/0 vicryl on both sides adjacent to the cervix. Use of a single clamp in the vaginal hysterectomy reduces the chance of ureteric damage.

The uterine fundus is now delivered out posteriorly by giving traction on the uterine fundus on the posterior aspect with tenaculum. By inserting fingers the utero-ovarian ligament is identified. Along with remaining portion of broad ligament and round ligament it is clamped and cut. The pedicles are double-ligated, first with a suture tie and then with a suture ligature medial to the first tie. The fallopian tubes and ovaries are now inspected by drawing them into the operative field. If adnexa are to be removed, then the round ligaments should be clamped, cut and ligated separately. By applying traction on the utero-ovarian pedicle the ovary is drawn into the operative field with a Babcock clamp. A Heaney clamp is placed across the infundibulopelvic ligament, and the ovary and tube are excised. Even this pedicle is double ligated with a suture tie and a transfixation suture ligature.

When uterus size is big following techniques may be employed to facilitate the removal of the uterus—morcellation, intramyometrial coring, uterine bisection, and wedge debulking. Morcellation can be used in enlarged uterus, fixed uterus or when there is limited vaginal exposure. It should not be performed if the uterine arteries cannot be ligated or when malignancy is suspected. Intramyometrial coring is done by circumferentially incising the outer myometrium beneath the uterine serosa with a scalpel while placing the cervix on traction. The enlarged uterus is delivered as an elongated mass inverting the uterine fundus. Uterine bisection is performed by cutting the uterus from cervix to the uterine fundus in the sagittal plane.

The entire broad ligament with the pedicles from the tubo-ovarian round ligament anteriorly to the uetrosacral ligament posteriorly are exposed. Wet mop is placed in the peritoneal cavity to allow the surgeon to visualise the pedicles on both side and confirm the adequacy of haemostasis. If any bleeding points are present, it is ligated under direct vision.

Peritonealisation is done using a delayed absorbable suture beginning from anterior peritoneal edge. A continuous purse-string suture is applied beginning from 12 o'clock position proceeding in clockwise direction to incorporate the distal portion of the left upper pedicle and then the left uterosacral and cardinal ligaments. The suture then incorporates the posterior peritoneum as high as possible. The suture is then carried through the uterosacral and cardinal ligament on the patient's right side, and then through the right upper pedicle. This type of high peritoneal closure will help to prevent future enterocele formation.

The vaginal mucosa can be approximated either in a vertical or horizontal fashion, using either interrupted or continuous sutures. These sutures should involve the entire thickness of the vaginal epithelium, taking care not to take bite into the bladder anteriorly.

Vagina is packed with sterile gauze pack soaked with iodine solution. Bladder is catheterised for 24 hours. Both this pack and catheter is removed after 24 hours.

Postoperative care:

- Patient is kept nil oral for 12-24 hours as the intestinal mobility is sluggish.
- Hydration is maintained by IV fluids.
- Pareteral antibiotics for 24 hours followed by oral preparation. Analgesics may be required as there may be pelvic discomfort during the first 24-48 hours.
- Early ambulation will help to prevent DVT.

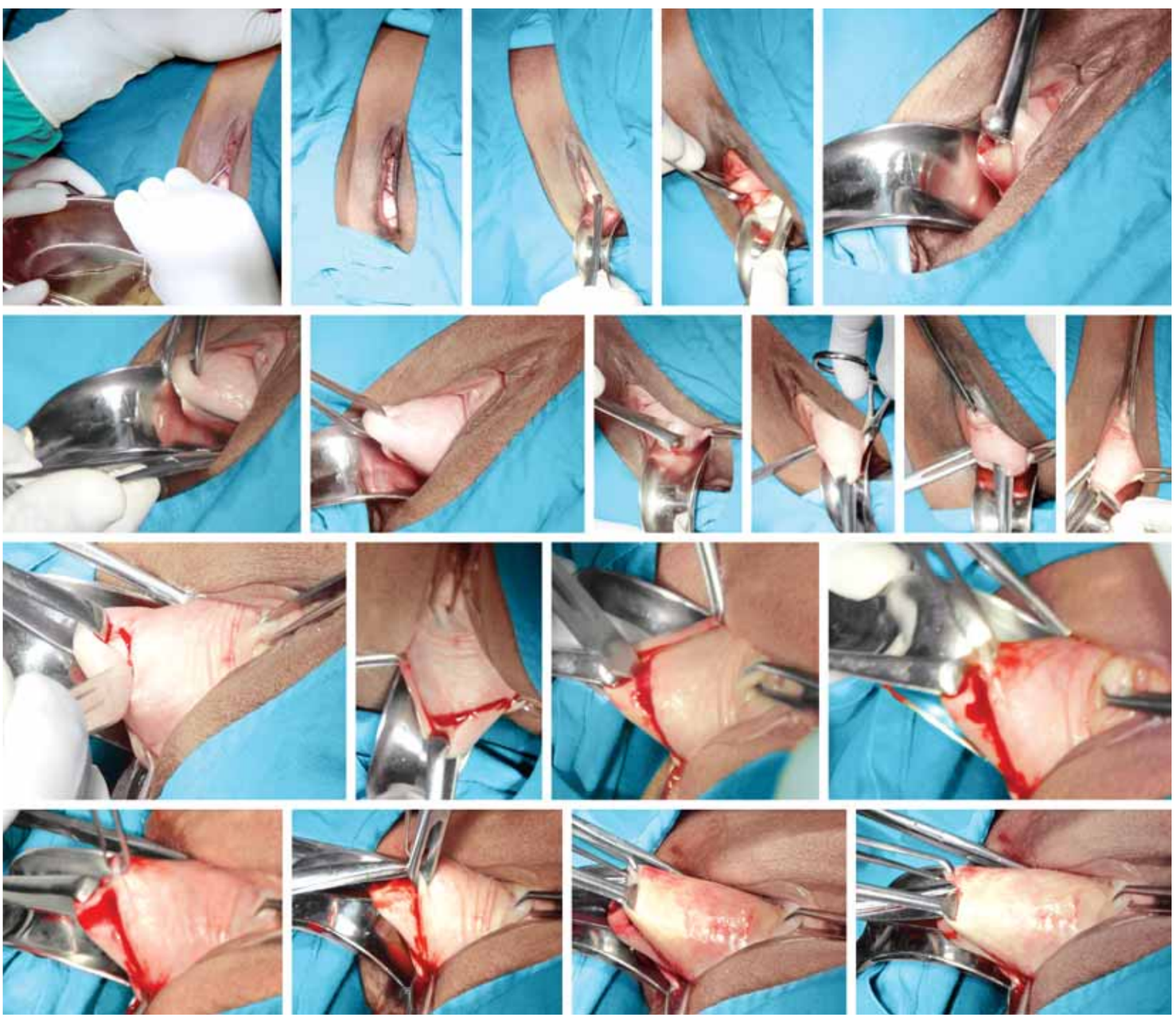
Complications

a. *Haemorrhage*—Bleeding may be from the vaginal cuff margin or from above from one of the pedicles. It may present as vaginal bleeding in the immediate postoperative period or retroperitoneal bleeding which may present with deterioration of vital signs with little amount of vaginal bleeding.

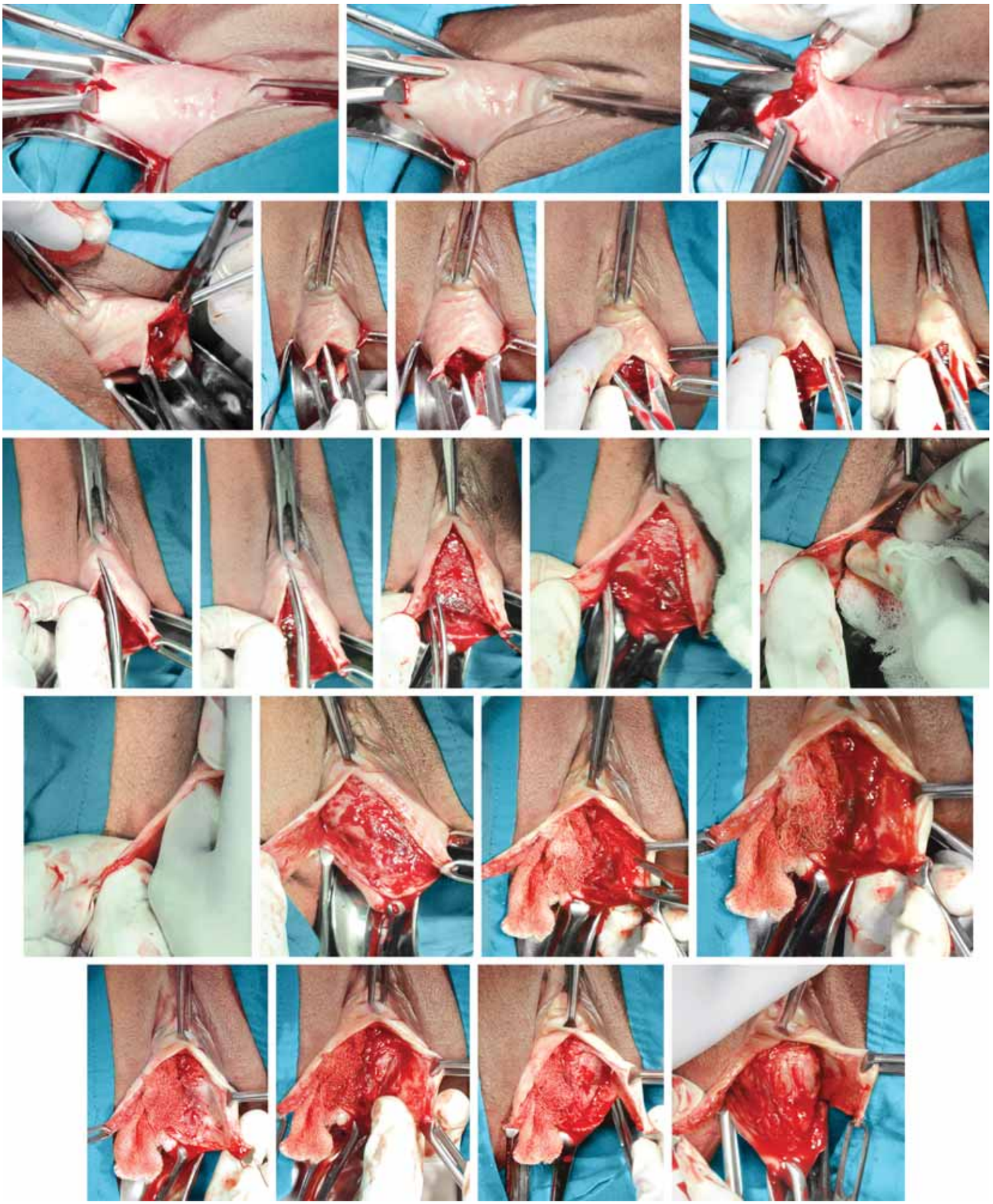
Resuscitative measures should be undertaken. Haematocrit in the immediate postoperative period will give an idea of amount of blood loss. Ultrasound may sometimes be helpful if retroperitoneal/intraabdominal bleed is suspected. Blood transfusion is arranged. Patient is shifted to the theatre. Under anaesthesia vagina is inspected with proper light. If it seems to come from the cuff margins one or two re-enforcing stitches will stop the bleeding. If it appears to come from above, the vault stitches are opened and the bleeding pedicle is identified and ligated. Sometimes the bleeding vessel may get retracted and cannot be controlled from below. In that cases laparotomy is done, bleeding vessel is identified if possible. If not then uni/bilateral anterior division of interneal iliac artery ligation is done. Many retroperitoneal bleed stops on its own by tamponade effect forming a haematoma which eventually gets absorbed. Higher cover of antibiotics is put to prevent the infection of this haematoma.

b. *Sepsis*—

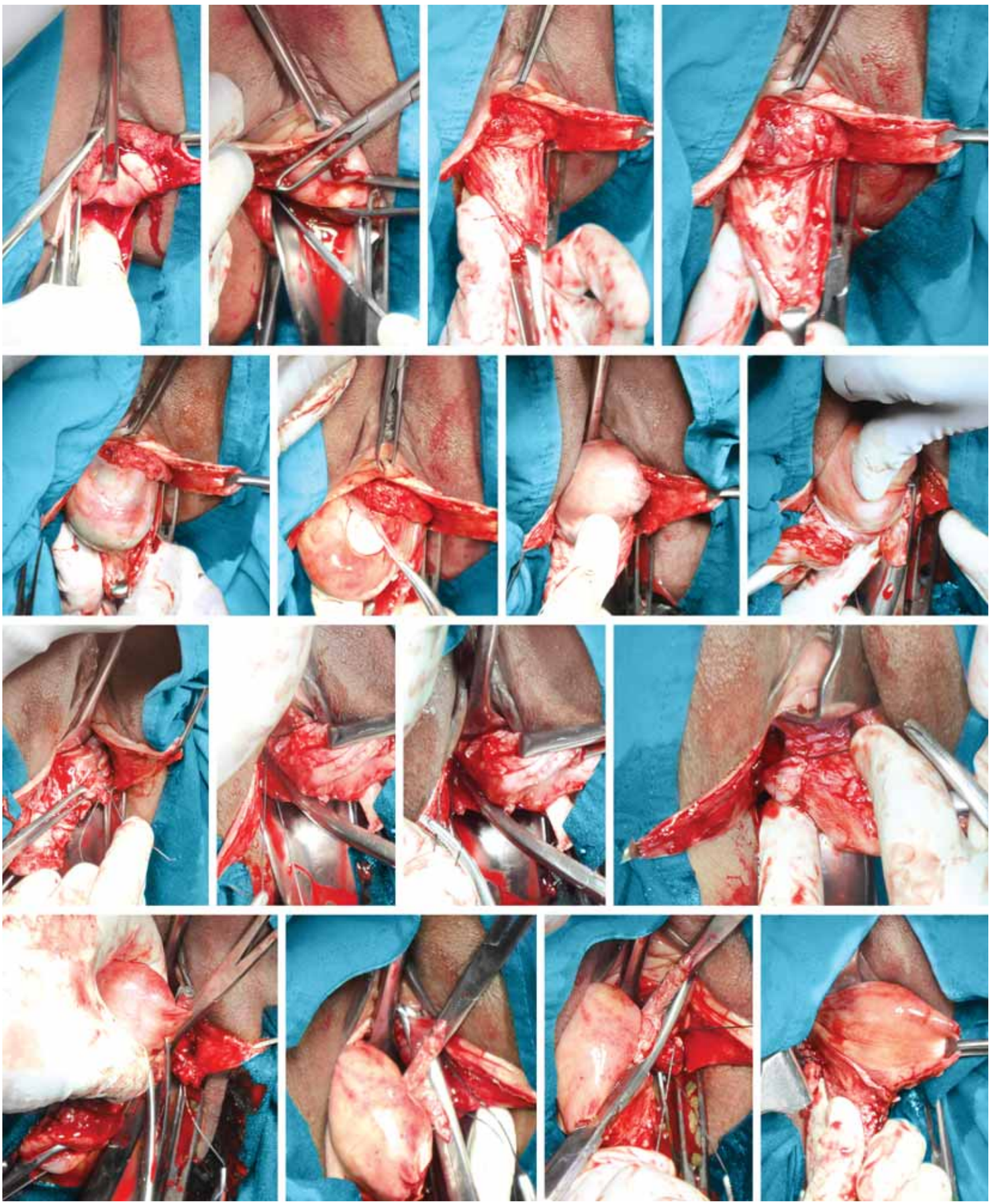
In the form of pelvic infection is known to occur quite commonly after vaginal hysterectomy. Patient presents with fever, pain in lower abdomen and pelvis, tenderness in the vaginal cuff. Infection ranging from vaginal cuff cellulitis, pelvic cellulitis, pelvic abscess, infected pelvic haematoma, and adnexal abscess is known to occur. Usually pelvic cellulitis or vaginal cuff cellulitis gets controlled with combination of parenteral higher antibiotics. Pelvic abscess should be suspected when in spite of higher antibiotics the fever fails to come under control. Ultrasound helps in diagnosis. Vaginal cuff may need to be opened with an artery forceps and drain out the purulent material. Infected haematoma if present is drained. Once this is drained usually the sepsis gets controlled. Parenteral antibiotics are continued for another 24-48 hours after the temperature has come to normal **(Figs 32-23 and 32-24)**.



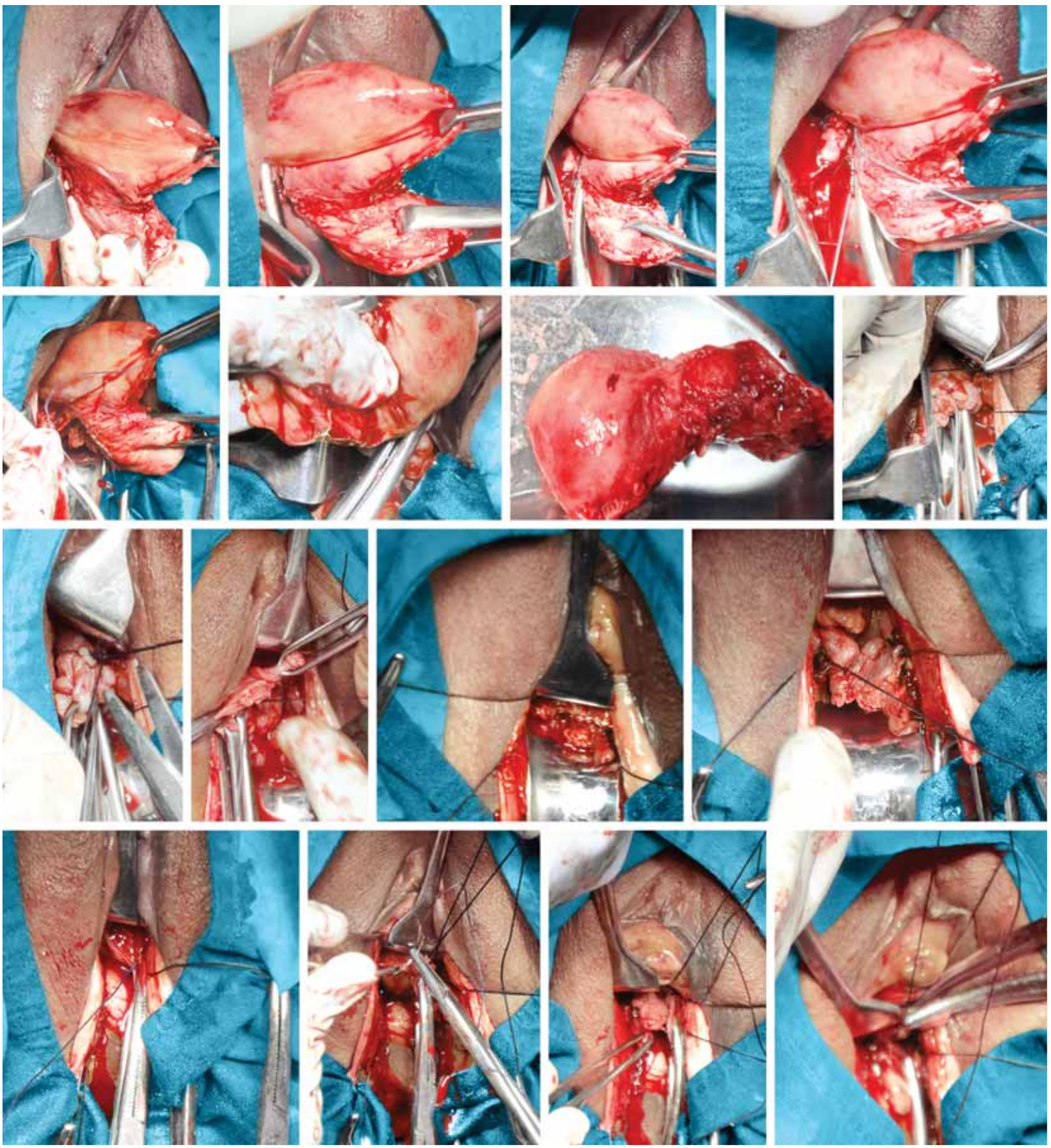
Figs 32-23(1)



Figs 32-23(2)

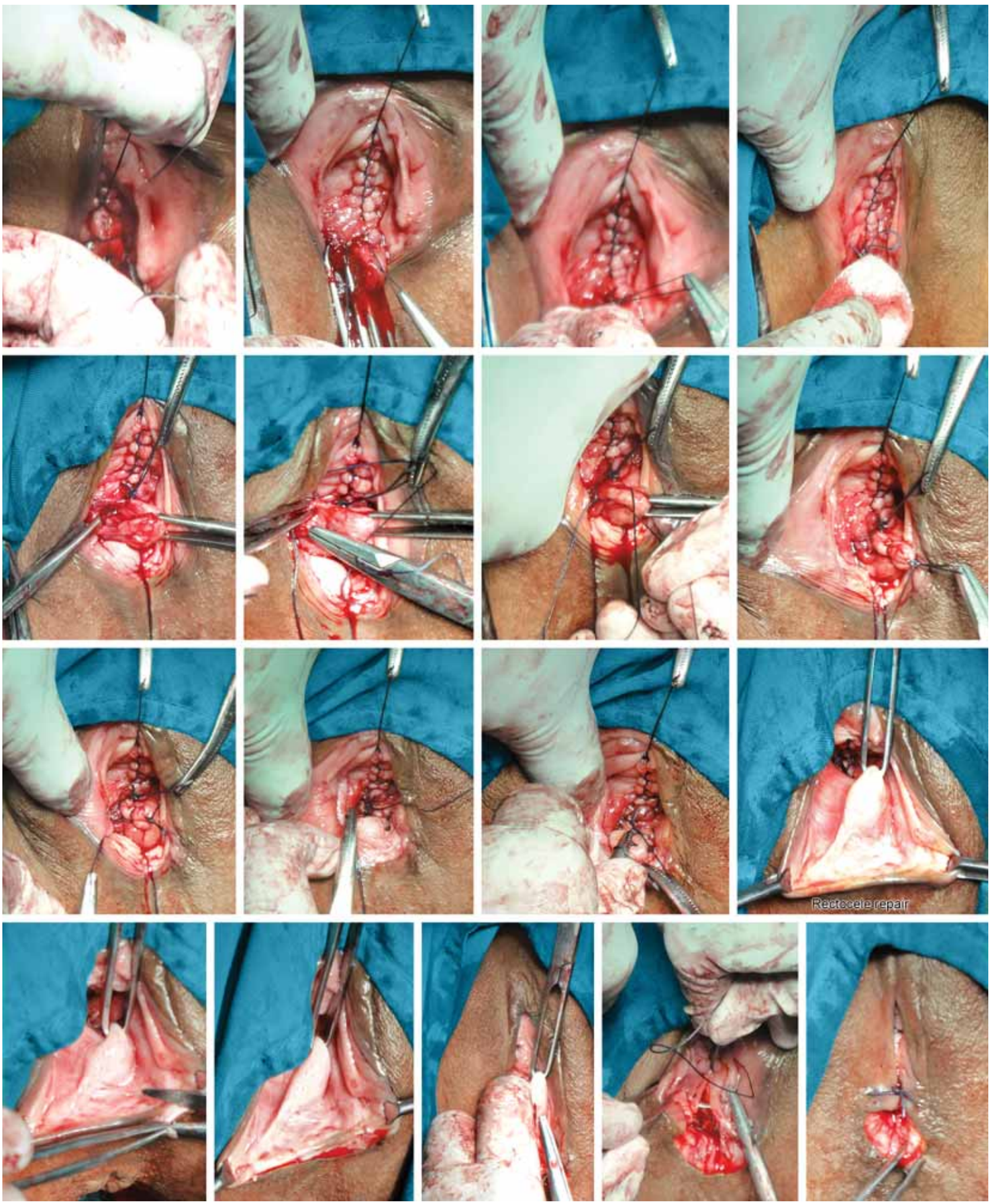


Figs 32-23(3)

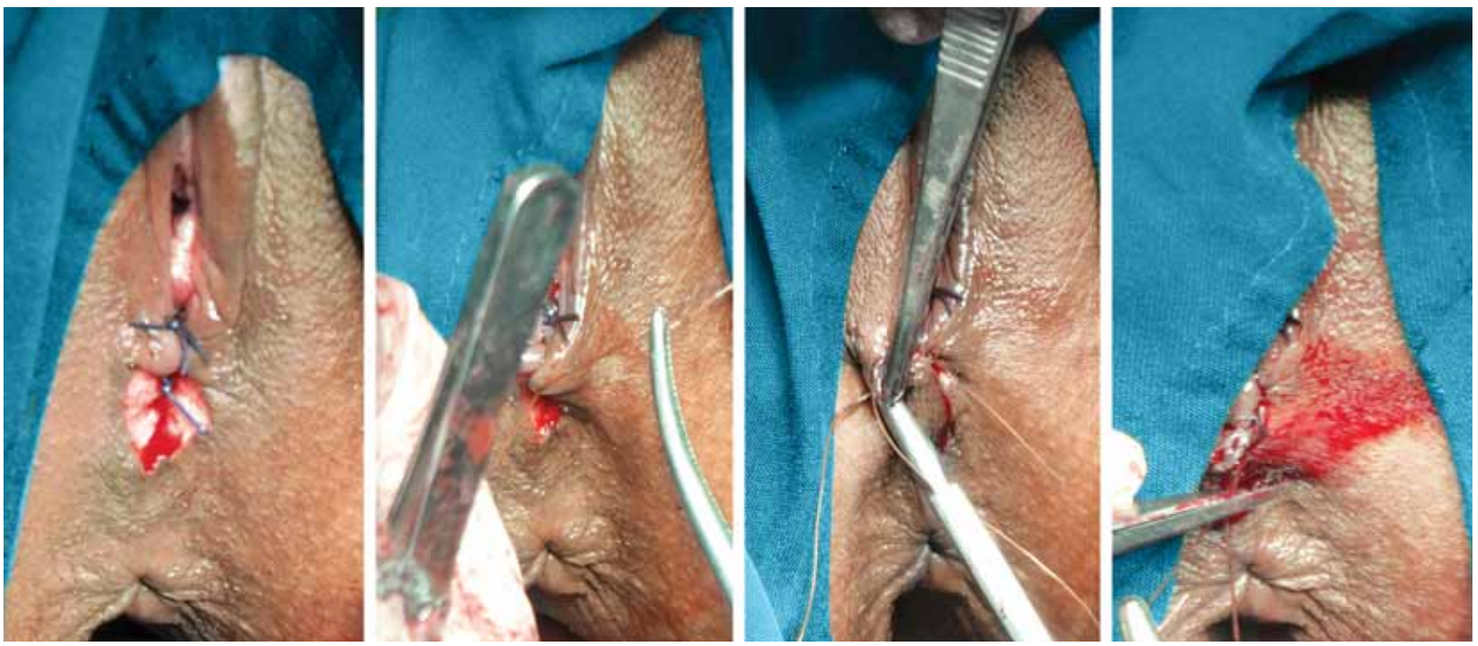


Figs 32-23(4)

Figs 32-23(5)



Figs 32-23(6)



Figs 32-23(7)

Figs 32-23(1 to 7): Vaginal hysterectomy for uterine prolapse is technically demanding, skilled time consuming procedure. It is done under spinal anaesthesia in lithotomy position. After cleaning and draping, bladder is emptied using metal catheter. Cervix is held with vulsellum forceps. Anterior vaginal wall is incised like inverting 'T'. Anterior vaginal wall is separated carefully by blunt gauze and sharp scissor dissection to push the adherent bladder underneath upwards up to the urethral opening. Laterally is dissected adequately so as to make feasible to place Kocher's clamp. Peritoneum is opened both at uterovesical fold in front and uterovaginal fold behind. Fundus of the uterus is delivered out. Mackenrodt ligament, uterine pedicle and ovarian ligaments are serially ligated with transfixation carefully after applying Kocher's clamp and divided these structures. Usually 1 or 2 zero vicryl is used for transfixation ligatures. Uterus is removed. Peritoneum is closed with vicryl purse string sutures. Bladder is invaginated using purse string 2 zero vicryl sutures. Often polypropylene mesh may be placed to prevent recurrence of cystocele. Tied sutures of both Mackenrodt ligaments on both sides which were already kept long are passed through a needle and passed across the vaginal wall to continue with perineorrhaphy. Extra vault is carefully excised vertically. Vault (anterior vaginal wall) is sutured with 1 zero vicryl from above downwards as continuous locking sutures till the lower end. Suture passed across from the both side Mackenrodt ligaments are tied firmly on the vaginal wall. If rectocele is present, it is repaired. Horizontal incision is made on the posterior vaginal wall just above the skin margin; posterior vaginal wall is raised off the anterior rectal wall; care should be taken not to injure rectum; once this flap is elevated. Rectocele is repaired by placing interrupted sutures over pararectal tissues. 2/3 interrupted sutures are placed over the levator ani and tissues of perineal body; Rectum is pushed backwards when sutures are applied; posterior vaginal wall is excised adequately; remaining cut margin is resutured vertically using continuous vicryl suture to complete the rectocele repair. Foley's catheter is passed and kept in place for 5 days. Vagina is packed with betadine soaked pack which is removed within 24 hours.

Laparoscopic Hysterectomy

Laparoscopic hysterectomy is not an alternative to vaginal hysterectomy but for abdominal. Its main aim is to reduce the abdominal procedure which has higher morbidity in terms of intestinal adhesions, infection, blood loss, hospital stay, and postoperative pain.

Drawbacks

- Need of trained surgeons, and hospital staff.
- Equipments which are costly and difficult to maintain.
- Cost factor—not all patients can afford the procedure.

Types of Laparoscopic Surgery

- Laparoscopic assisted vaginal hysterectomy (LAVH)
- Laparoscopic subtotal hysterectomy (LSH)
- Total laparoscopic hysterectomy (TLH)

Though laparoscopic supracervical hysterectomy (LSH) has been associated with a shorter operating time, decreased chances of visceral trauma, and less technical difficulty, however, some patients continue to have cyclical bleeding until menopause, and there is a small risk of developing cervical cancer in the retained cervix.

Preoperative Preparation

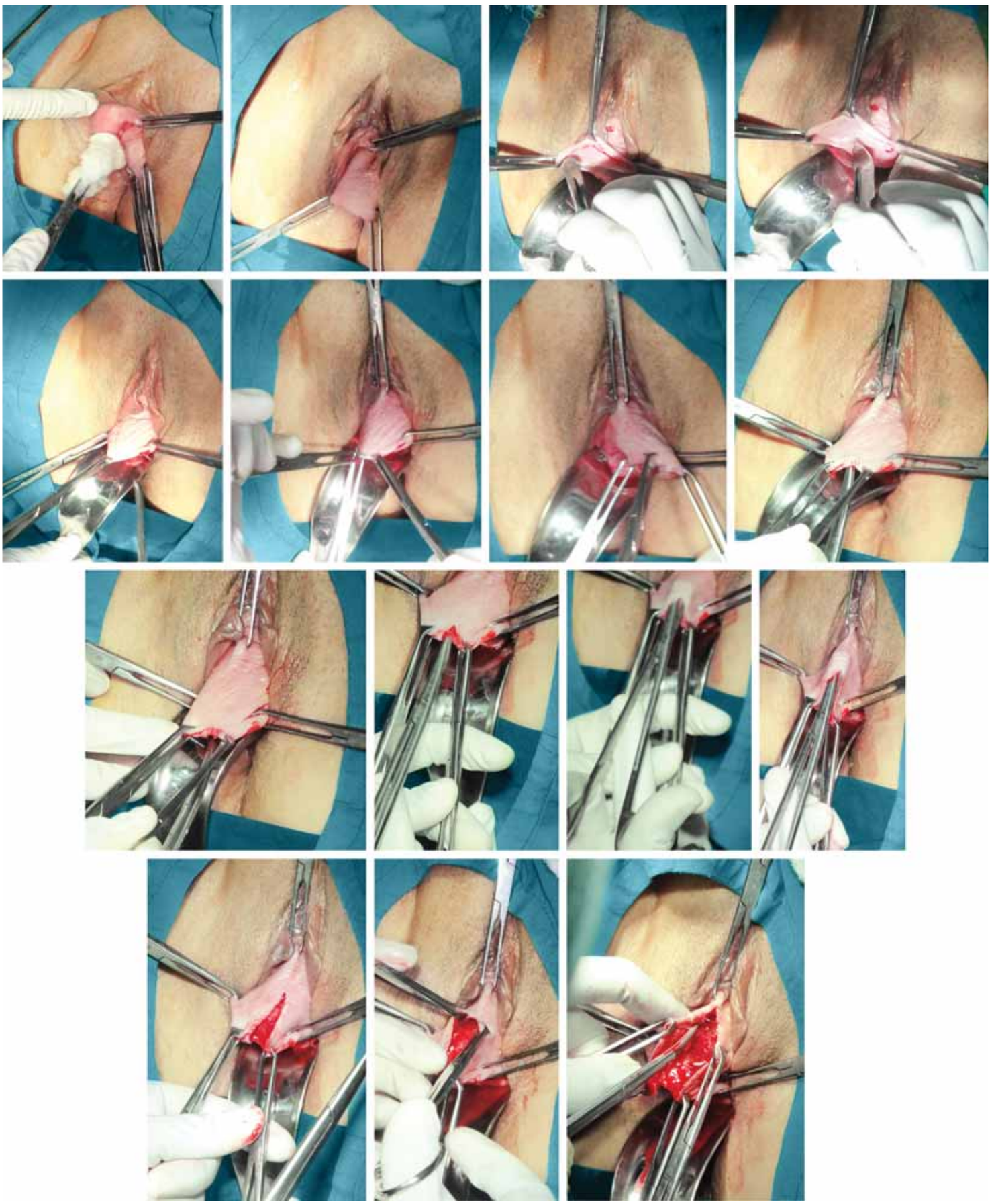
Routine tests including chest X-ray, ECG, ECHO is done. Patient kept fasting for 6-8 hours. Bowel is evacuated on the previous evening by enema. Prophylactic antibiotics are given. Informed consent taken. The chances of conversion to laparotomy is explained.

Preparation and Positioning

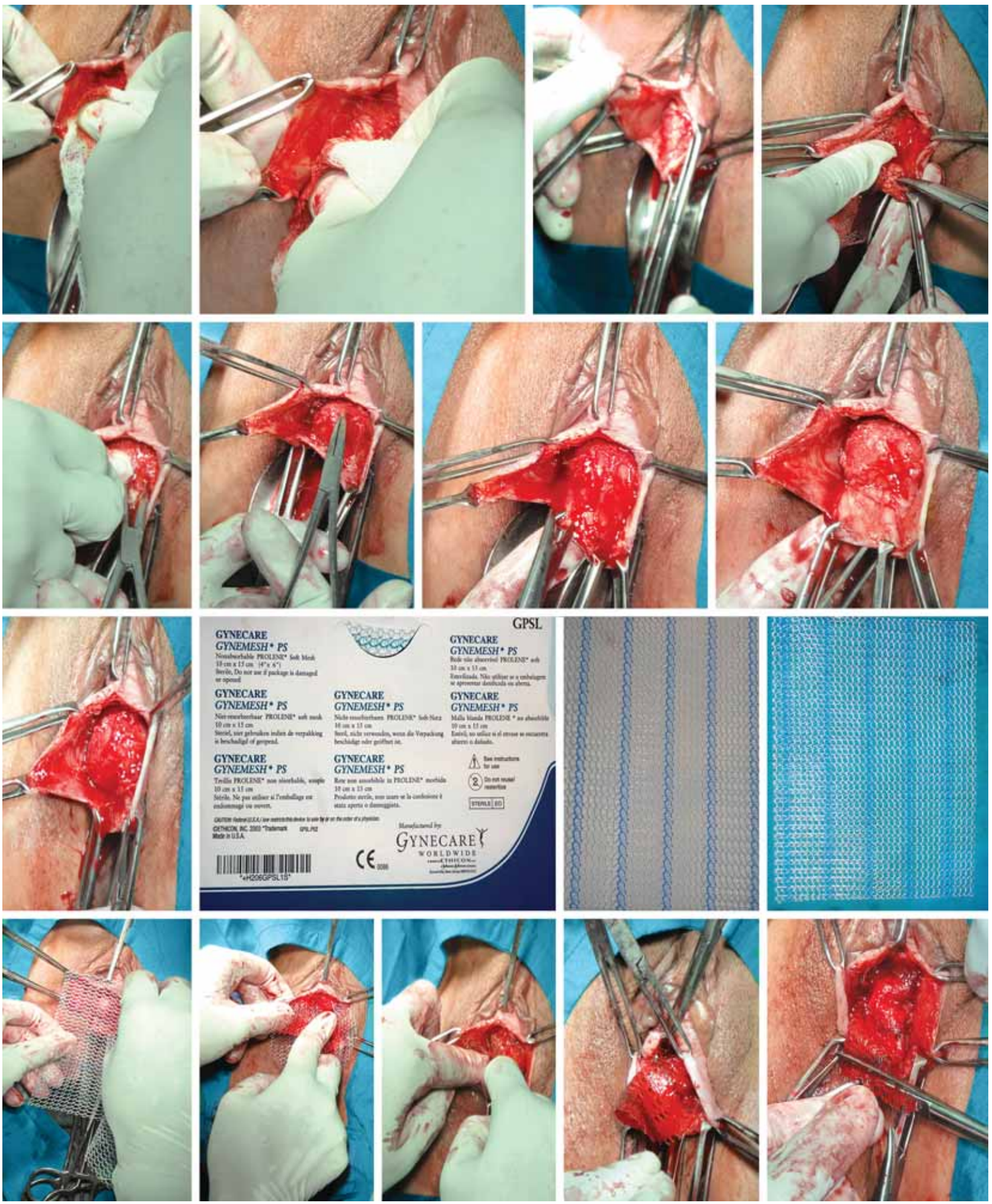
Patient is placed in a dorsal lithotomy position with pneumoboots. The arms are tucked by the sides and a foam mattress under the patient prevents the sliding during steep Trendelenburg position. Or the patient needs to be tied to the table to prevent from sliding. The table is kept in a lowest position. Monitor is placed directly facing the surgeon. Bladder is catheterised. Uterine manipulator is inserted after cleaning the perineum and vagina.

Instruments

- 10 mm telescope 0°/30°
- Video camera
- Light source—xenon source best



Figs 32-24(1)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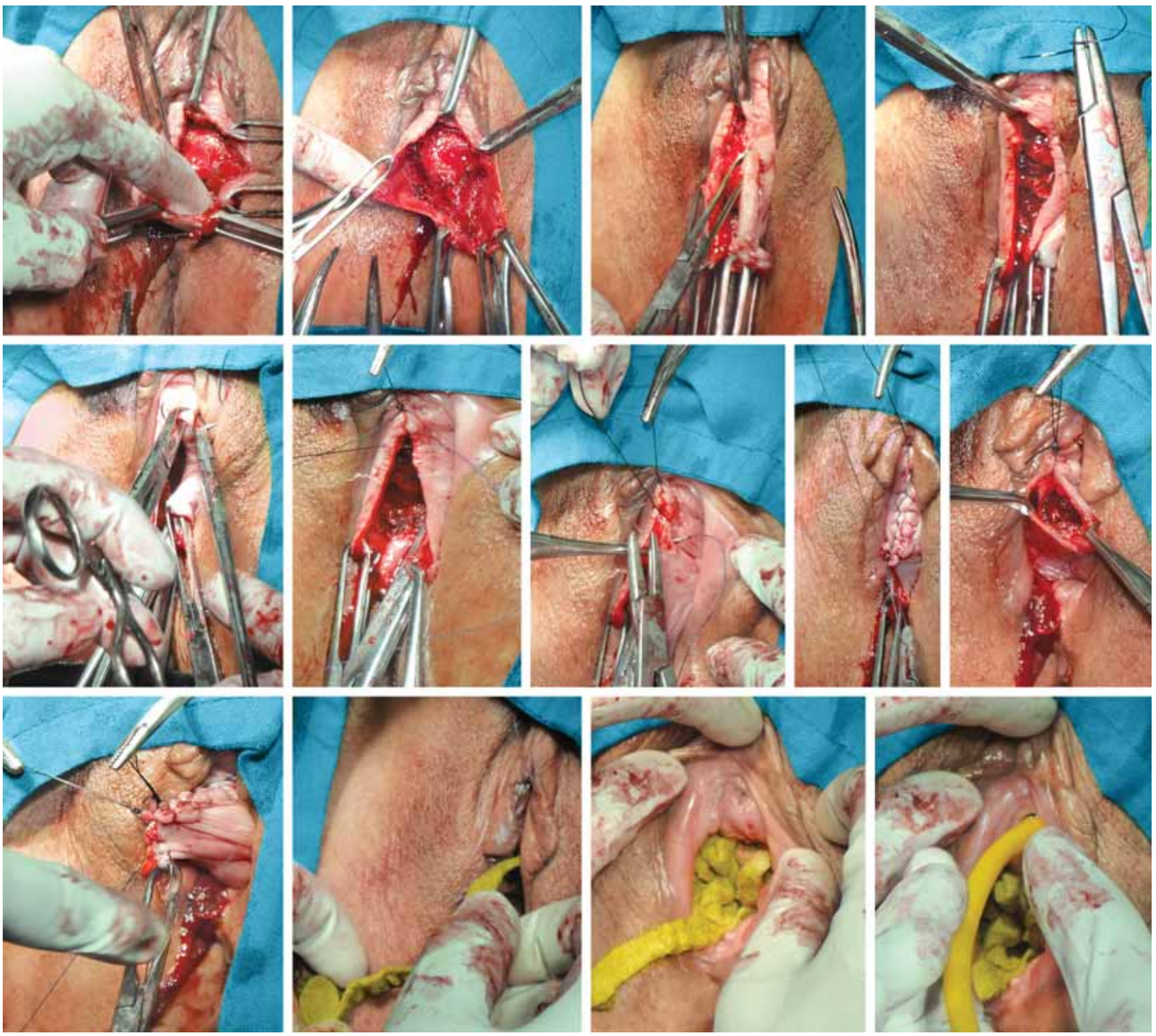
Figs 32-24(2)



Figs 32-24(3)

Figs 32-24(1 to 3): Cystocele repair done by placing specialised polypropylene mesh under the anterior vaginal wall. After opening the anterior vaginal wall, urinary bladder is separated from the anterior vaginal wall laterally upto the pubic ramus. Mesh is placed snuggly over the bladder, the sides of which is anchored to the vaginal flaps near the pubic ramus. Vaginal flaps are trimmed. Excess trimming is avoided. Anterior vaginal flaps is closed with continuous locking sutures using n0.1 chromic catgut.

- Trocar—two 5 mm , three 10 mm
- 5 mm grasping forceps—toothed/plain
- Scissors
- Unipolar electrode
- Bipolar forceps and the electrical cable
- Suturing forceps
- Suction and irrigation system
- Optional—harmonic scalpel, ligasure, morcellator.

Technique

Primary trocar is inserted just below the umbilicus or above if the uterine size is big. It is inserted either by closed method with help of verres needle or by open method by making a small incision near the umbilical margin and opening the peritoneum under vision. CO_2 gas is insufflated into the peritoneal cavity. 0° telescope is inserted through this trocar. Whole of the abdomen and pelvic anatomy is visualised. Any visceral injury during trocar insertion is looked for. Liver, under surface of the diaphragm, paracolic gutters, appendix are visualised for any additional pathology. Now the number of working ports and their site is decided by the individual surgeon and the pelvic pathology. Two lateral ports for 5 mm trocar are inserted under vision 2 cm above and medial to anterior superior iliac spine. Care is taken to avoid injury to inferior epigastric vessel. One 10 mm port lateral to the rectus at the level of umbilicus is put on left side (surgeon

side). Additional ports may be put depending on requirement of the surgeon.

Round ligament on both sides is coagulated first with bipolar forceps and cut with scissors, 3 cm from the uterus. This can also be done with ligasure/harmonic scalpel. Elevation and traction to the opposite side with uterine manipulator will give proper exposure of the pedicles to be coagulated. If the ovary is to be removed, ureter is identified at the pelvic brim which is usually easy on the right side, but may be more difficult on the left due to sigmoid colon. The ovary or fallopian tube is grasped from the contralateral side for proper exposure of the infundibulopelvic ligament. Infundibulopelvic ligament is coagulated with bipolar forceps/ligasure under vision and sectioned. It is better to coagulate the pedicle with bipolar before using harmonic scalpel. While coagulating care is taken to see that ureter and iliac vessels are far away from the coagulating instrument. The coagulation and ligation is then proceeded anteriorly to join the previously sectioned area of the round ligament. The procedure is repeated on the opposite side.If the ovaries are to be preserved then the utero-ovarian ligaments are coagulated close to the ovaries and sectioned. Special care is taken to desiccate the parametrial veins that run between the ovary and the round ligament as these can be quite tortuous and tend to bleed if left unattended.

The procedure can now be carried from vaginal route (LAVH). Vaginal route can also be proceeded after opening the uterovaginal pouch and pushing the bladder down.

At the junction where round ligament is sectioned, the leaves of the broad ligament is sparated with a Maryland grasper. The anterior leaf of broad ligament is opened downwards and forwards towards the bladder on either side with monopolar hook. Utero-vesical junction is identified, grasped and elevated with forceps, cut with scissors or monopolar hook. The blader pillars are identified, cut with scissors thereby freeing and pushing the bladder off the lower uterine segment and cervix with a blunt suction probe. In patients with history of prior cesarean delivery, this area may be scarred and is important to stay relatively high on the uterus during the dissection. A re-evaluation of the route of dissection is advised if fat is encountered because the fat belongs to the bladder indicating that the dissection is moving too close to the bladder.

Due to variation in anatomy and the course of the uterine vessels it is initially helpful to skeletonise them. With the uterine manipulator uterus is pushed cephalad and to opposite side which helps to move the uterine vessels away from the ureter. The ascending uterine vessels are coagulated with the bipolar forceps at the level of internal cervical os, staying above the rim of the cervical cup. When the bubbles stop coming from the vessel it means that the vessel is desiccated completely and is safe to transect with the scissors or harmonic scalpel. Uterine artery can also be coagulatd and cut with ligasure. Uterosacral ligaments are desiccated and cut.

Disposable silicone tube of diameter of 45 mm or 35 mm is inserted into the vagina and is pushed upwards and forwards. This tube helps to stretch the cervicovaginal junction and helps in identifying the vaginal fornices. The outer end of the tube is covered with a cap thus helping to maintain the pneumoperitoneum. The uterine movements can be controlled with help of myoma screw inserted through 5 mm trocar. Colpotomy is done along the indentation of the vaginal tube, first anteriorly with monopolar hook or harmonic scalpel and extended laterally. The lateral angle of the vault may need to be coagulated with bipolar or ligasure as vaginal branches of uterine arteries are frequently encountered. Colpotomy is continued on posterior aspect. Thus uterus with cervix is separated. It can be drawn out through the vagina. If uterus is large it can be broken down with morcellator. Vaginal vault can be sutured laparoscopically or from the vagina. If vault suturing is done laparoscopically then pneumoperitoneum has to be maintained either by a wet mop placed in the vagina or placing the uterus drawn from the pelvis in the vagina. Vault is closed laparoscopically by 1/0 vicryl continuous sutures using needle holder forceps. With training and practice suturing by laparoscope would not be a difficult job **(Fig. 32-25)**.

Once the suturing is done mop from the vagina is removed. Pelvis is irrigated with saline. All pedicles are seen for any sign of bleeding. Once haemostasis is confirmed CO_2 gas insufflation is stopped. Trocars are removed under vision. Telescope is removed. Trocar site is closed with 2/o vicryl sutures/Dermabond.

Patient is kept nil oral for 24 hours. Catheter can be removed in 24 hours. Antibiotics are continued for 5 days. Patient can be discharged from the hospital in 3-4 days.

Complications

a. *Injury to bladder*—Endometriosis, previous surgery, inexperience of surgeon, over distended bladder, and pelvic adhesions are proposed risk factors for bladder injury. Bladder injury can occur during insertion of trocar, especially in the suprapubic site piercing dome of the bladder; in base while separating the bladder off the cervix especially in patient who had previous caesarean section where adhesion are present between the bladder wall and cervix; or as the result of thermal energy. Fistula may result due to thermal injury. In suspected cases, the bladder is filled with methylene blue dye and observed for leakage of dye. Unrecognised cases present with abdominal discomfort and oliguria as cardinal sign. According to type, size, and localisation of injury, surgical management is planned via laparoscopy, laparotomy, or vaginal approach. Bladder can be repaired successfully by laparoscope or by laparotomy with 2 layer of 2/0 vicryl sutures.

b. *Ureteral injury*—Electrocautery (unipolar or bipolar) is the leading cause of laparoscopic iatrogenic ureteral injury. Injuries with loop suturing, trocars, laser devices, staples, and sharp dissection are also known. The 3 following locations carry the risk for ureteral injury during laparoscopic surgeries: at the pelvic brim, where the ureters lie beneath the insertions of the infundibulopelvic ligaments; deep ovarian fossa where the ureter passes; and the ureteral canal. Ureters are often injured while coagulating the uterine arteries, 4-5 cm above the uterovesical junction. Lack of precise recognition of the cervicovaginal margin and dissection too far down the vagina can injure the ureter 2 cm to 3 cm from the ureterovesical junction. Injuries may include transection, ligation, avulsion, crush injury, devascularisation, resection, fulguration, and perforation.

Intraoperative methods for identifying ureteral injury—

- 5 mL to 10 mL intravenous indigo carmine injection
- Intraoperative ureteral catheterisation
- Intravenous excretory urography
- Dissection of the ureter.

Intraperitoneal urine leak cannot be demonstrated in a coagulated or ligated ureter when tested intraoperatively. Absence of ureteral jet on cystoscopic examination reveals the problem clearly in such a case.

Depending on the type of injury, patients may present in the early postoperative period or the presentation of thermal or laceration injuries may be delayed by several days or weeks. Postoperative presentation is variable and nonspecific, such as acute pelvic pain,

Uterine manipulator is used per vaginally
Lithotomy, head down position. Uterine manipulator from below
Ligaseal/Ligasure is used
Monitor
Perineal part draping
Vaginal tube is used during bladder separation
Perineal part vaginal tube

Figs 32-25:(1)

Extraction of the uterus
Suturing of the vault can be done from above or below like shown here
Vault closed using 2 zero vicryl
Skin apposition using glue
STERILE UNI PACK
Marvilyte

Figs 32-25:(2)

Figs 32-25(1 and 2): External part of the laparoscopic hysterectomy—position, ports, vaginal tube and uterine manipulator.

nausea, vomiting, malaise, and leakage of fluid though the trocar sites, abdominal distension, costovertebral angle tenderness, ileus, fever, peritonitis. X-ray of the abdomen may reveal a ground-glass appearance indicating fluid collection; CT scan reveals the presence of urine in the peritoneal cavity after intravenous injection of contrast medium.

Repair by laparoscope can be done if recognised intraoperatively. If recognised in the early postoperative period passing double J-shaped stent allows spontaneous healing of focal ureteral injuries. But delayed recognition, and extensive damage may require laparotomy to perform an end-to-end anastomosis or ureteral re-implantation.

c. *Intestinal injury*—Nearly half of bowel injuries occur during trocar insertion and the rest occur during the operation. Entry-related bowel injuries are mostly lacerations common in patients with previous laparotomies. Most of the intraoperative bowel injuries are thermal and is not diagnosed during surgery leading to delayed intervention which may be life-threatening. If intraoperatively unrecognised, patients present with nonspecific complaints not exactly pointing to peritonitis, such as mild abdominal pain, fever, diarrhoea, and abdominal distension, further delaying the diagnosis. Late consequences may be generalised peritonitis, abscess formation, and septic shock. Intestinal obstruction though rare can occur when obstructive small-bowel adhesions develop to the vaginal apex.

d. *Haemorrhage*—Present as vaginal haemorrhage, retroperitoneal haemorrhage, and intraabdominal haemorrhage. Intraabdominal haemorrhage can be due to inadequate coagulation or excessive coagulation leading to charring and break off of the adjacent vessel wall. Bleeding can also occur due to trauma to abdominal wall vessels while trocar insertion. Injury to inferior epigastric vessel and less commonly muscular arteries are known to occur. They may present as continuous dripping of blood from the port during surgery or massive intraperitoneal bleed in postoperative period or abdominal wall haematoma which may get infected. Bleeding is controlled by tamponade or suturing. Sometimes may require exploration of the portal site to visualise the bleeding vessel and ligate it under vision. It is good practice to inspect all the trocar sites for any active bleeding before the laparoscope is finally withdrawn. Retroperitoneal major vascular injuries are related to the Veress needle, trocar, or energy source. It is trauma to aorta, vena cava, or, more commonly, the common iliac vessel. Major vascular injuries rarely remain unrecognised intraoperatively. Immediate laparotomy is done by midline incision and the vessel repair is done.

e. *Sepsis*—May present with wound infection especially of umbilical site, vault granuloma, pelvic cellulitis.

f. *Hernia*—It can occur at the trocar site. It is common in the extraumbilical port of ≥10 mm size not adequately repaired. Bowel, omentum may get sucked into the portal site leading to intestinal obstruction. Laparotomy is needed for this. To minimise the risk of herniation, secondary trocars should be removed under supervision before the primary one, valves should be kept closed to prevent a sucking effect, 5 mm trocars should be preferred as much as possible and the trocar site should be correctly closed.

g. *Others problems related to pneumoperitoneum*—Subcutaneous emphysema, pneumomediastinum, and pneumothorax, gas embolism. All discussed in detail in the previous chapters.

Radical Hysterectomy

Indications: Radical hysterectomy is performed as a primary therapy for—

- Stage IB or IIA cancer of the cervix.
- Selected patients with stage IIb adenocarcinoma of endometrium (with gross cervical invasion)
- Upper vaginal carcinoma, uterine or cervical sarcomas, and other rare malignancies confined to the area of the cervix, uterus, and/or upper vagina.
- As a potential salvage therapy for women with cervical cancer who have been treated with irradiation and subsequently develop a small central pelvic recurrence or have a small central area of persistent disease.

Types of radical hysterectomy:

- *Type 1 hysterectomy is extrafascial, or simple hysterectomy* which involves removal of the cervix along with the uterine corpus, but does not require ureteral mobilisation or removal of a significant amount of the parametria. It is used as primary treatment for stage IA1 disease and after concurrent chemotherapy and radiation therapy for stage IB2 and bulky stage IIA cervical carcinoma
- *Type 2 (modified) radical hysterectomy, or Wertheim operation*, involves more extensive dissection than the extrafascial hysterectomy where the central portion of the parametrial tissues is removed while minimising disruption of the ureteral and vesical vasculature. It involves removal of medial half of the uterosacral ligaments and the cardinal ligaments, ligation of the uterine artery just medial to the point where it crosses the ureter, removal of a 1–2 cm portion of the upper vagina along with pelvic and para-aortic lymphadenectomy. Here it does not involve dissection of the ureter from the vesicouterine ligament. It is done in stage IA2 cervical carcinoma.
- *Type 3 radical hysterectomy*, originally described by *Meigs*, aims at removal of parametrial tissue as much as possible. It involves transaction of the uterosacral ligaments near their origin from the sacrum, excision of the cardinal ligaments as widely as possible after the uterine artery is ligated at its origin where it branches off from the hypogastric artery, removal of a 2-3 cm portion of the upper vagina along with pelvic and para-aortic lymphadenectomy. Care is taken to preserve the superior vesical artery.
- *Type 4 hysterectomy* is seldom done, represents an extended radical hysterectomy. It involves complete dissection of the ureter from the vesicouterine ligament along with sacrifice of the superior vesical artery. 3/4th of the vagina along with the uterus and parametria are removed along with complete lymphadenectomy.
- *Type 5 hysterectomy* also has limited application. This procedure involves resection of involved portions of the bladder, distal ureter, rectum along with the uterus, parametria, adnexa, and pelvic lymph nodes. Subsequent ureteral reimplantation is done.

Preoperative preparations:

- Abdominal and pelvic CT scan/MRI helps to evaluate the pelvic disease, ureter and lymph nodes.
- Along with routine blood investigations patients should have a thorough evaluation to insure that there are no other major medical contraindications to surgery. ECG, ECHO, chest X-ray are done to rule out cardiac complications.
- As there is potential for blood loss in these patients, central venous access should be done by an anaesthetist and required amount of properly typed and cross-matched blood should be kept ready. Anaemic patients should receive preoperative blood transfusion.
- Prophylactic antibiotic, usually a first generation cephalosporin is started.
- Patients are asked to start liquid diet 24 hours before surgery. Bowel preparation is done with Peglec/exelyte.
- For thromboembolic prophylaxis subcutaneous injection of low molecular weight heparin is started prior to surgery and continued in the postoperative period.
- Sequential compression devices (SCDs) are placed on both lower limb immediately prior to surgery, and are left in place until the patient becomes ambulant.

Technique

The patient is placed in the modified dorsal supine lithotomy position (15° Trendelenburg). The urethral orifice, vaginal introitus,

and anal orifice are all available for instrumentation in this position and a second assistant can stand at the foot of the table between the patient's legs. The thighs are elevated 15 to 20° relative to the abdomen as there will be less strain on the patient's lumbosacral spine in this position. Care is taken to avoid pressure on the peroneal nerves in the legs by giving cushions. The abdomen from the rib margin to the midthigh, perineum, and vagina are surgically prepared. The bladder is emptied with a Foley catheter. A thorough bimanual examination is always performed. This can be followed by cystoscopy or proctosigmoidoscopy.

An abdominal incision is made in the midline, extending around and 2-3 cm above the umbilicus and inferiorly up to the pubic symphysis. Self-retaining retractors are used to retract the muscle. Moist pack is placed beneath each arm of the self-retaining retractor to avoid excessive compression of the epigastric vessels that course beneath the rectus muscles and it is advisable to release the mechanical retractors at periodic intervals to improve circulation through the abdominal musculature.

Before starting the dissection in the pelvis, the entire abdominal cavity is carefully evaluated for evidence of metastatic disease. This includes superior and inferior surfaces of the liver and under surface of diaphragm, the celiac plexus, omentum, serosal surface of small and large bowel as well as the mesentery. The kidneys and the retroperitoneal space along the aorta and vena cava is palpated because these are the major sites of extrapelvic spread of cervical cancer. Pelvic and para-aortic/para-caval lymph nodes are palpated, and any enlarged or suspicious nodes are removed and sent for histopathology. If there is histopathologic evidence of unsuspected, metastatic tumor in a para-aortic lymph node, radical hysterectomy operation is abandoned. These patients are treated with concurrent chemotherapy and extended-field radiation therapy.

Intestines are packed in upper abdomen with moist packs. Uterus is held by Kelly Clamps applied at its corneal ends. The round ligament is clamped, cut, and ligated near the lateral pelvic wall. The anterior leaf of the broad ligament is incised inferiorly along the lateral pelvic wall for a distance of approximately 3 cm. The posterior leaf of the broad ligament is incised superiorly along the lateral pelvic wall to the level of the infundibulopelvic ligament. The infundibulopelvic ligament is clamped, cut, and doubly ligated at the lateral pelvic wall. Next the utero-ovarian ligament is clamped, cut, and ligated, and the tube and ovary are removed. The procedure is repeated on the other side.

The retroperitoneal space is approached along the lateral pelvic wall. The common iliac, external iliac, and internal iliac arteries and associated lymph nodal tissue are exposed. The ureter is identified. By placing two silk sutures in the adjacent medial peritoneum the ureter is pulled medially away from the iliac vessels. The base of the aorta is exposed. The lymph nodal tissue surrounding the common iliac, external iliac, and internal iliac arteries are all removed by sharp dissection from the bifurcation of the aorta to the inguinal ligament at the femoral canal. Care is taken to avoid bleeding from the middle sacral vessels as well as from the proximal part of the left external iliac vein, which courses through this retroperitoneal space. Only the loose areolar tissue and fascial sheath from the iliac vessels; should be removed avoiding trauma to the intima or wall of the vessels particularly the veins.The external iliac and common iliac arteries are retracted laterally, and lymph nodal tissue surrounding the common iliac, external iliac, and internal iliac veins are removed by sharp dissection. The genitofemoral nerve lying lateral to the external iliac vessels, should be preserved because damage to this nerve produces postoperative discomfort in the groin and medial aspect of the thigh. Lymph nodes from each of the major anatomic sites (i.e., common iliac, external iliac, internal iliac) is placed in separate containers, labeled accordingly and sent for histologic analysis. The external iliac artery and vein are retracted laterally by a vein retractor. All lymphatic tissues are removed from behind these vessels and from the obturator fossa by sharp dissection. Particular care is taken to avoid trauma to the obturator nerve and vessels. They are also labeled separately and sent for histology. The obturator nerve is identified and preserved. The uterine artery is identified as it comes off the anterior division of the internal iliac artery and is ligated and tied with 2-0 suture. All these procedure is repeated on the opposite side.

By blunt dissection the pararectal space and paravesical spaces are exposed on both sides with the intervening web, which is the lateral extent of the cardinal ligament.

The paravesical space composed of loose connective tissue and fat is bounded by—

- Medially by the bladder and the retropubic space
- Laterally by the pelvic sidewall and obturator internus muscle
- Posteriorly by the cardinal ligament
- Anteriorly by the pubic symphysis
- Floor by the levator muscle
- Roof by the anterior leaf of the broad ligament that blends with the bladder peritoneum medially and the parietal peritoneum laterally.

The pararectal space is bounded by—

- Medially by the rectum
- Laterally by the hypogastric artery (the internal iliac artery)
- Posteriorly by the sacrum
- Anteriorly by the cardinal ligament.

The lateral aspect of the cardinal ligament containing the vascular web is clamped, cut, and ligated on both sides with 2-0 silk ties.

The distal stump of the transected uterine artery is traced entering the tunnel and it is related to the ureter within the tunnel where it crosses the ureter from lateral to medial side. The ureter is seen as it enters the tunnel. Two horizontal curved clamps are inserted beneath the roof of the tunnel over the ureter. The tissue in the roof of the tunnel which also consist the uterine artery and vein, is clamped, cut, and ligated. This dissection is undertaken on both sides. The ureter on both sides are rolled laterally out of the tunnel and dissected free from surrounding tissue lysing the flimsy adhesions between it and floor of the tunnel until its entrance into the bladder.

The bladder is dissected from the anterior vagina by sharp dissection. The uterus is retracted upward.The cul-de-sac peritoneum between the uterus and the rectum is incised. Retracting the uterus upwards, finger is inserted between the uterosacral ligaments, and the posterior wall of the vagina is dissected off the anterior rectal wall. Keeping the uterus under upward traction the upper portion of the uterosacral ligaments is clamped, cut and ligated on both sides. The lower portion of the uterosacral ligaments, containing the parasympathetic nerves to the bladder, is retained.

The anterior, posterior, and lateral attachments of the uterus and parametria have now been ligated. The paravaginal tissue on either side is clamped with Haeney's clamp, cut, and ligated with 1/0 vicryl sutures. The vagina should be transected approximately 3 cm below the cervix and the isolated bleeding sites on the vaginal cuff are ligated using 2-0 vicryl sutures. The vagina is closed with continuous interlocking 1/0 vicryl suture.

Abdomen is closed in layers after placing a closed suction drains in both retroperitoneal spaces. These drains are brought out through the anterior abdominal wall in each lower quadrant and are sutured to the skin.

Postoperative Complications

a. *Infectious and febrile morbidity*—It is the most common postoperative complication. Prophylactic use of broad-spectrum antibiotics reduces the frequency of this complication.
b. *Postoperative bleeding*—Most often they are self-limited and can be treated conservatively with close observation for haemodynamic instability and blood transfusions but sometimes may require re-exploration.
c. *Bladder dysfunction*—Due to interruption in the autonomic nerve supply to the bladder resulting from bilateral stripping of sacral nerves, excision of large portion of paracervical and paravaginal webs of retroperitoneal tissue and bilateral pelvic node dissection will damage the sympathetic fibres of the bladder. This results in transient hypertonia, gradually being replaced by hypotonia. Most patients get back the ability to void within 2–3 weeks; however, it may persist in approximately 5% of patients. In addition, a substantial number of patients develop persistent urinary incontinence postoperatively.
d. *Lymphocyst formation*—Results from interruption of efferent pelvic lymphatics leading to lymphedema, pelvic discomfort, and infection and also increase the frequency of deep venous thrombosis and pulmonary embolism. Lymphedema develops insidiously over time, occurs more frequently when pelvic lymphadenectomy is followed by radiation or groin node dissection. Similarly, lymphocyst formation can occur as a result of extensive pelvic lymphadenectomy. Lymphocyst may cause ureteral obstruction or presents as a pelvic mass. Percutaneous drainage under ultrasound guidance or surgery with marsupialisation may be necessary.
e. *Sexual dysfunction and surgical menopause*—Reduces the quality of life, can impose psychological problems.
f. *Vesicovaginal and ureterovaginal fistula*—Most dreaded and troublesome complication, results from ligation of the superior vesical artery and disruption of blood supply to the distal ureter. The need for postoperative radiotherapy will worsen this problem. Patient presents with fever, continuous dribbling of urine per vagina, sometimes with enlarged pelvic mass. To determine whether it is a vesicovaginal or ureterovaginal fistula, intravesical instillation of methylene blue followed by intravenous injection of indigo carmine is done and colour change in the swab placed in the vagina at high, mid, and low level is noted (*three swab test)*. Alternatively, an intravenous pyelogram or computed tomography may help to locate the fistula. Most often uretero-vaginal fistula is located in the distal 1/3rd of ureter. Small vesicovaginal fistulas may heal spontaneously with prolonged bladder catheterisation; however, larger defects that fail to heal with conservative management needs surgical repair. Stenting is required for uretero-vaginal fistulas. If retrograde stent cannot be passed, then percutaneous nephrostomy with anterograde stenting is done. Repair of uretero-vaginal fistula is done after 3-6 months.
g. *Ureteric stricture*—can also occur after radical hysterectomy.

REPAIR OF GENITOURINARY FISTULAS

Types of Genital Fistulas

a. *Ureters*—ureterovaginal, ureterocervical, ureterouterine
b. *Bladder*—vesicovaginal (high, mid, low), vesicocervical, vesico-uterine
c. *Urethra*—urethro-vaginal

Investigation

Per speculum examination: Most fistula can be easily seen by perspeculum examination after instilling the bladder with dilute methylene blue especially VVF. Continuous trickling of urine from the vagina is seen. Vaginitis and vulvitis may be present due to constant dribbling of urine.

Fluid creatinine estimation and simultaneous comparison with serum creatinine is done. If the fluid creatinine is many times more than the serum creatinine, then the fluid is nothing else but urine because only the kidney has the capacity to concentrate creatinine to a high level.

Moir's three swab test—Three swabs are placed in the vagina at three levels. Bladder is filled with dilute methylene blue. Patient is made to walk for 10-15 minutes. If the lower most swabs get wet and stained blue it is incontinence per urethra. If the middle swab gets wet and stained blue it is due to VVF. If the uppermost swabs get wet but not stained blue it is uretero-vaginal fistula.

Cystoscopy—Helps to identify the level of fistula, its relation to the ureter, number of fistula. It is of limited use in large fistula as it is difficult to distend the bladder. In these cases the bladder can be distended with air/CO_2.

Intravenous urogram—helps to identify the level of fistula. If this fails then retrograde pyelography is done.

Spiral CT scan—reveals renal and ureteric anatomy, abscess, fluid collection.

Uretero-Vaginal Fistula

Invariably the distal 1/3rd ureter is involved.

Sites of ureteral injuries:

- At or just below the pelvic brim, dorsal to the infundibulopelvic ligament.
- Along the course of the ureter in lateral pelvic wall above the uterosacral ligament.
- At the base of the broad ligament where the uterine artery crosses the ureter from lateral to medial side.
- As the ureter passes in the tunnel in Mackenrodt's ligament
- In the intramural portion of the bladder.

Nature of injury:

- Trauma to the vascular sheath leading to ischaemia—damage to the adventitia should be avoided as much as possible during dissection of ureter.
- Ligature incorporation.
- Segmental resection.
- Thermal injury—though the mean distance of thermal damage with most of the instruments is approximately 2 mm, it may be as much as 5 mm.
- Injury by staplers in laparoscopic surgery.

Though abdominal hysterectomy for conditions like endometriosis, pelvic inflammatory disease, ovarian tumors is the commonest cause it is known to occur in radical hysterectomy, caesarian hysterectomy. The best way to prevent ureteric fistula is its identification in the retroperitoneal space and trace its course from pelvic brim to the bladder. Blind application of clamps over the bleeding uterine vessels should be avoided. Judicial usage of thermal current near the ureter will help to avoid thermal injury. As the pelvic part of ureter receives blood supply from lateral aspect, dissection and mobilisation is carried out from medial aspect so as to avoid devascularisation injury.

Repair

In the immediate postoperative period, repair is not attempted. Ureteric stenting with J stent is done. Indwelling catheter is placed. Only when there is infected urinoma or in generalised sepsis measures are taken to divert the urine from the kidney like percutaneous nephrostomy so to protect the kidney function. Small fistula often heals spontaneously. If fails to heal then after 3-6 months once the tissue oedema subsides ureteral resection and re-implantation is done. The ureter is transected above the healthy site and re-implanted in to the posterior aspect of the bladder. If the ureter cannot be reached to the bladder without tension then *psoas hitch* is done. The entire ventral surface of the bladder is freed from its areolar attachment in the retropubic space. On the anterior wall of the bladder a curved incision is put. This incision is put at 90° to the direction desired to elongate the bladder. Two fingers are inserted into the postero-superior portion of the bladder. A pliable bladder can be extended to reach the psoas tendon across the iliac vessels to reach the transected proximal end of ureter. The posterior surface of the bladder is anchored to the psoas tendon by interrupted absorbable sutures. These sutures are attached to the bladder wall without entering the bladder lumen. The transected ureter is implanted into the posterior aspect of the bladder dome, some distance from the trigone so as to minimise any potential stenosis or injury to the contralateral ureteral orifice. The ureter is stented, and the bladder is closed in two layers at right angles to the way it was opened. A drain is placed near the ureteroneocystostomy which is to removed in the 2 to 3 days once it is certain that there is no leak. The bladder is drained for 10 days and ureteral stent is removed after 6 weeks.

Vesicovaginal Fistula

Bladder trauma commonly occurs during hysterectomy and caesarian section while dissecting the bladder off the cervix and vagina. Failure to identify the bladder injury, thermal injury, suture placement through the bladder and vaginal wall while closing the vaginal cuff, ichaemic necrosis of the bladder wall due to prolonged pressure of the fetal head in 2nd stage of labour, forceps delivery of the baby are the common cause of vesicovaginal fistula.

Treatment

Once the fistula has occurred it is wise to wait for 3-6 months. Indwelling catheter antibiotics are put to subside the infection and edema. Small fistulas <3 mm may heal spontaneously during this waiting period. Meanwhile local condition is improved with vaginal estrogen cream; zinc oxide cream for ammoniacal dermatitis. Small fistulas can be tried to close with fibrin sealants.

a. *Vaginal repair*

Patient is placed in lithotomy position. Fistula is exposed properly. This may demand an extended episiotomy especially for high fistulas near the vault. Foleys is passed across the fistula. Bulb inflated and the fistula is given mild traction below.

- *Flap-splitting technique*—In this technique, the vaginal epithelium is incised circumferentially around the fistula and widely dissected from the underlying endopelvic fascia for a distance of about 2 cm. the tract is left unresected, the bladder is closed, tension-free, in 2 layers with 3 or 4/0 vicryl–first layer includes the full thickness of vaginal skin previously left intact at the fistula tract, along with the partial thickness of the bladder wall, and second layer involves closure in the muscularis placed perpendicular to the prior suture line. Martius bulbocavernosus flap can be advanced near the fistula for vasularisation.The surgery is completed with the vaginal closure over the bladder defect.
- *The Latzko procedure*—It is an excellent procedure for correcting small posthysterectomy fistulae at the vaginal apex with adequate vaginal length. A circumferential incision is made around the fistula. Vaginal epithelium is stripped from the anterior and posterior fascia at least 2.5 cm in all directions around the fistula tract. The fistula is not excised. The vesical edges of the fistula are not denuded. The pubovesical fascia is closed in two layers, and vaginal epithelium is closed using interrupted sutures. The walls have a natural tendency to fall together and are easily approximated without tension. The vaginal wall in contact with the bladder becomes the posterior vesical wall and which eventually gets re-epithelialised with transitional epithelium. Indwelling catheter is placed to prevent undue filling of bladder and tension over the stitches.

b. *O'conor's abdominal repair*

Indication for abdominal approach—

- The need for concomitant abdominal surgery, such as augmentation cystoplasty and ureteral reimplantation
- Adequate vaginal exposure of the fistula not possible
- VVF involving the ureters, bowel, or other intra-abdominal structures
- Involvement of the VVF with ureteric orifices.

By midline/Pfannenstiel incision laparotomy is done. After entering the peritoneal cavity the posterior wall of the bladder is dissected free as much as possible. Incision made on the posterior wall of the bladder is extended down to the level of the fistula. Stay sutures may be placed along the incision for every few centimeters to permit traction so as to aid in exposure and dissection. Location of fistula and its relation to the ureteric orifice is identified. If necessary ureteral catheters may be placed. The fistula tract, scarred and necrotic tissue are resected. The posterior wall of the bladder is dissected from the underlying endopelvic fascia and vagina. The bladder and vagina are closed separately. The bladder is closed in 2 layers of 3/0 vicryl suture in continuous fashion beginning from the apex. First layer includes the mucosa and full thickness bladder wall, second layer involves the seromuscular layer inverting the first. Bladder is drained by a suprapubic catheter removed after 2-3 weeks and transurethral catheter removed after 4-5 days.

c. *Bladder mucosal autologous grafts*

By laparotomy, cystotomy is done and bladder mucosa is denuded circumferentially near the fistula site for a distance of 1 cm. The fistula

tract and vaginal wall are left undisturbed. At the edge of the anterior cystotomy margin a free bladder mucosal graft is dissected sharply from underlying muscularis layer. This mucosal graft is then secured with interrupted 4-0 vicryl sutures over the fistulous tract. These sutures are placed into the superficial muscularis at a distance of 2-3 cm. The bladder is closed in 2 layers. A transurethral catheter is used for 4-5 days. A suprapubic Malecot catheter is placed for 2-3 weeks.

Rectovaginal Fistula Repair

It is the abnormal communication between rectum and anal canal. Though obstetric trauma is the commonest cause, carcinoma cervix invading the posterior vaginal wall tuberculosis, radiotherapy induced are other causes.

Foul smelling discharge or faeces though the vagina is the presentation. Fistula may *below* just above the anal sphincter or *high* up near the vault.

Investigation

- *Contrast study*—using a contrast material a vaginogram or a barium enema is done to identify a fistula located in the upper rectum.
- *Computerised tomography (CT) scan*—of abdomen and pelvis helps to locate a fistula and determine its cause.
- *Magnetic resonance imaging (MRI)*—can show the location of a fistula, as well as involvement of pelvic organs or the presence of a tumor. MR fistulogram can be more useful.

Preparation

Complete mechanical bowel preparation is essential for the repair of rectovaginal fistula (RVF). Diversion colostomy is essential in high fistula, radiation induced fistulas and in recurrent/failed repair of RVF. Vagina is prepared with antiseptic solution. Preoperative higher antibiotics are started.

Technique

Patient is put in lithotomy position. Vaginal mucosa is incised circumferentially round the fistula. The vaginal flap is raised all round the fistula. Extreme care is taken to see that the bowel mucosa is adequately mobilised and the devitalised, scarred, or avascular portions of the mucosa is been excised. After adequate mobilisation of the intestinal mucosa, its edges are sutured in an inverting fashion with interrupted 3-0 vicryl sutures. A second layer of closure involving the perirectal fascia and sometimes even levator ani muscle is done. To improve the vascularity of the area bulbocavernosus flap may be drawn into the area. A longitudinal incision down the labia majora is done through the pad of fat until the bulbocavernosus muscle is exposed. After its dissection it is transected above its insertion into the perineal body, leaving its blood supply from the pudendal artery intact. A tunnel approximately 3 cm wide is created from inside the vaginal canal and the bulbocavernosus muscle is drawn through this tunnel underneath the labia minora. It is placed over the repaired area and is sutured over the perirectal fascia with interrupted 3-0 vicryl sutures. The vaginal mucosa and the labial skin are sutured with 2/0 vicryl sutures. Stool softeners are given for 3-6 months.

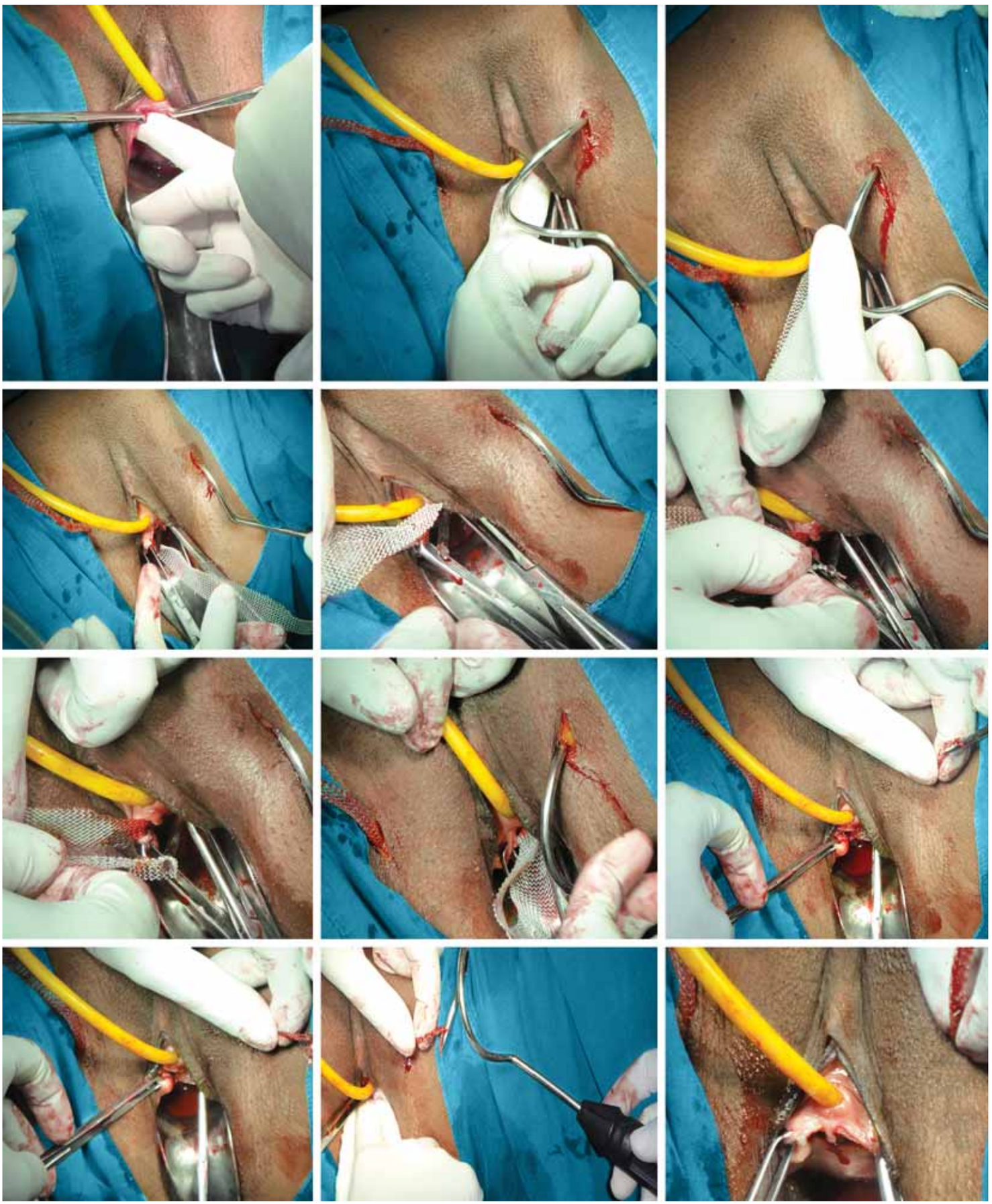
However higher fistulas cannot be dealt satisfactorily through vagina and may require open abdominal approach. After dissecting the rectovaginal septum, the fistula is divided, and the rectum and vagina are closed primarily without bowel resection. Omentum may be interposed in between to separate the suture lines. This is useful when the fistula is not large and the tissues available for closure are healthy. But when tissues are unhealthy because of irradiation, inflammation, or neoplasm, unless the abnormal tissues are resected this type of repair is likely to fail. Functional anal sphincters are preserved whenever possible by use of a low anterior resection, and coloanal anastomosis.

TRANSOBTURATOR TAPE (TOT) FOR STRESS URINARY INCONTINENCE

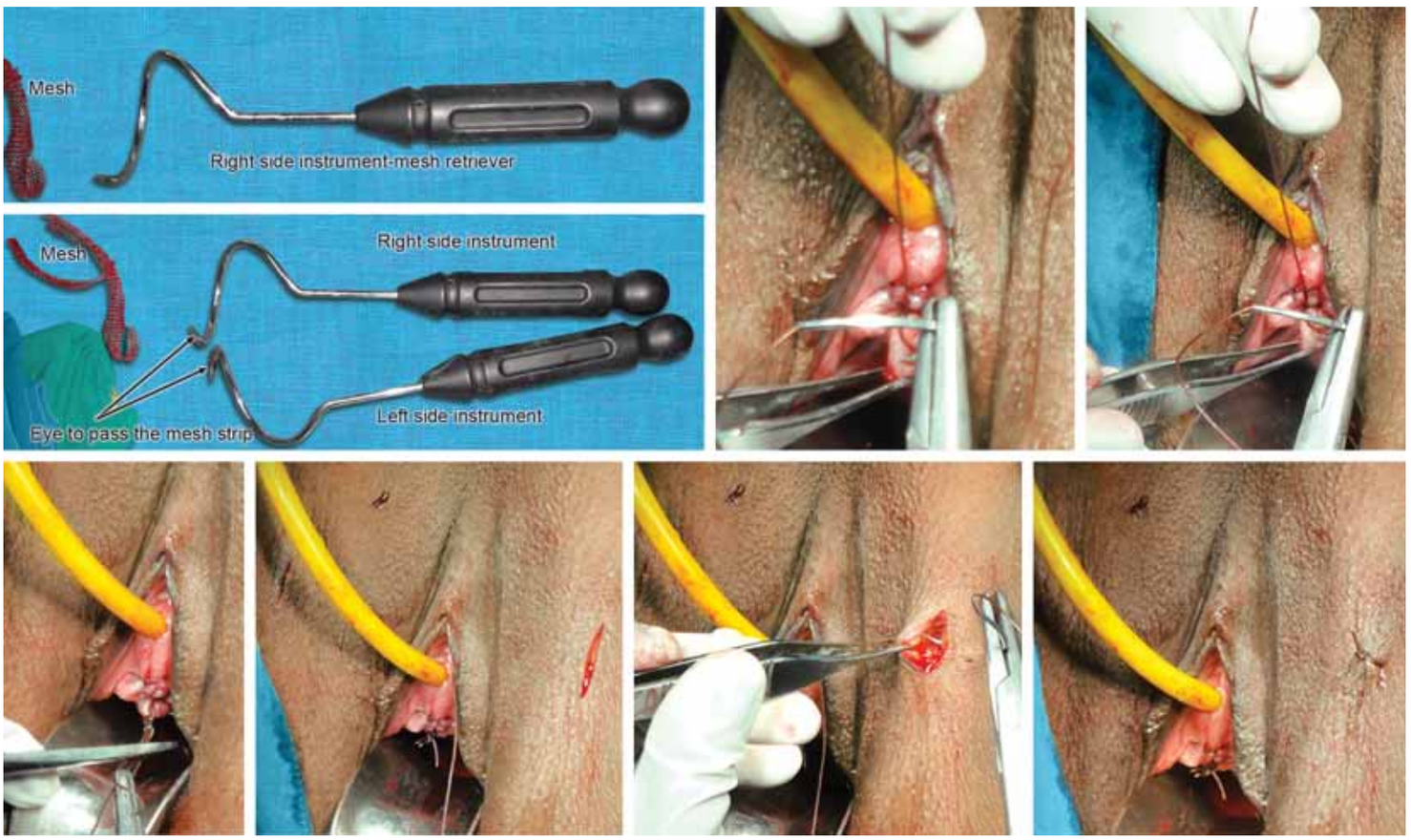
Under spinal anaesthesia, in lithotomy position, Foley's catheterisation is done. A point is marked on the outer aspect of the labia majora which is a point of intersection of an imaginary horizontal line passing to the clitoris and vertical line passing through the adductor longus tendon. Suburethral anterior vaginal wall flap is raised for 2 cm by making a vertical incision. Dissection upwards and laterally is carried out as far near the pubic ramus. A stab incision is made on the marked point on the outer aspect of the labia majora (vertical incision). Through this small incision specialised curved stout trocar which is having an opening (helical trocar) is inserted under guidance over the pubic bone and then to pass under and around the pubic bone across the obturator membrane so as to enter its tip into the anterior vagina adjacent and under the flap created; through the eye at its tip polypropylene tape (strip of lengthy mesh) is fed and gradually withdrawn to bring the tape out through the incision on the skin. Helical trocars are different for right and left side. Similar procedure is repeated on the opposite side to pass another end of the tape (mesh strip) to the opposite side labia majora incision. One should confirm that tape should fit only snugly neither too tight nor too loose. Ends of the mesh tape are buried under the skin (both sides) and skin is closed on both sides. Anterior vaginal wall incision is closed using chromic catgut. Urinary catheter is kept for 2 days.

Problems

Injury to bladder, obturator vessels, mesh displacement, failure of the procedure, it is a blind procedure. It is considered to be safe in spite of the fact that it is blind **(Fig. 32-26)**.



Figs 32-26(1)



Figs 32-26(2)

Figs 32-26(1 and 2): Technique of transobturator tape (TOT) placement for stress urinary incontinence.

Chapter

33

Other Procedures

ROBOTIC SURGERY

Word—*Robota (Czech)* means for compulsory labour. First robot was deviced by Leonard da Vinci. Surgical robot is powered computer-controlled manipulator with artificial sensing that can be reprogrammed to move and position tools to carry out a range of surgical works. Initially da Vinci robot is developed from defense advanced research project agency (DARPA) for military research of remote battlefield surgery. Cholecystectomy was performed remotely via telesurgery from 300 miles away. Intuitive surgery created in 1999 after acquiring military patent rights from military. First robotic prostatectomy was performed in 2001 **(Fig. 33-1)**.

There are three parts in robotic system:

- Surgeon's console
- Patient's cart
- Optical cart.

As the surgeon manipulates the remote control unit, movements of the surgeon is translated to robotic arms. Each robotic arm contains multiple appendages connected by joints. The 'hand' of the robot holds interchangeable surgical instruments that can be moved in a manner similar to wrist of human. Scaled, filtered, translated movements are achieved without hand dominance. In laparoscopy, it is surgeon's hand, team work and proper instruments, tremor at the working end is always present; camera is controlled by camera surgeon not operator whereas in robotic surgery camera is controlled by operator. Endowrist moves 360° at all angles, makes dissection and suturing perfect **(Fig. 33-2)**.

Special features are: Binocular stereoscopic 3D vision with stability of camera; increased dexterity because of endoinstrumentation; high density camera with 15X magnification; easy dissection; quick intracorporeal suturing and knotting; precise technique; surgeon sits comfortably and operate with arms rested; adequate ergonomics with equal tremor less movements of right and left arms; multitasking instrumentations; harmonic robotic arm; three arms with 3D HD robotic camera arm with 4th arm robot for retraction; patient friendly as well as surgeon friendly.

Advantages: It is less painful; less blood loss; fast recovery; needs short hospital stay; small incision; cosmetically accepted; better outcome. Robot facilitates the performance of most complex procedures with minimally invasive high standard techniques.

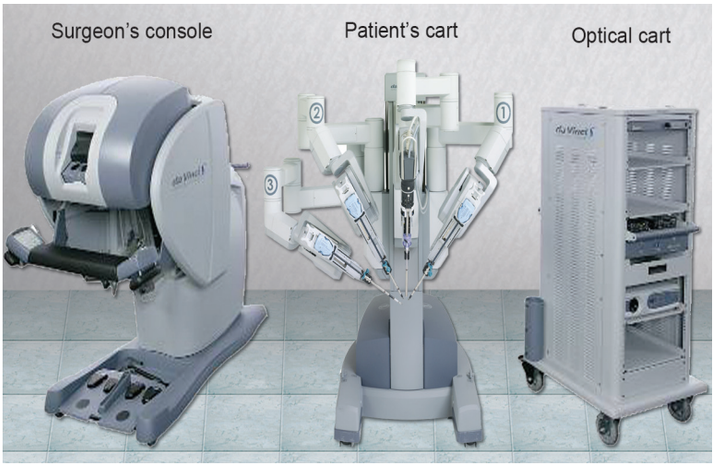


Fig. 33-1: Robotic surgical device set.

Fig. 33-2: Robotic endowrist which moves in all angles—360°.

Fig-33-3: Robotic skill simulator.

Procedure done: All procedures done through laparoscopy can be done through robotic surgery. Nephrectomy, prostatectomy, hysterectomy, oesophageal surgeries; thyroid surgeries; oropharyngeal surgeries.

Learning curve: Surgical simulator to learn the robotic surgery is available—as red dragon/blue dragon. This skill simulator can teach endowrist manipulation, cameras and clutching; 4th arm integration; system settings; needle control and driving; energy use and dissection **(Fig. 33-3)**.

Limitations: Absence of tactile feedback, fixed patient position; increased cost to patient.

Future: Present set has got following features – monopolar/bipolar/advanced bipolar energy; harmonic; advanced grasper; laser.

Future set will have linear cutter, seal, suction irrigation, drill, etc. Endowrist one vessel single use 8 mm diameter sealer with compact snake wrist is designed to seal and cut up to 7 mm diameter vessels. Image guidance fluorescence, lymph node mapping are newer one. Firefly fluorescence imaging of da Vinci identified real time anatomy using near infrared guidance which enhances visualisation of the critical vasculature like of mesentery, permits real time perfusion of the bowel prior to resection mainly in colon.

Advanced single port robotic set is the future. Single port very flexible robotic arm with snake like robots are possible in coming days **(Figs 33-4 to 33-6)**.

Robotic scrub nurse as a helper robot in changing instruments like a scrub nurse.

LIPOSUCTION

Liposuction, also known as *lipoplasty* ("fat modelling"), *liposculpture suction lipectomy* ("suction-assisted fat removal") is a cosmetic surgery operation that removes fat from many different sites on the human body. Areas affected can range from the abdomen, thighs and buttocks, to the neck, backs of the arms.

Several factors limit the amount of fat that can be safely removed in one session. Finally, the operating surgeon and the patient make the decision. There are negative aspects to removing too much fat. Unusual "lumpiness" and/or "dents" in the skin can be seen in those patients "over-suctioned". The more fat removed, the higher the surgical risk.

Liposuction may be performed under general, regional ("tumescent"), or local anaesthesia. The safety depends on the amount

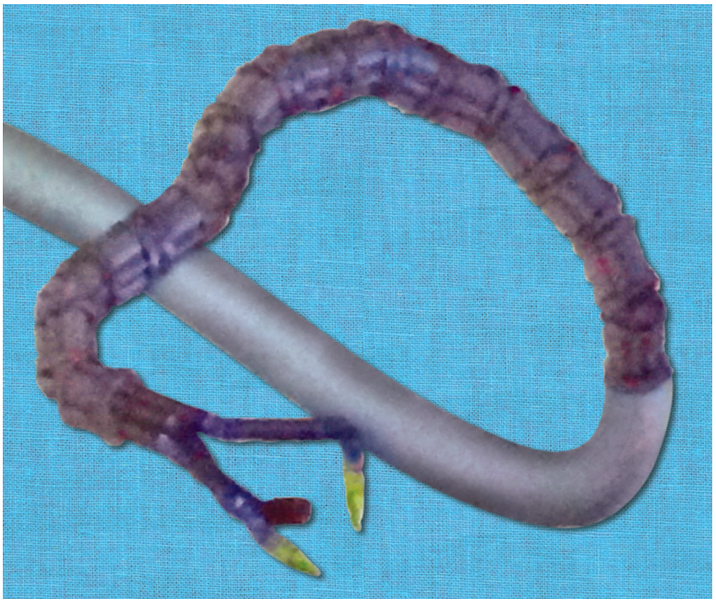


Fig. 33-4: Robotic flexible system.

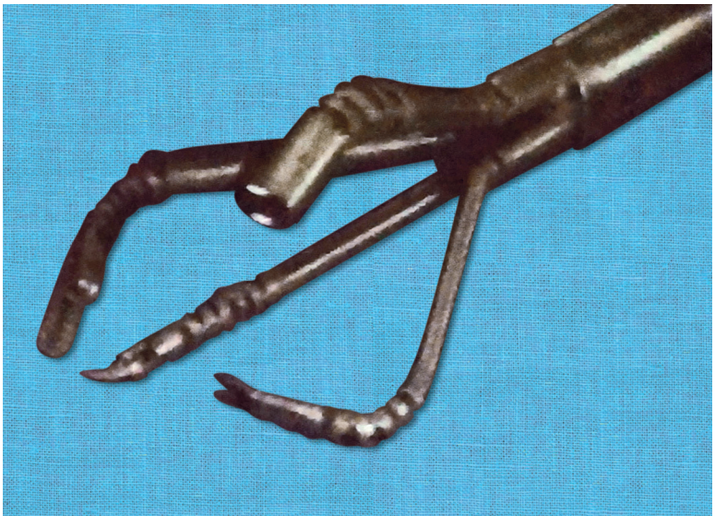


Fig. 33-5: Robotic SILS port.

of tissue removed, the choice of anaesthetic and the patient's general condition. Fit patient, patients who have stopped smoking for many months are ideal candidates for this contour correction surgery.

Technique was first performed by a French surgeon, Charles Dujarier. In 1926, a French model underwent contour surgery of leg by Charles Dujarier to later develop gangrene of the leg was a tragic story. This was the oldest history about contour surgery. In 1960, curettage surgery was proposed with variable results and morbidity. Again a French surgeon, Dr Yves-Gerard Illouz, in 1982 originated a method of suction-assisted lipolysis after infusing fluid into tissues using blunt cannulas and high-vacuum suction—Illouz method. In 1985, Klein and Lillis described the "tumescent anaesthesia", a regional technique which with high volumes of fluid containing local anaesthetic with intravenous sedation. High volume of fluid and potential toxicity of xylocaine tumescent technique later changed to low volume "super wet" tumescence. In the late 1990s, ultrasound was introduced to facilitate the fat removal by first liquefying the fat using ultrasonic

Fig. 33-6: Robotic snake instrument.

energy. But it showed more complications. Laser thermal lipolysis is modern technology. Whatever the type is used, it is the surgeon's skill finally matters for adequate liposuction to create normal contour without complications.

Diabetes, cardiac illness is the relative risks for liposuction.

Principles: To remove the right amount of fat; to cause the least disturbance of other tissue, such as blood vessels; to keep the person's fluid balance normal.

Sites where liposuction is done: Abdomen; hips; outer and or inner thigh; flanks; back; inner knee; upper arm; submental/chin; gynecomastia in males.

Preparation

Anticoagulants should be avoided for 2 weeks. Pre-operative antibiotics are needed. Cardiac evaluation, respirator exercises are given.

Technique

Power-assisted liposuction cannula is often used nowadays.

Fat is removed through a cannula and a suction device. Liposuction technique depends on the amount of fluid injection and the mechanism by which the cannula functions. The surgeon creates

forwards and backwards motion, carefully through the fat layer, breaking up the fat cells and drawing them out of the body by suction. The patient will feel only a scraping or rasping sensation from the cannula movement. During liposuction, multiple small puncture wounds are made for inserting the cannula that can vary in size depending on the technique **(Fig. 33-7)**.

Ultrasound-assisted liposuction is useful for working on more fibrous areas, like the upper back or male breast area. It takes longer time; but with less blood loss.

Water-assisted liposuction is done by using a thin fan-shaped water beam, which loosens the structure of the fat tissue, so that it can be removed by a special cannula. During the liposuction, the water is continually added and almost immediately aspirated via the same cannula. It utilizes less infiltration solution and oedema is less in this.

Postoperative Management

A compression garment which can easily be removed by the patient is worn for four weeks, this garment must have elasticity. Analgesics may be needed. Patient can go for work in 1-2 weeks.

Side-effects

Bruising which is painful; swelling; scars; pain in the abdominal wall; numbness in the abdomen which will subside in few weeks; post-operative weight gain; restricted mobility due to abdominal binder; pain, inflammation.

Fig. 33-7: Liposuction technique and device.

Complications

Allergic reaction to medications or material used during surgery. Infection: any time the body is incised or punctured, bacteria can get in and cause an infection. Damage to the skin: most surgeons work on the deeper levels of fat, so as to avoid wounding the skin any more than they must for the insertion of the cannula. Sometimes the cannula can damage tissue beneath the skin. Skin necrosis can occur rarely; and adjacent skin falls off in the necrotic area. Injury to internal organ during puncture of the abdominal wall can occur; such as the intestines during abdominal liposuction. Contour irregularities can occur. Thromboembolism and fat embolisation can develop occasionally. Burns due to friction of the cannula can occur. xylocaine toxicity presenting as tingling and numbness and eventually seizures, followed by unconsciousness and respiratory or cardiac arrest. Fluid imbalance as fat contains a lot of fluid and is removed in liposuction, and also the surgeon injects fluid for the procedure, a very large amount for tumescent liposuction, fluid imbalance can set in. This could happen afterwards, after the patient is at home. If too much fluid remains in the body, the heart, lungs and kidneys could be badly affected.

DRESSINGS

They are the materials used to cover wounds, ulcers to provide support and to encourage healing.

Advantages

It covers the wound and so prevents further contamination. It gives comfort to the patient.

Disadvantages

It may get soaked. It may delay the epithelial layer formation.

Types

Dry dressings: It is used in clean, sutured operated wound. It is not changed at regular intervals.

Wet dressings: It is used in ulcers and wounds. Dressings are made wet by using jelly or Sofra-Tulle sheets.

Components of Dressing

Inner contact layer: It is non-absorbent and only allows secretion to pass into the absorbent layer. It does not allow penetration of granulation tissue. It is usually kept wet. Either mesh gauze or Sofra-Tulle is used.

Intermediate absorbent layer made up of cotton which absorbs the secretions.

Outer layer as supportive is made up of gauze.

Dressings are fixed to the place by—Bandages; Plasters; dynoplast; crepe bandages; depending on the condition and amount of discharge from the wound/ulcer, it is changed as required—twice a day/once a day/once in two days. Small dressings are done without anaesthesia. Large areas like burn wounds or dressing in children require general anaesthesia.

BANDAGES

Technique of bandaging is called as ***dysmergia***.

Indications

To reduce the swelling like in lymphoedema; to keep dressings in position; to support splint; to stop bleeding/oozing.

Types of Bandages

Roller bandages: It is a continuous roll of material, which is rolled over the part to cover the area. It is used in limbs.

It is available in different lengths and widths—1 inch, 2 inches, 4 inches or 6 inches. It is used in different ways.

- ***Circular turns:*** Continuous rolls placed over the same place.
- ***Spiral turns:*** After the initial turn of the bandage, it ascends proximally overlapping the distal 2/3rd of the previous turn.
- ***Reverse spiral turn:*** Here each spiral turn is reversed in opposite direction so as to attain uniform pressure. It is used in limbs and areas which end as cones.
- ***Figure eight turn:*** It is used in knee, elbow, wrist, ankle and for clavicle.
- ***Recurrent turn:*** It is used in head and amputation stump. Here initially circular rolls are made and over that half turns are made to cover other parts of the area required.
- ***Spica bandage:*** It has got ascending and descending turns, with each turn overlap and cross each other. It is used in hip, groin, shoulder, breast or thumb. *Spica means eye of a bean.*

'T' bandages: It is used in perineum and groin.

***Tailed bandages*:** It may be four tailed bandages or many tailed bandages. It is used to support dressings on a wide area like in burns dressing, over abdomen or chest wall.

Tubular bandages: These are stockings which are unrolled over the limb to give pressure effects. It is used in lymphoedema, varicose veins and in the post-operative period following surgeries of the limb.

Triangular bandage: These are used for supporting the elbow or forearm. Here a wide gauze is used to cover the arm, forearm and elbow, which again winds around the neck.

Cravat bandages: It is a folded type of triangular bandage, which is used as sling around the neck, when elbow requires to be rested.

Principles of Bandaging

Bandage is applied to the part from distal to proximal end. Proper positioning of the limb is a must before bandaging. After initial few circular turns, the required type of bandaging is then done. Bandage is unrolled outwards. During bandaging, latter turn should overlap 2/3rd of earlier turn. Firm, adequate pressure should be used during bandaging. After completing the procedure, the knot should not lie over the area or over the bony points or over the back. It should not cause venous or arterial compression. Digits should be left open and circulation in the digits should be observed for.

Size of bandages used at different places are: Finger/toe—One inch; Arm—Two and half inches; Leg—Four inches; Thigh—Six inches; Trunk—Six inches; Head—Four inches.

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